

Overcoming the Design Challenges of High Performance Building Envelopes

TH102

Thursday, June 21, 7:00 AM – 8:00 AM

1.00 Learning Unit

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Speakers List

- **Andrea Love, AIA**

Principal / Director of Building Science, Payette, Boston, MA

- **Robert Pasersky, AIA**

Associate Principal, Payette, Boston, MA

- **Wesley Schwartz, AIA**

Senior Associate, Payette, Boston, MA

- **Jeffrey Abramson, AIA**

Associate, Payette, Boston, MA

Course / Learning Objectives

- Articulate the challenges of designing a glass facade from the standpoints of design, indoor environmental quality, and energy performance.
- Identify the key elements of a successful integrated design team dynamic, such as clear goalsetting, constant communication, and data sharing.
- Understand the selection process of a glass type, including the timeline in which performance, appearance, cost, and commercial availability must be evaluated.
- Recognize how best practices from the presented case studies can be applied to similar projects in the region.

1 Introduction

2 Form-Giving Sunshades

Northeastern University
Interdisciplinary Science and Engineering Complex

3 Minimalist Design

Amherst College, New Science Center

4 Orchestration of Standard Components

Tufts University, Science and Engineering Complex

5 Moderated Discussion | Q&A

1 Introduction

2 Form-Giving Sunshades

Northeastern University
Interdisciplinary Science and Engineering Complex

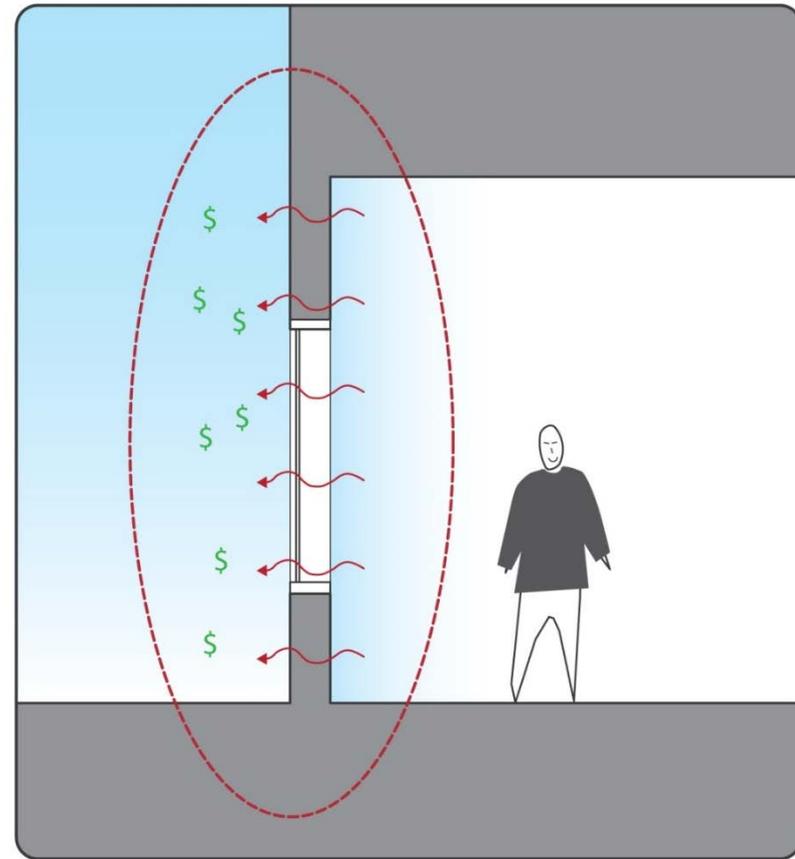
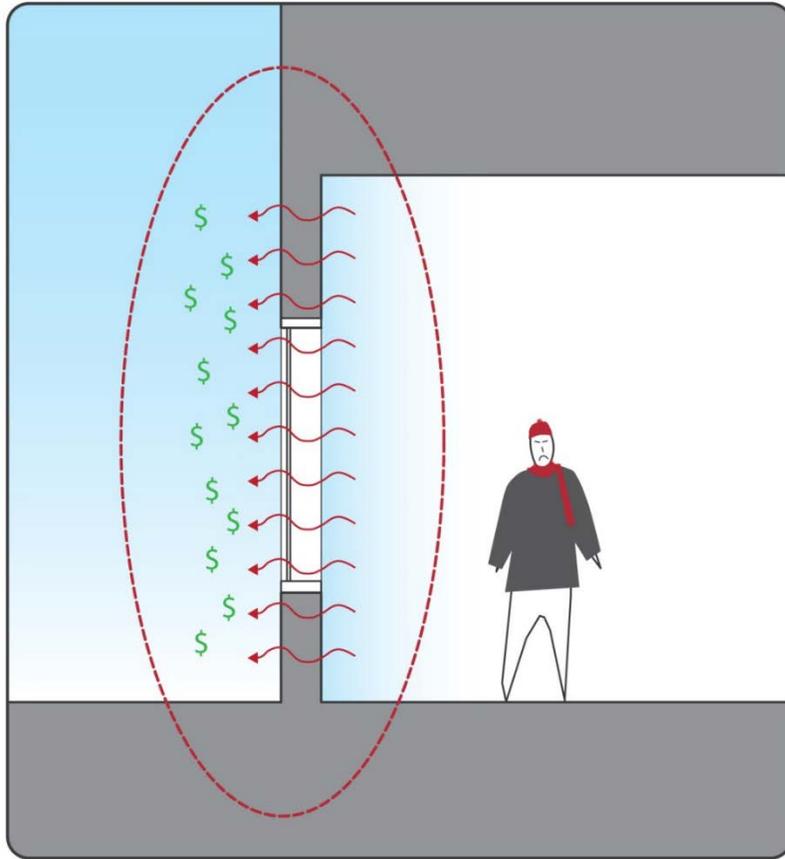
3 Minimalist Design

Amherst College, New Science Center

4 Orchestration of Standard Components

Tufts University, Science and Engineering Complex

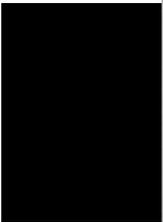
5 Moderated Discussion | Q&A

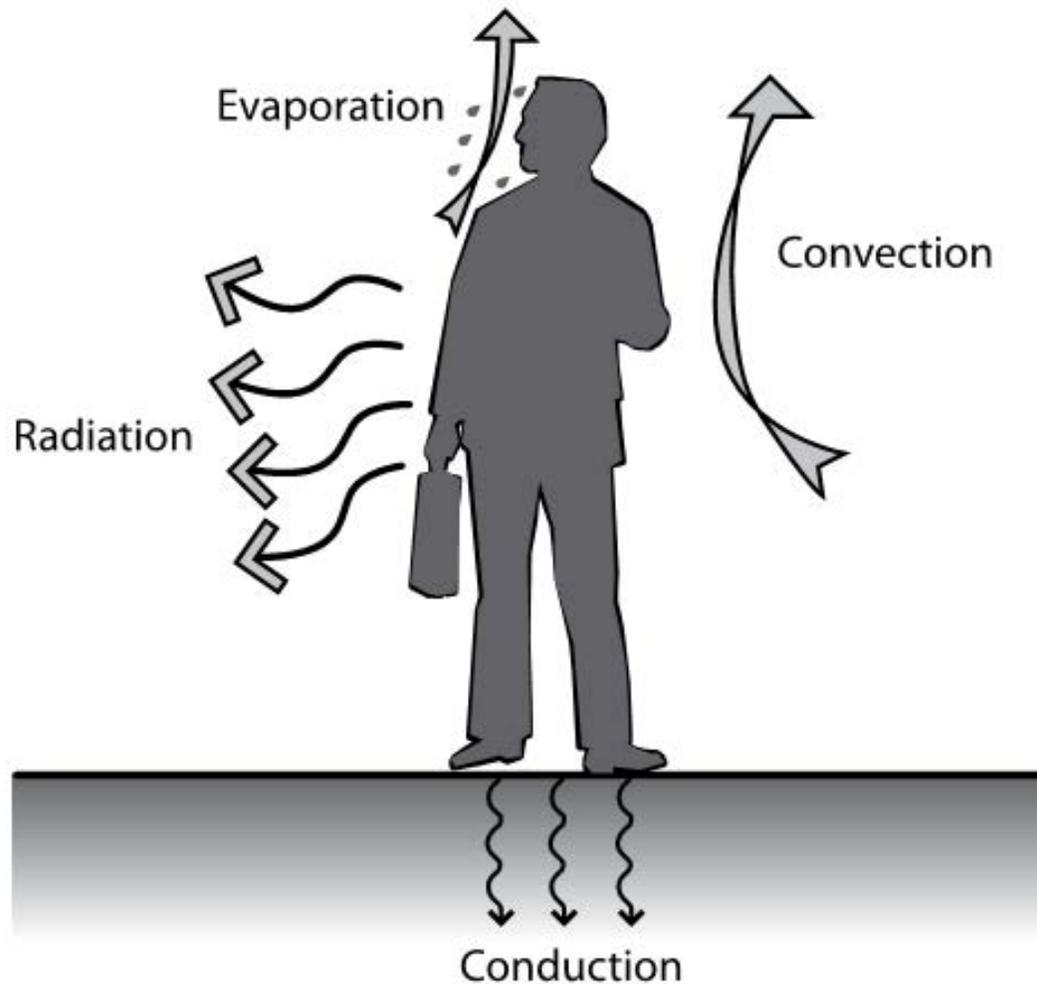


Informed envelope design decisions can lead to **lower energy costs**
and **increased occupant satisfaction**



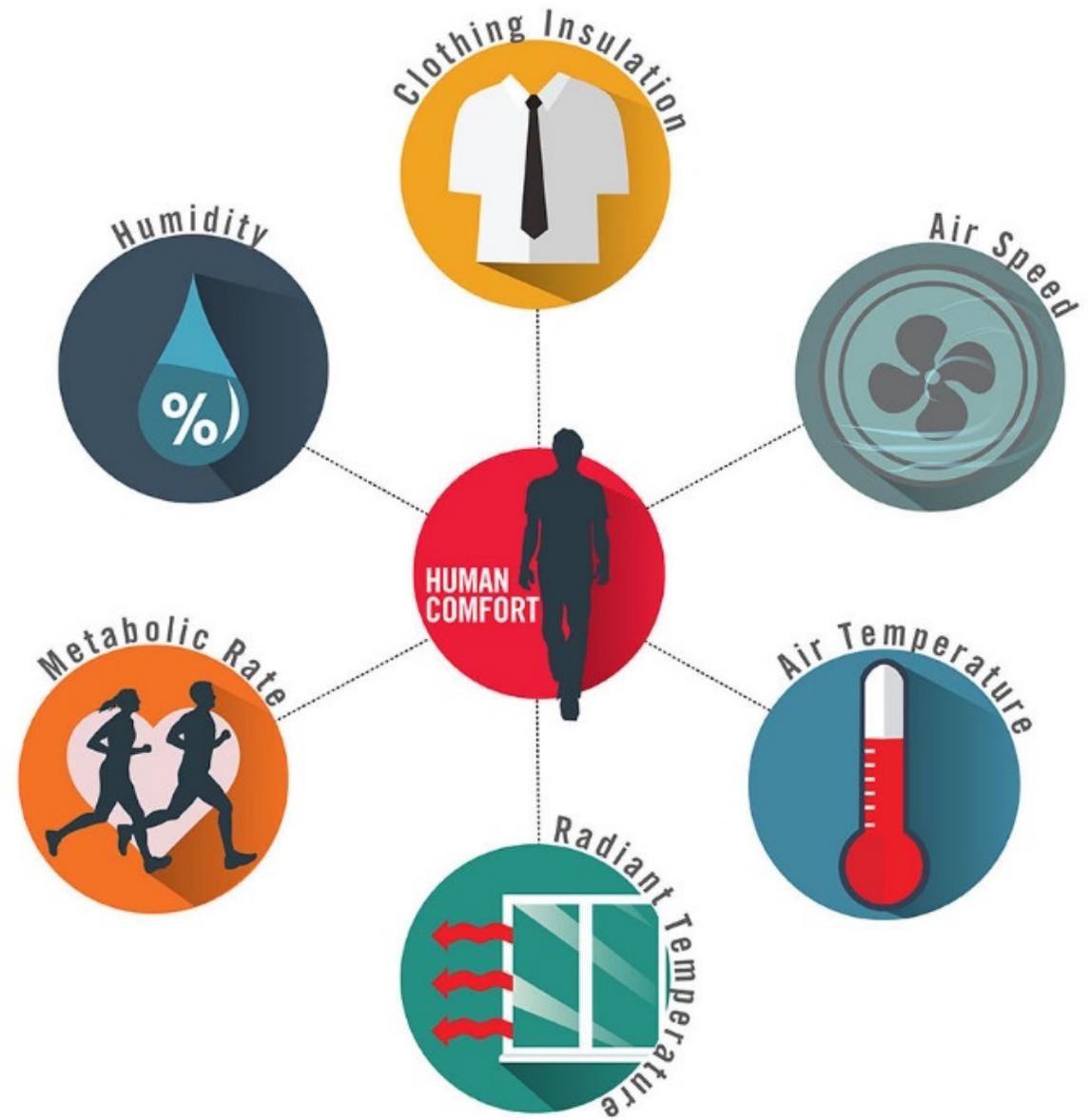
Comfort

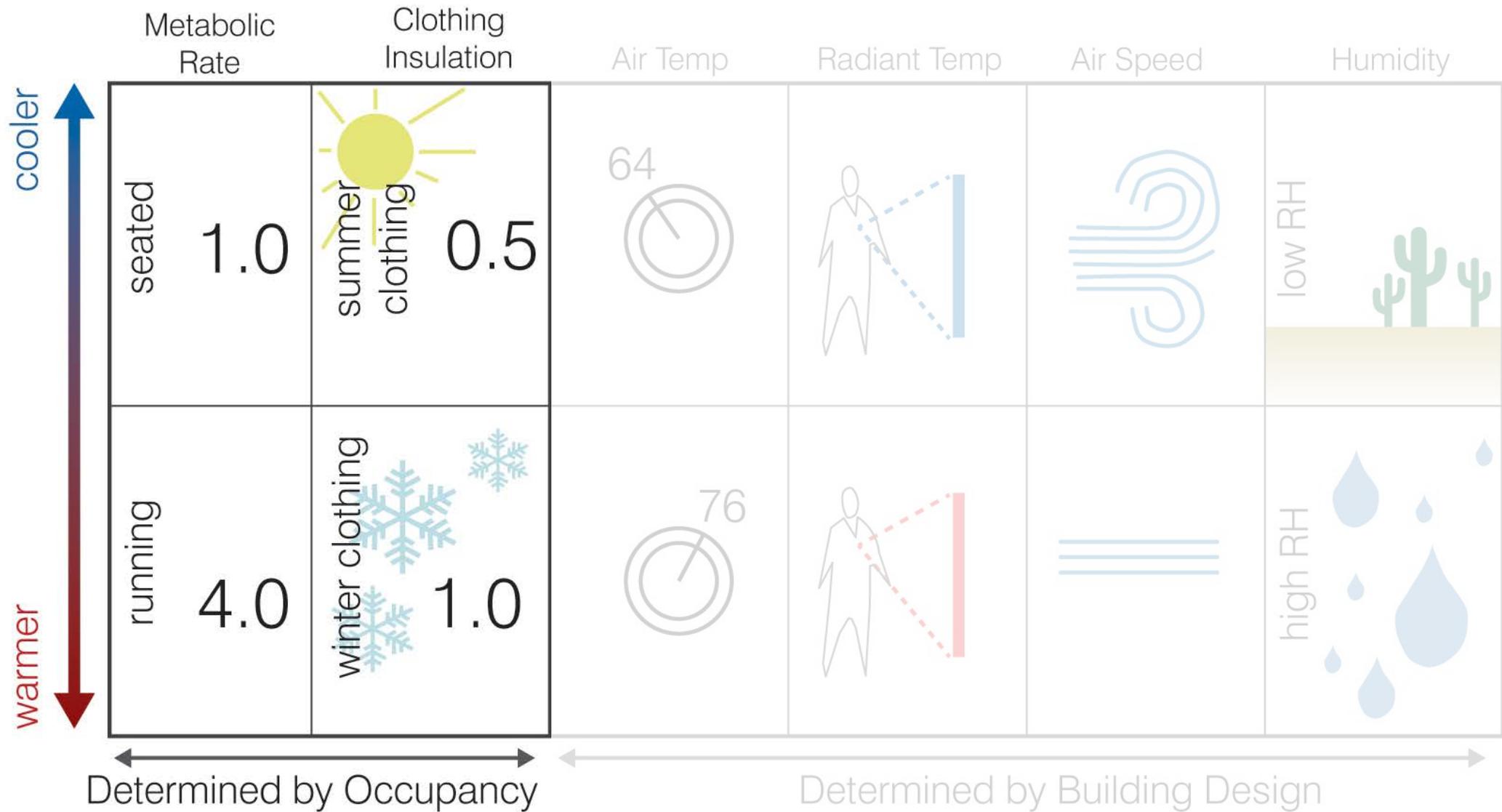


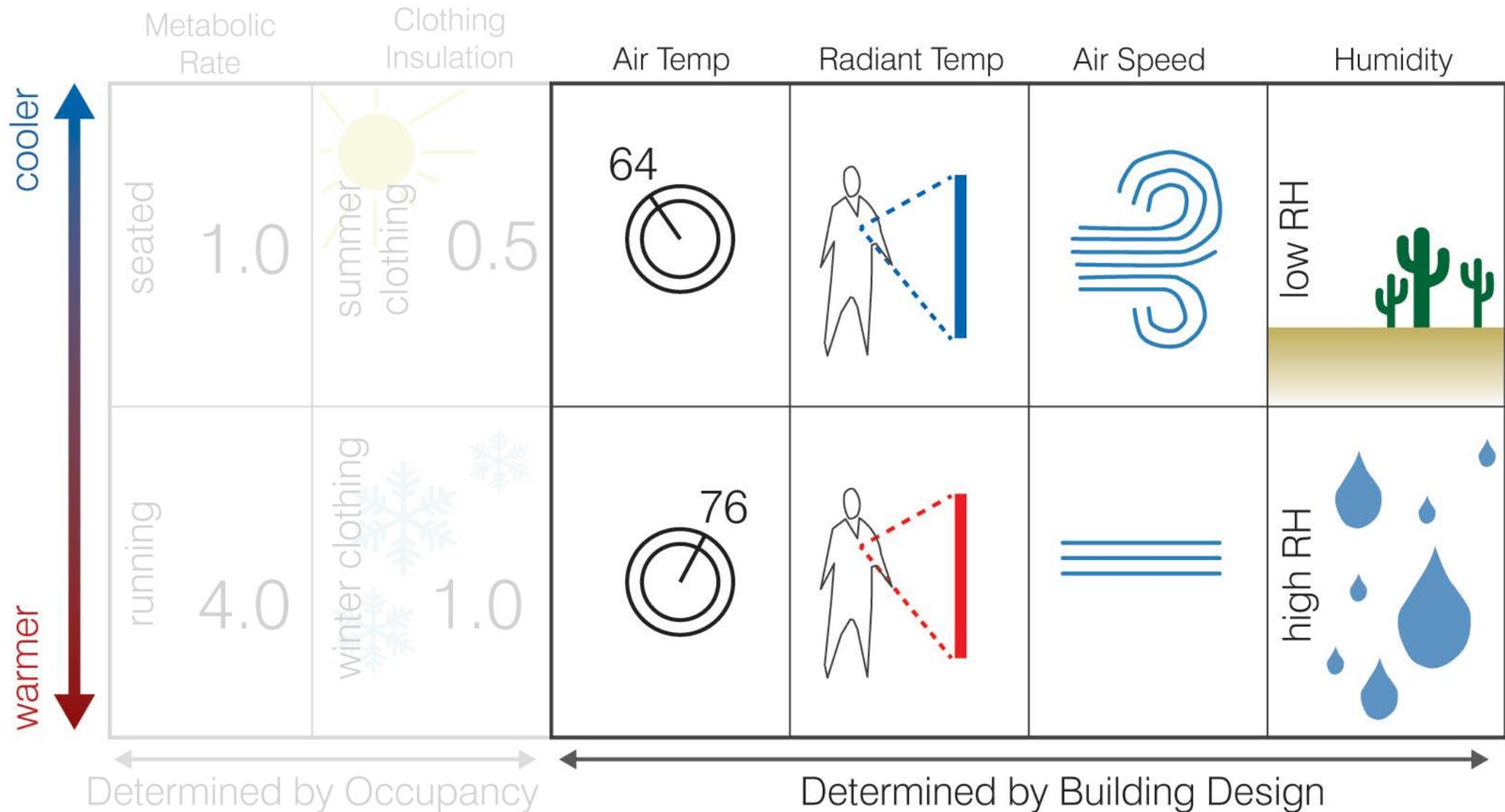


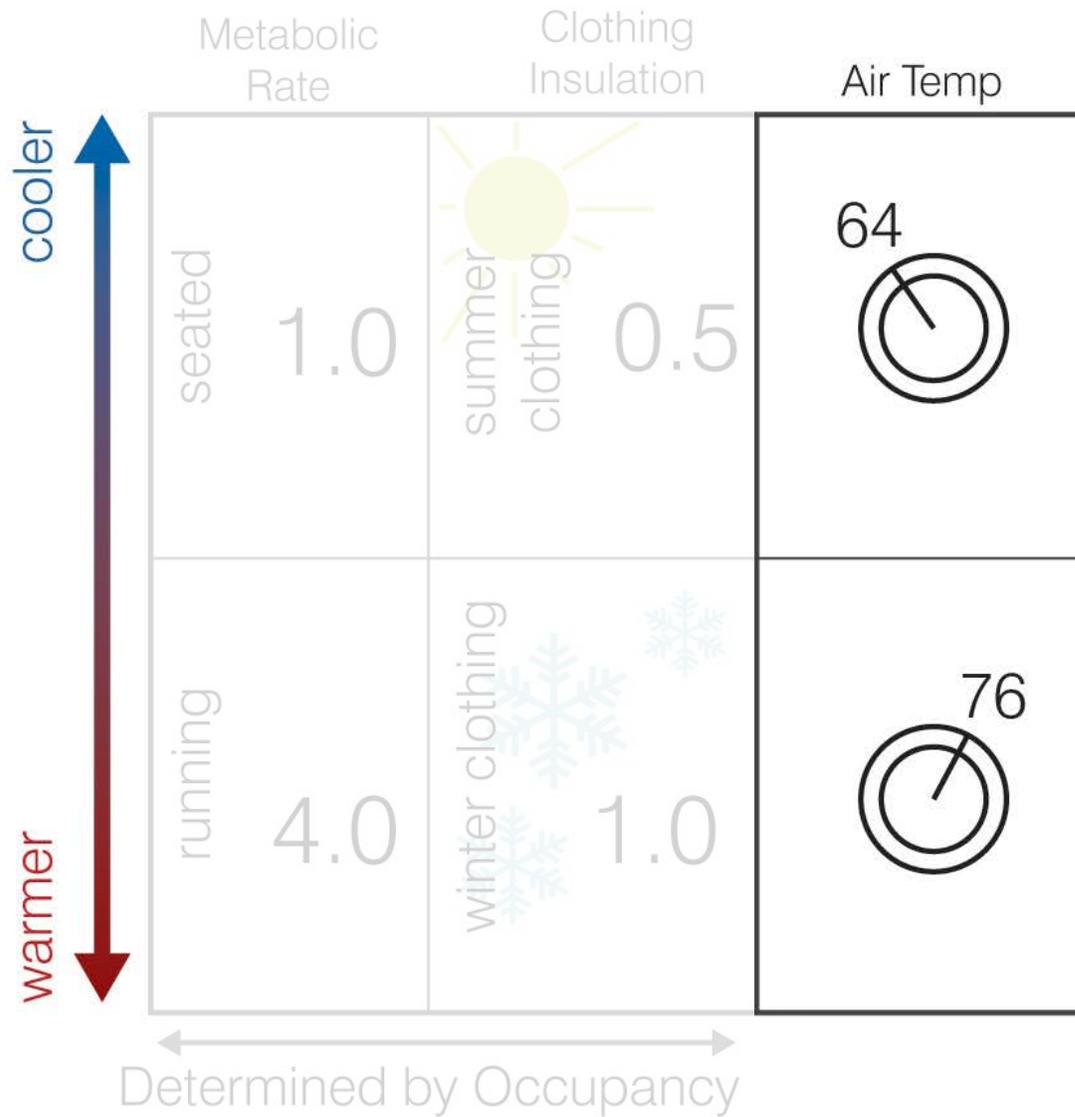
Modes of Heat Transfer:

- Conduction
- Convection
- Radiation
- Evaporation

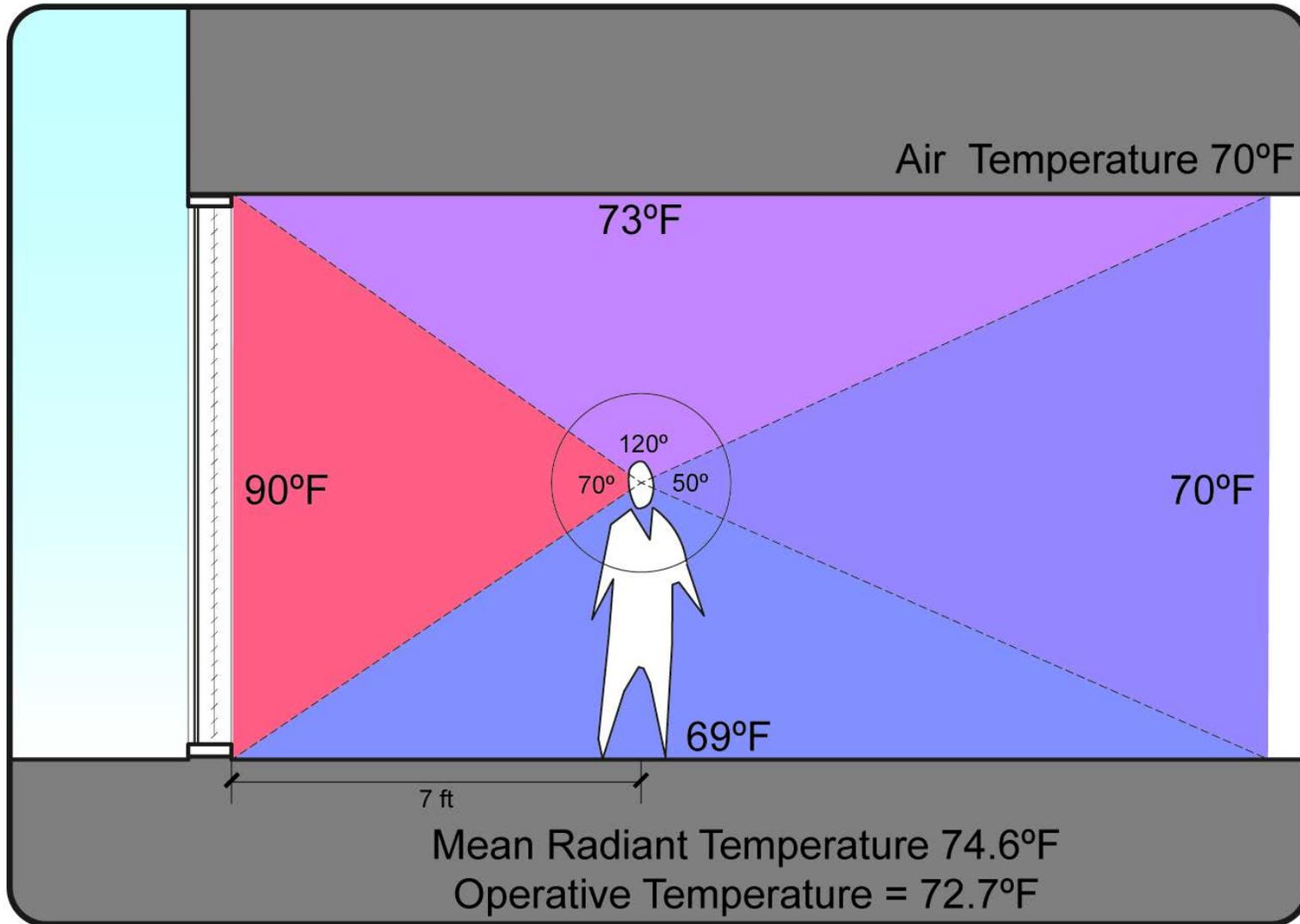








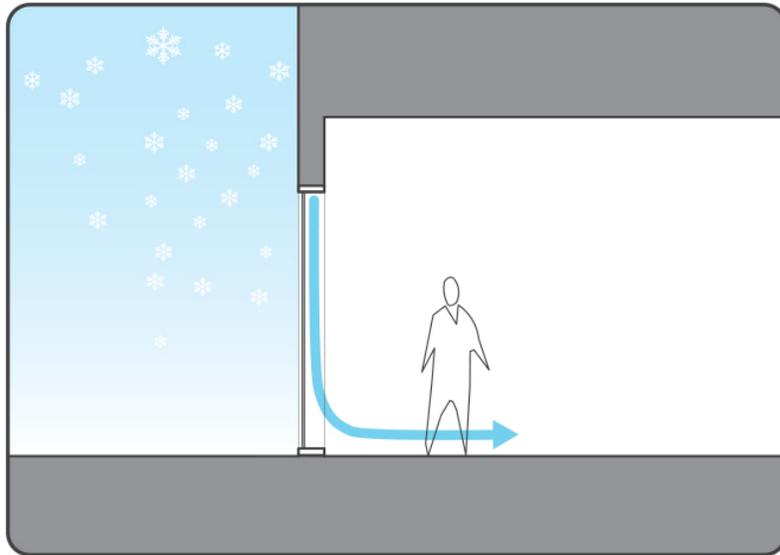
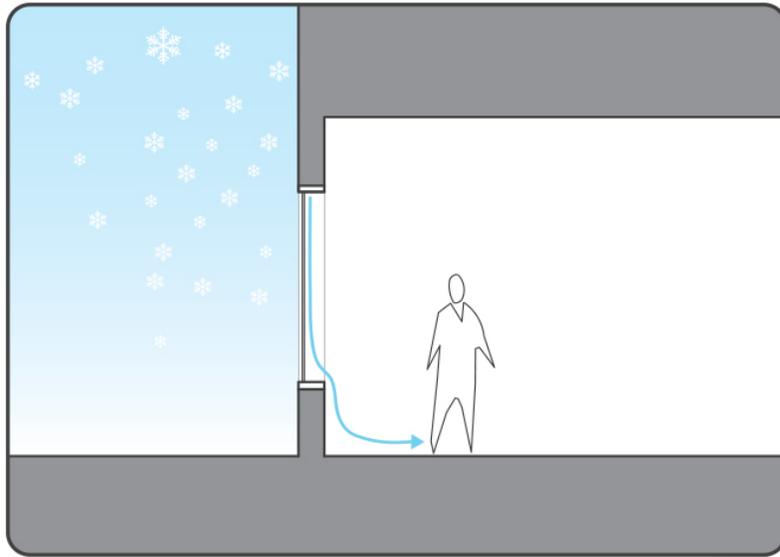




Equivalent MRT and Air Temperature for a Feeling of 70°

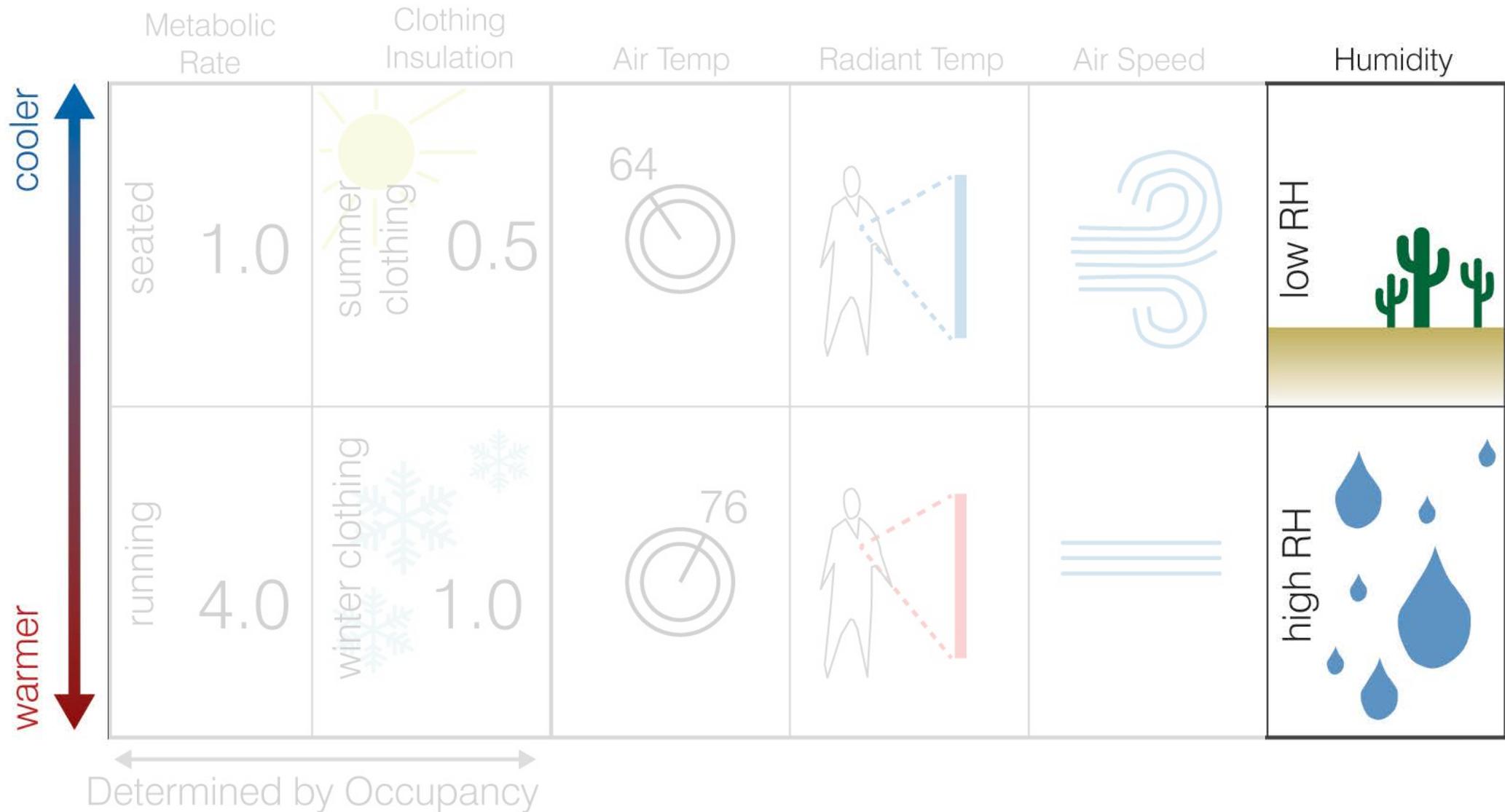
MRT	Air T
50	98
55	91
60	84
65	77
68	73
69	71
70	70
71	70
72	69
73	68
75	63
80	56

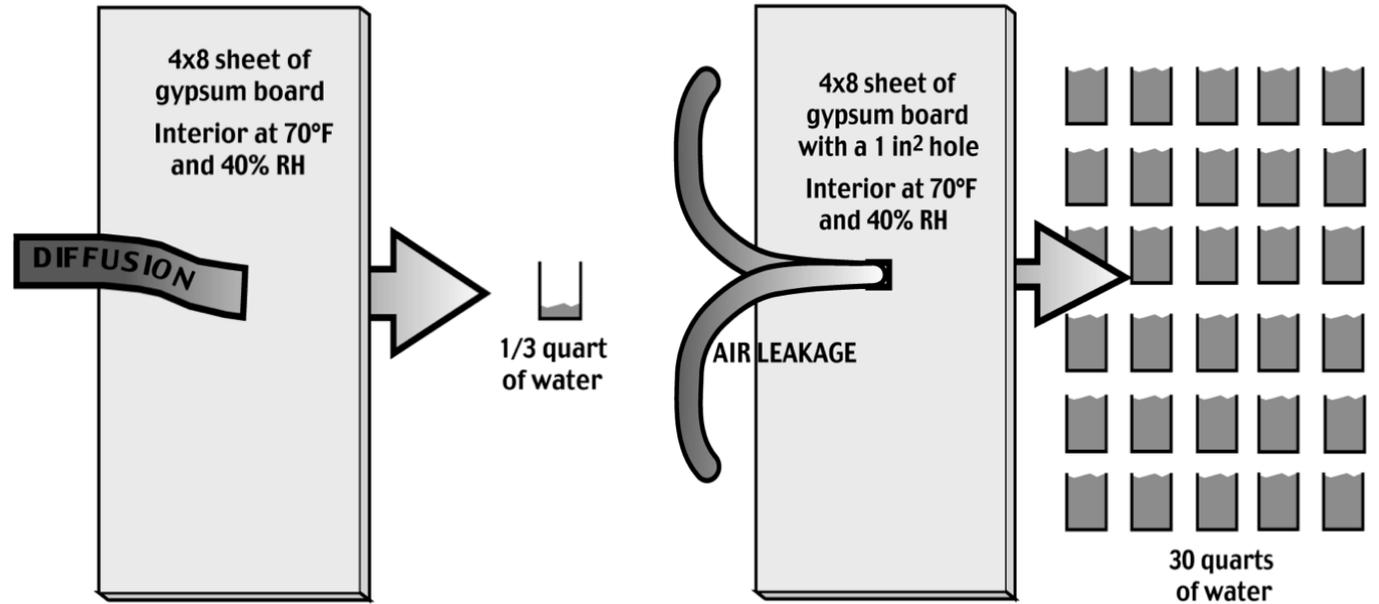
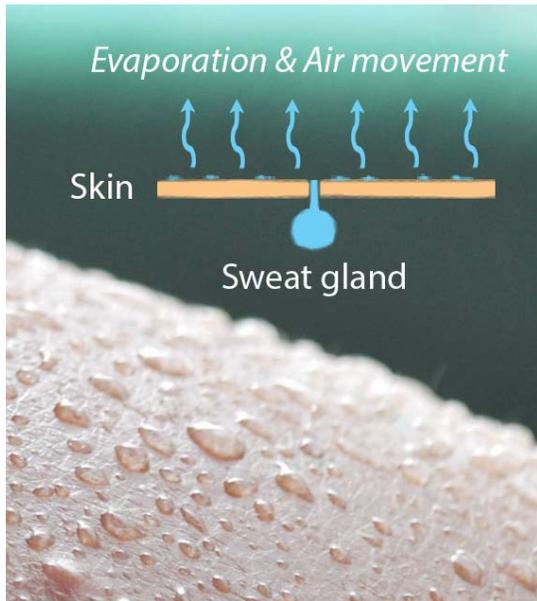


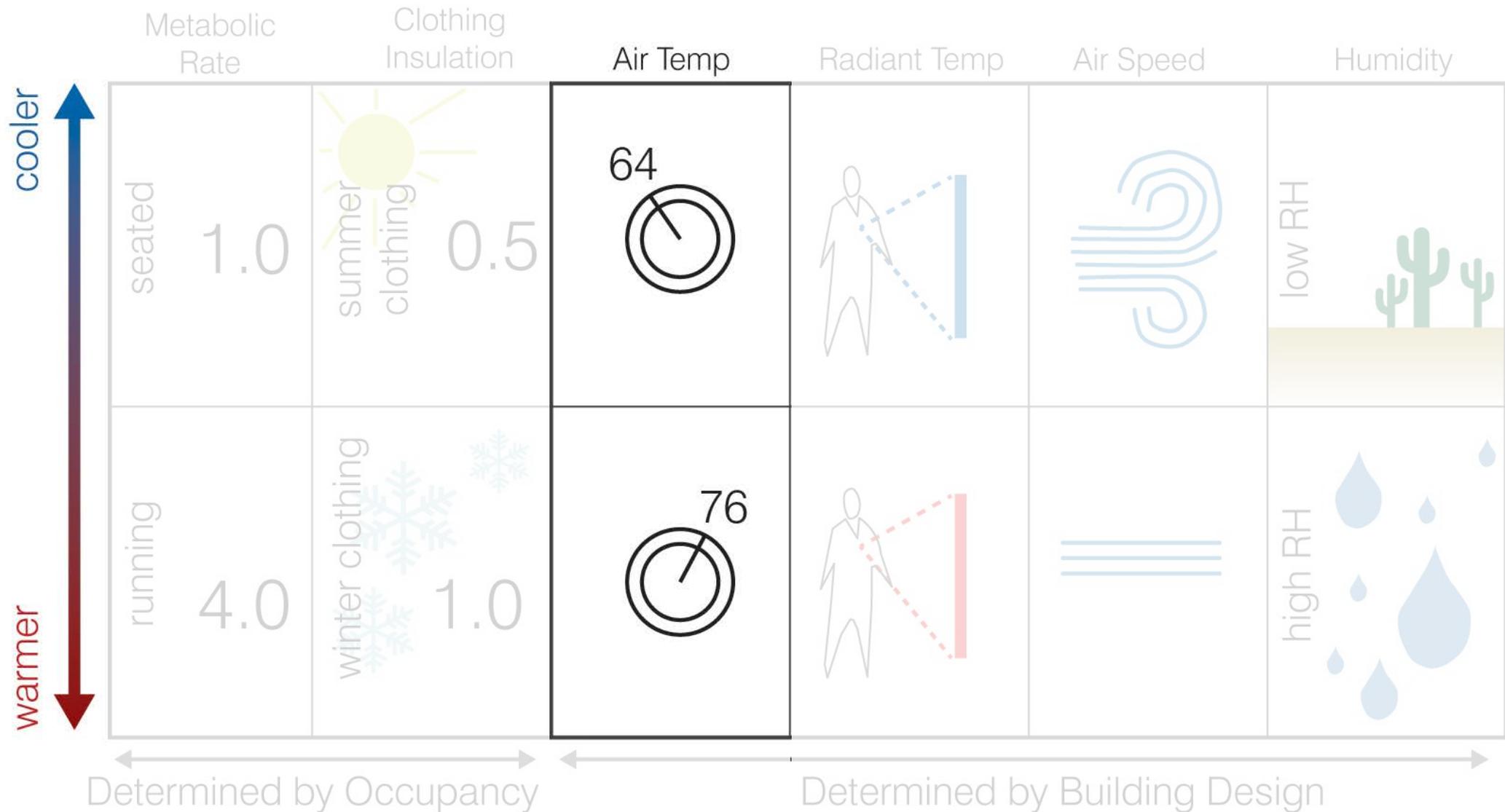


Draft Strength Depends On:

- How **cold** each surface is
- How **tall** the cold surface is
- How **close** the occupant is
(to the surface)



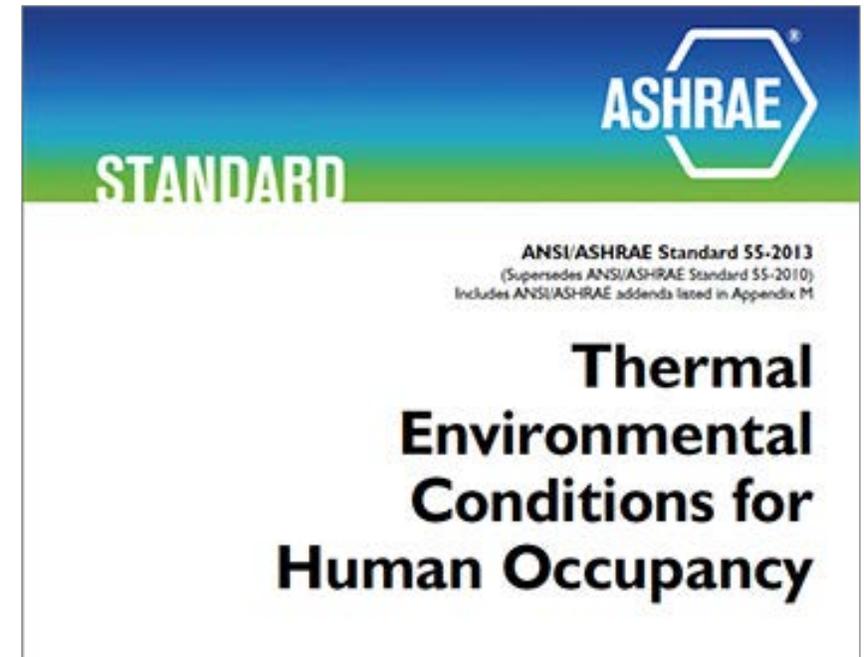




Fanger Model (1960's)

- Measured thermal comfort of college aged students
- Method for HVAC Engineers to predict thermal comfort
- Basis for numerous standards

ASHRAE 55-2015



Thermal Comfort History



1960 = 3-piece suits

=



2018 = Snuggie?

THE GREAT ARCTIC OFFICE CONSPIRACY



CHRIS MACHIAN FOR THE NEW YORK TIMES

Chilly at Work? A Decades-Old Formula May Be to Blame

- It happens every summer: Offices turn on the air-conditioning, and women freeze into Popsicles.
- A new study says most office buildings set temperature based on a model developed in the 1960s that uses the metabolic rates of men.

[New York Times](#)

CHILLING CAPACITY



OLIVIER SCHRAUWEN

Enduring Summer's Deep Freeze

Why is America so over air-conditioned?

[New York Times](#)

THE NEW YORKER

AUGUST 3, 2015

IS YOUR THERMOSTAT SEXIST?

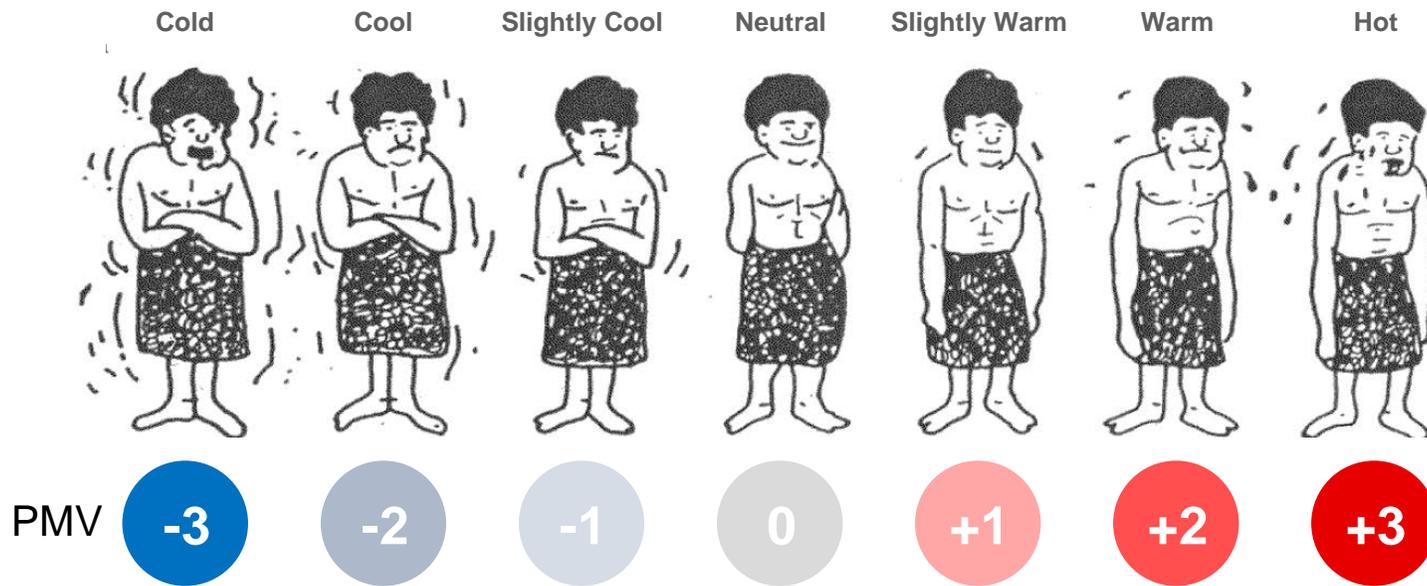
BY ANTHONY LYDGATE



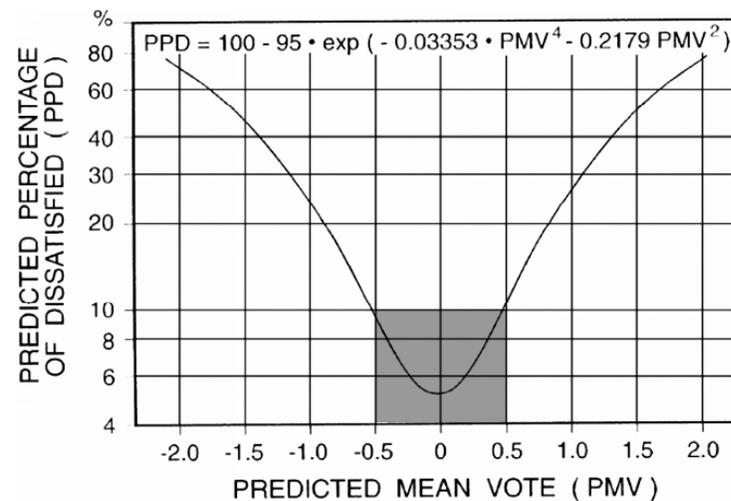
Since the nineteen-sixties, the science of thermal comfort has tended to neglect women.

ILLUSTRATION BY TOMI UH

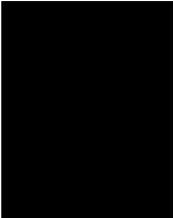
Even before Adam and Eve picked and ate the fatal fruit of the tree of knowledge, condemning humanity to lives of sweat-soaked toil, they knew the meaning of good thermoregulation. Halfway through

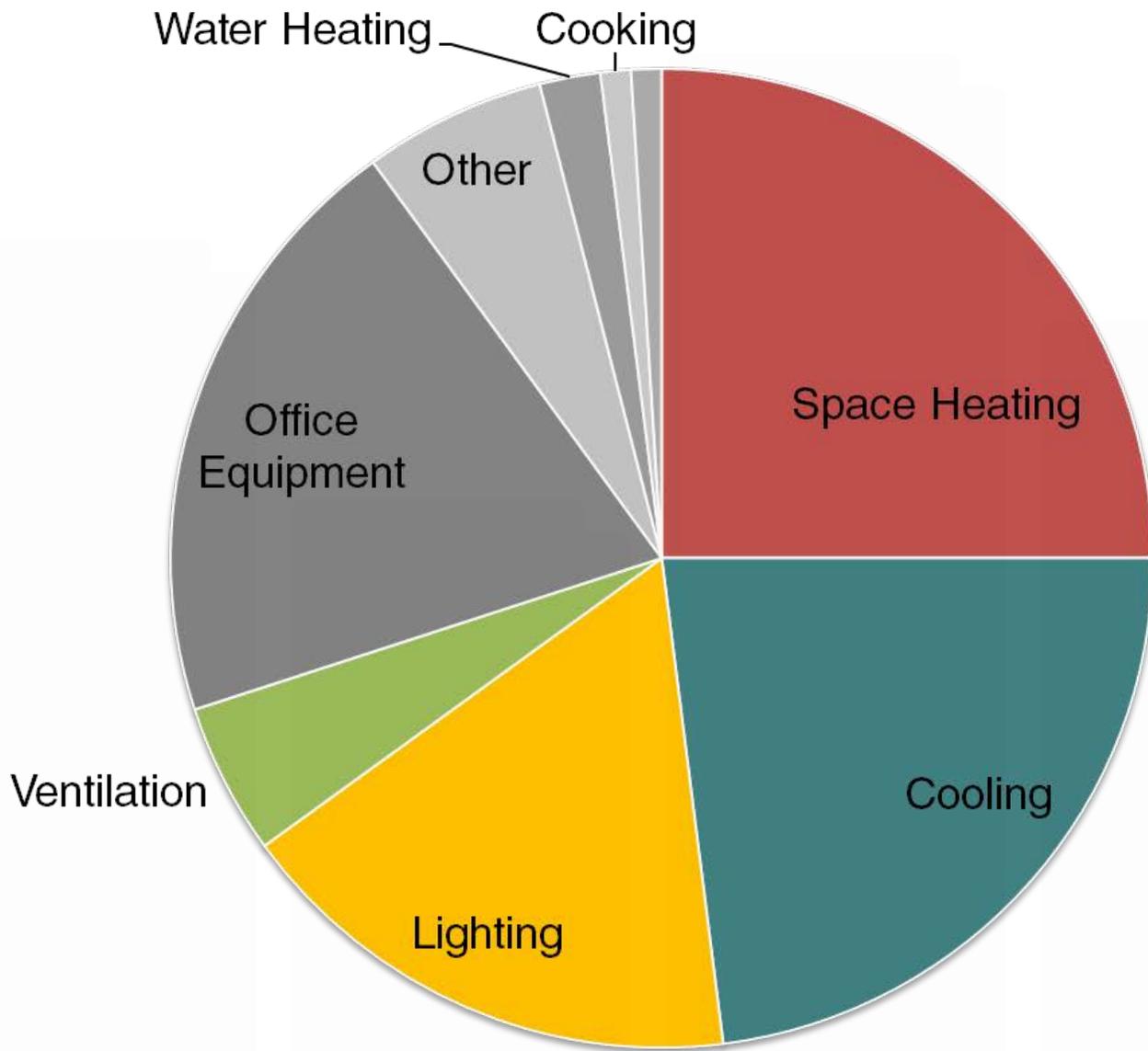


■ Comfort Zone



Energy

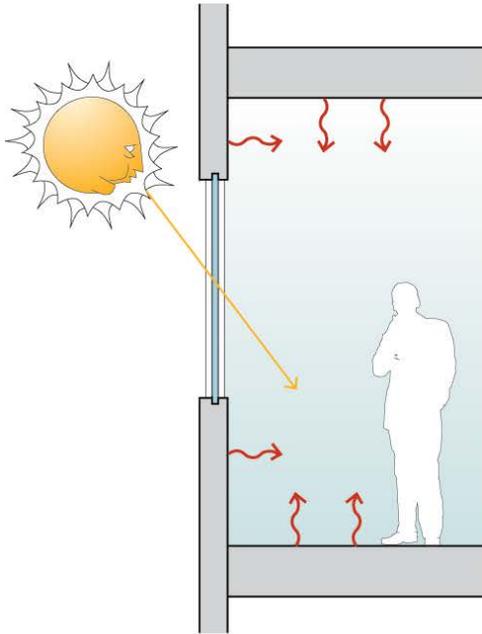




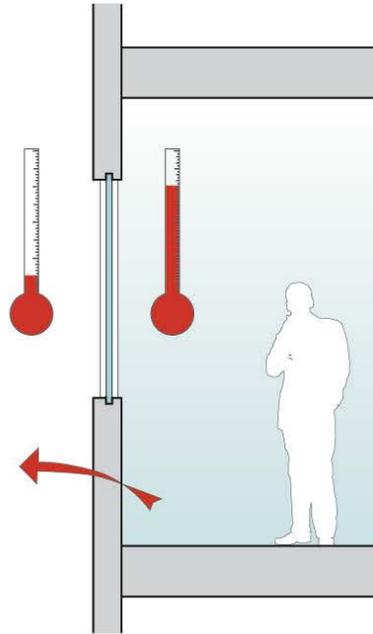
70%
of commercial building's
energy is impacted by the
design of the envelope

- CBECS, 2003

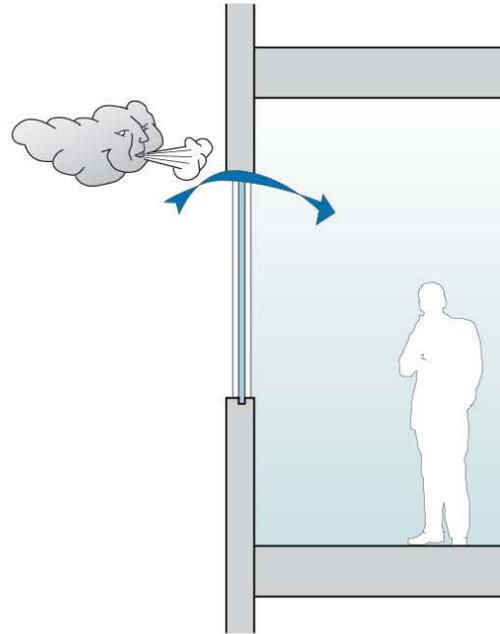
Thermal
Mass



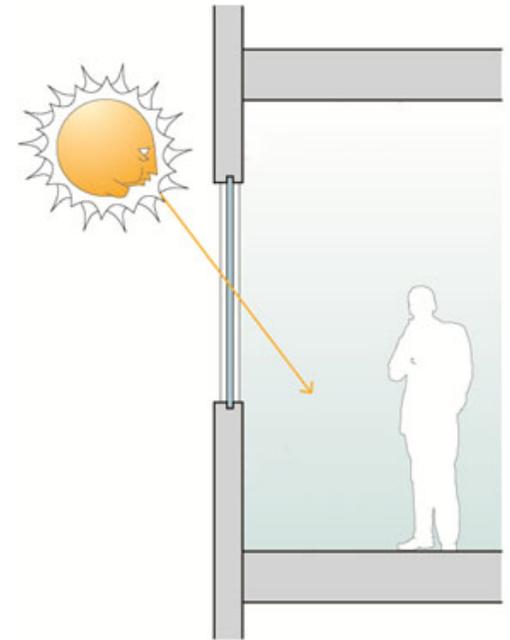
Thermal
Resistance



Infiltration



Glazing Visual
Transmittance
& Solar Heat
Gain



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4 **Orchestration of Standard Components**

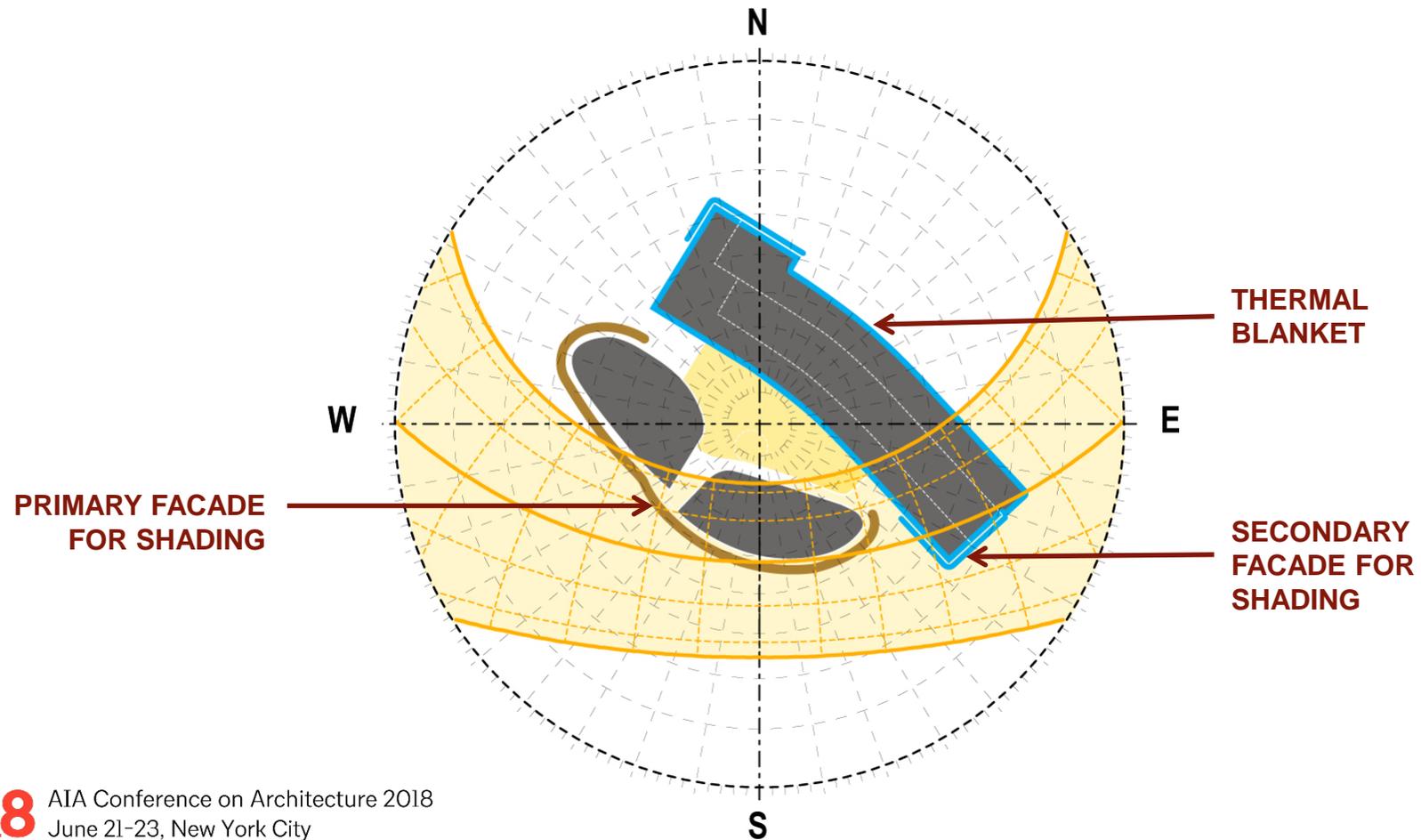
Tufts University, Science and Engineering Complex

5 Moderated Discussion | Q&A



INTUITION: TRUST WHAT YOU KNOW

- Easier to control north/south light than east/west
- High energy intensive activities on the side with the least solar exposure
- Low energy intensive activities on the side with higher amounts of solar exposure

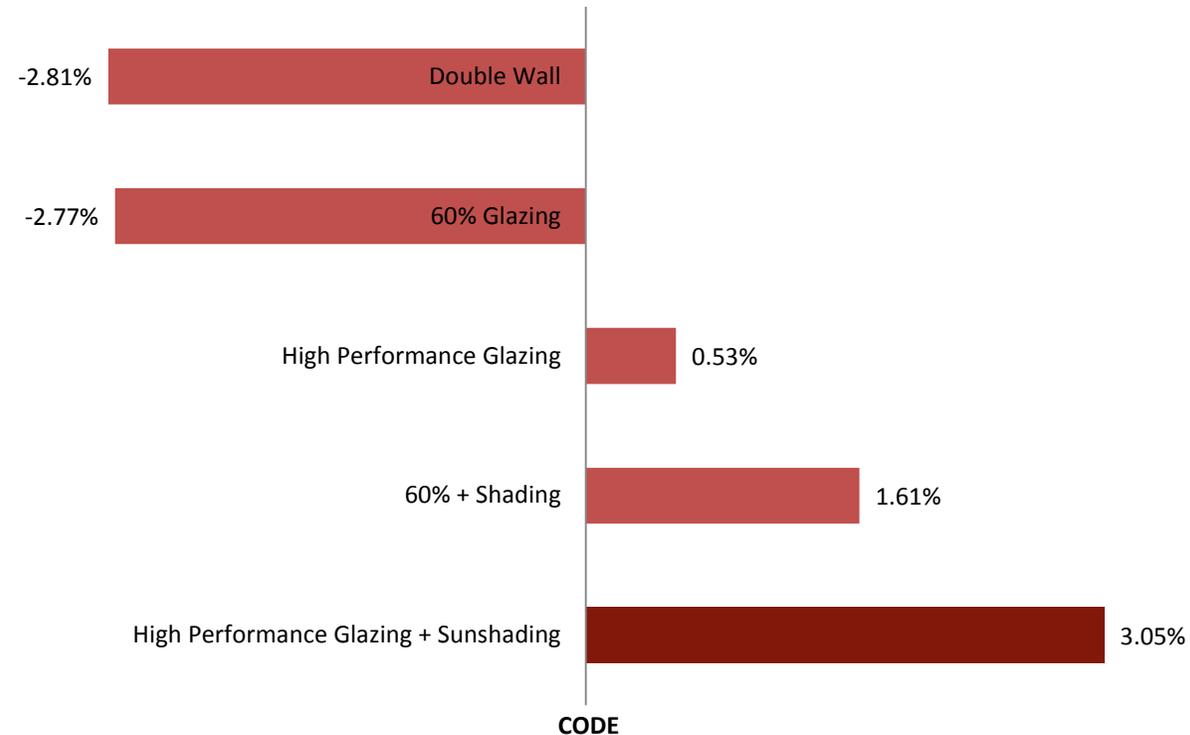


CONCEPT VALIDATION: EARLY STAGE ENERGY MODELING

- “shoe box” energy models based on program, orientation and climate
- Tests variations and sensitivity of different design strategies
- Passive Double skin is not recommend due to cost and performance
- Exterior Shading systems can achieve aesthetic intentions with greatest benefit



Net Energy Saving from Code Baseline



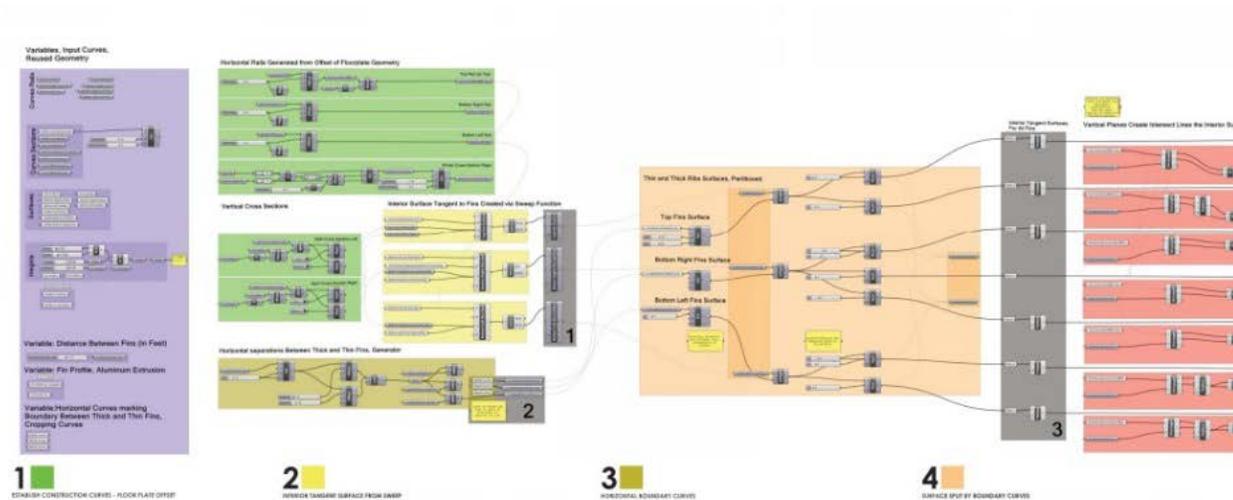


PARAMETRIC MODELING | OPTIMIZING DESIGN

- Highly iterative modeling platform
- Optimal for testing variations and revising geometry
- Used for both Design & performance studies

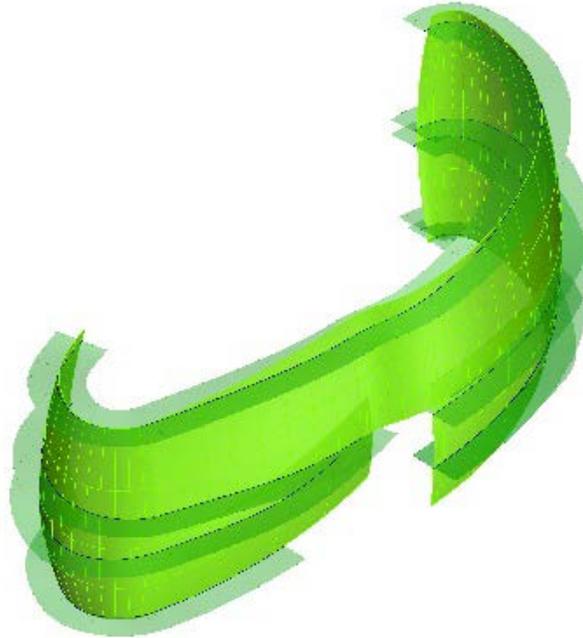
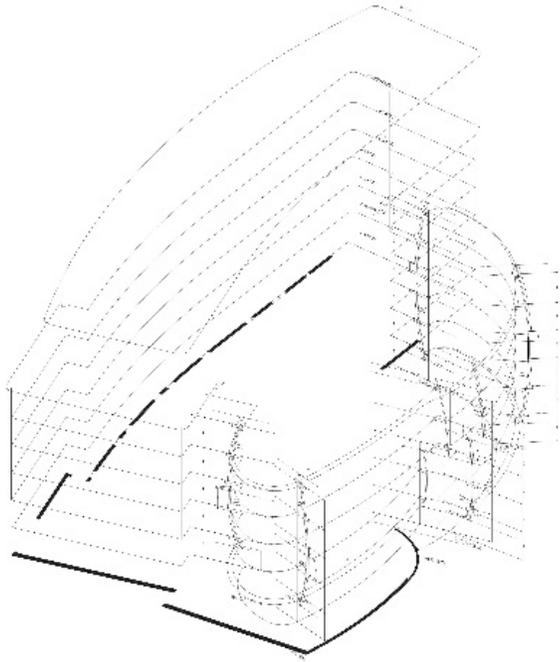


Rhino/Grasshopper



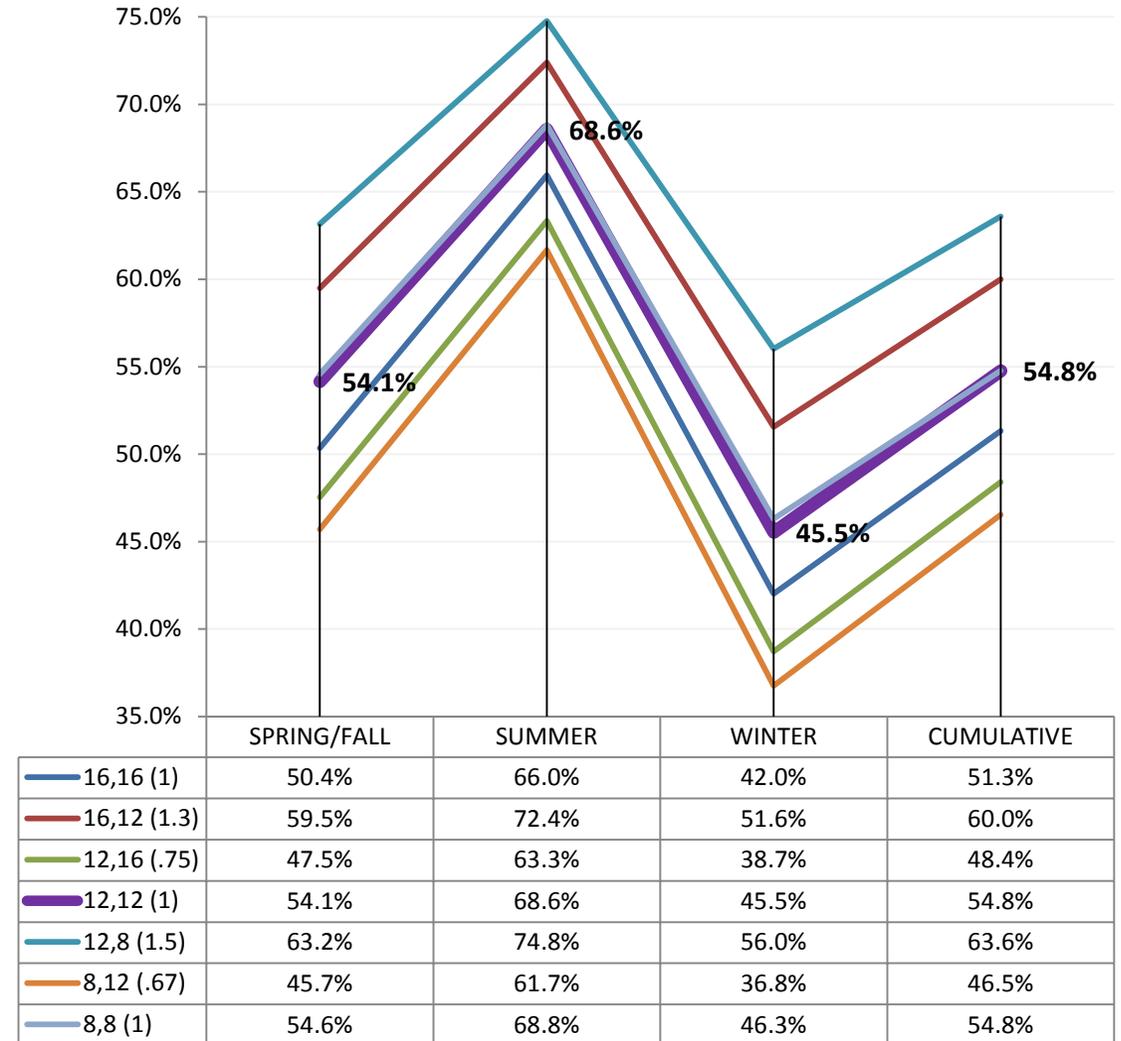
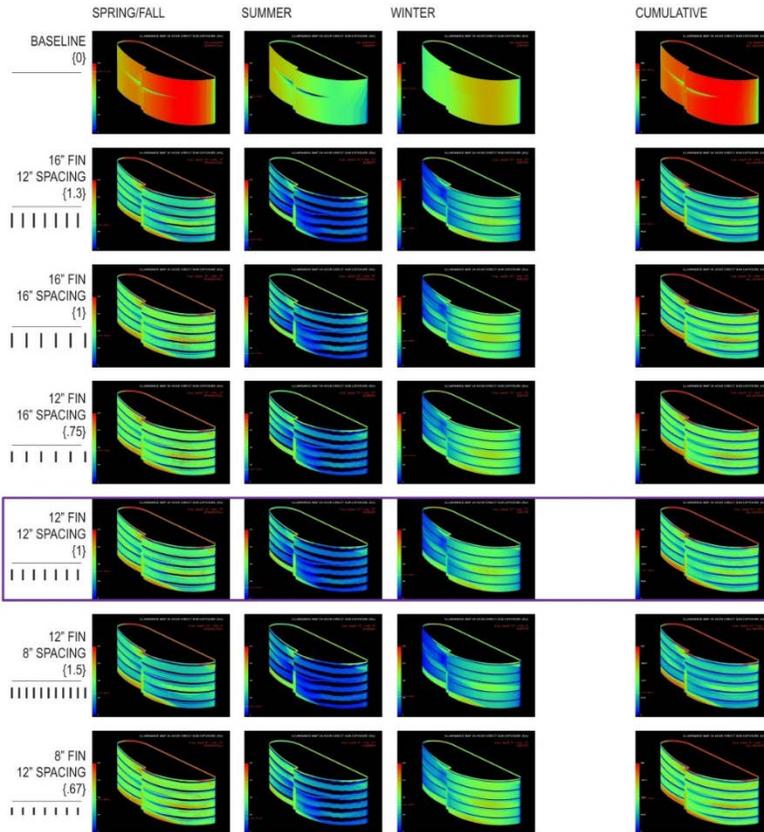
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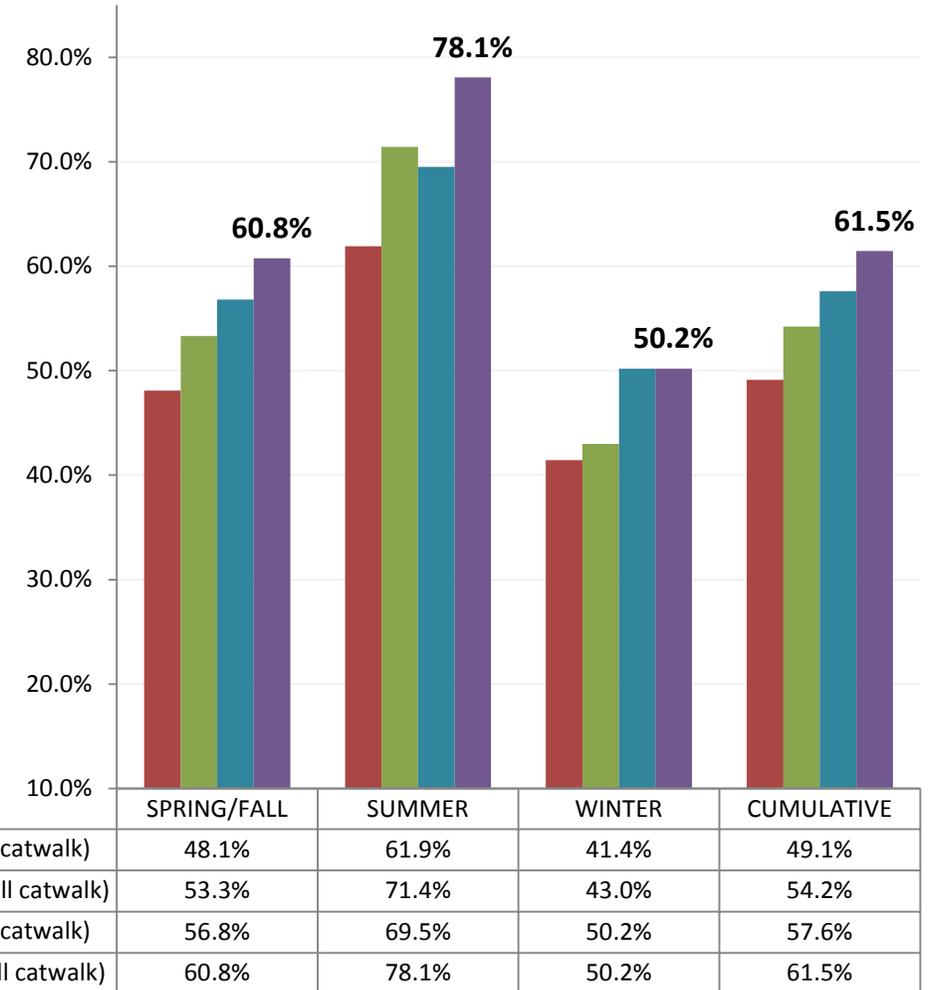
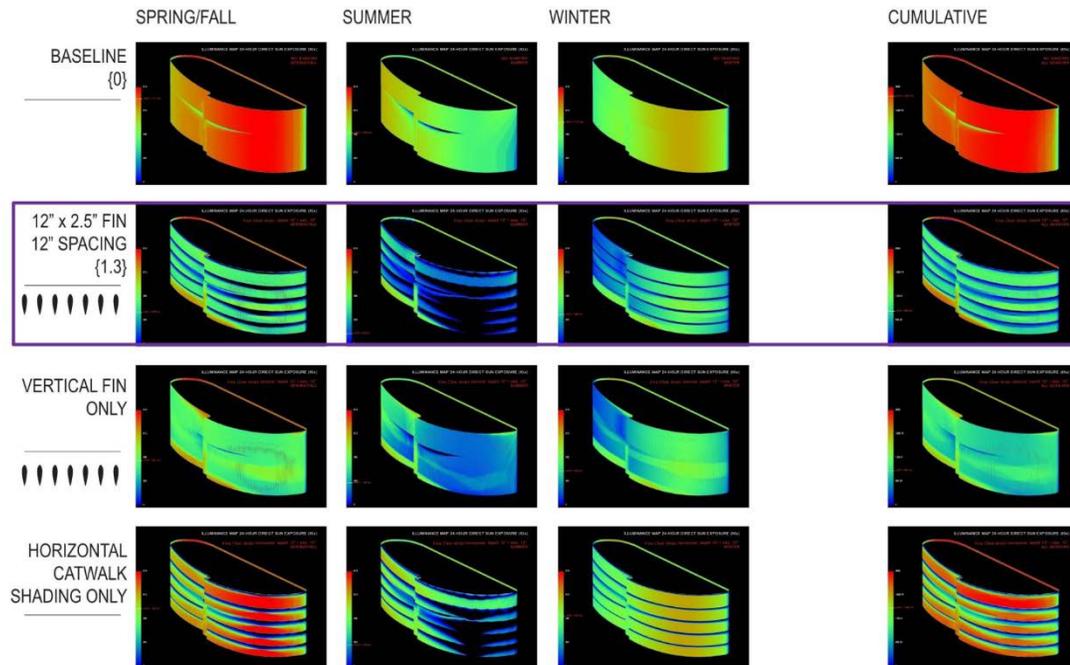
PARAMETRIC MODELING | OPTIMIZING PERFORMANCE

- Nuke software was a custom solution to measure illuminance
- Ladybug would be current integrated software
- Visual and numerical outputs



PARAMETRIC MODELING | OPTIMIZING PERFORMANCE

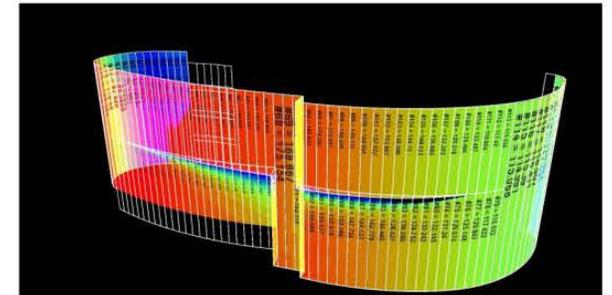
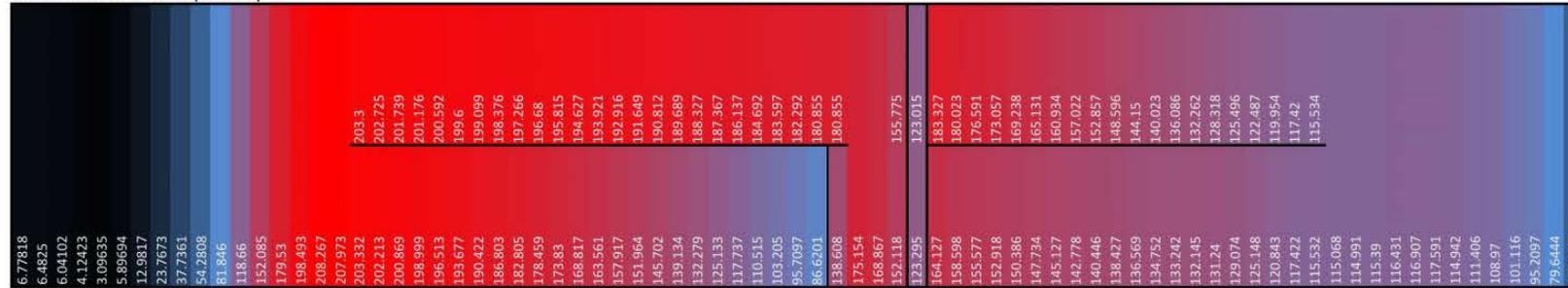
- Iterative Studies to refine detail level design
- Quantification of design moves



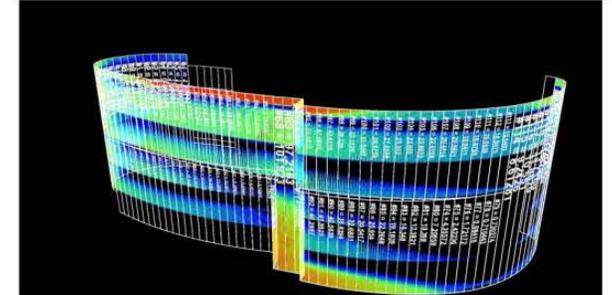
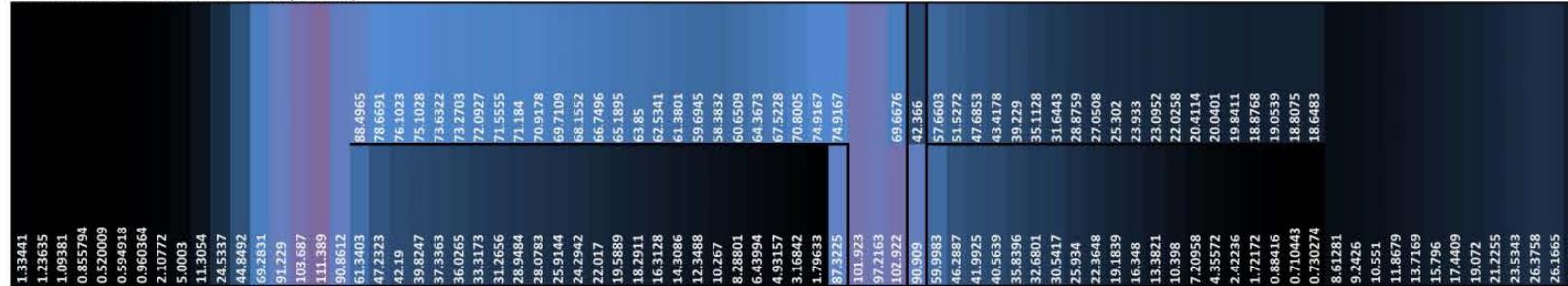
PARAMETRIC MODELING | ENERGY MODEL INTEGRATION

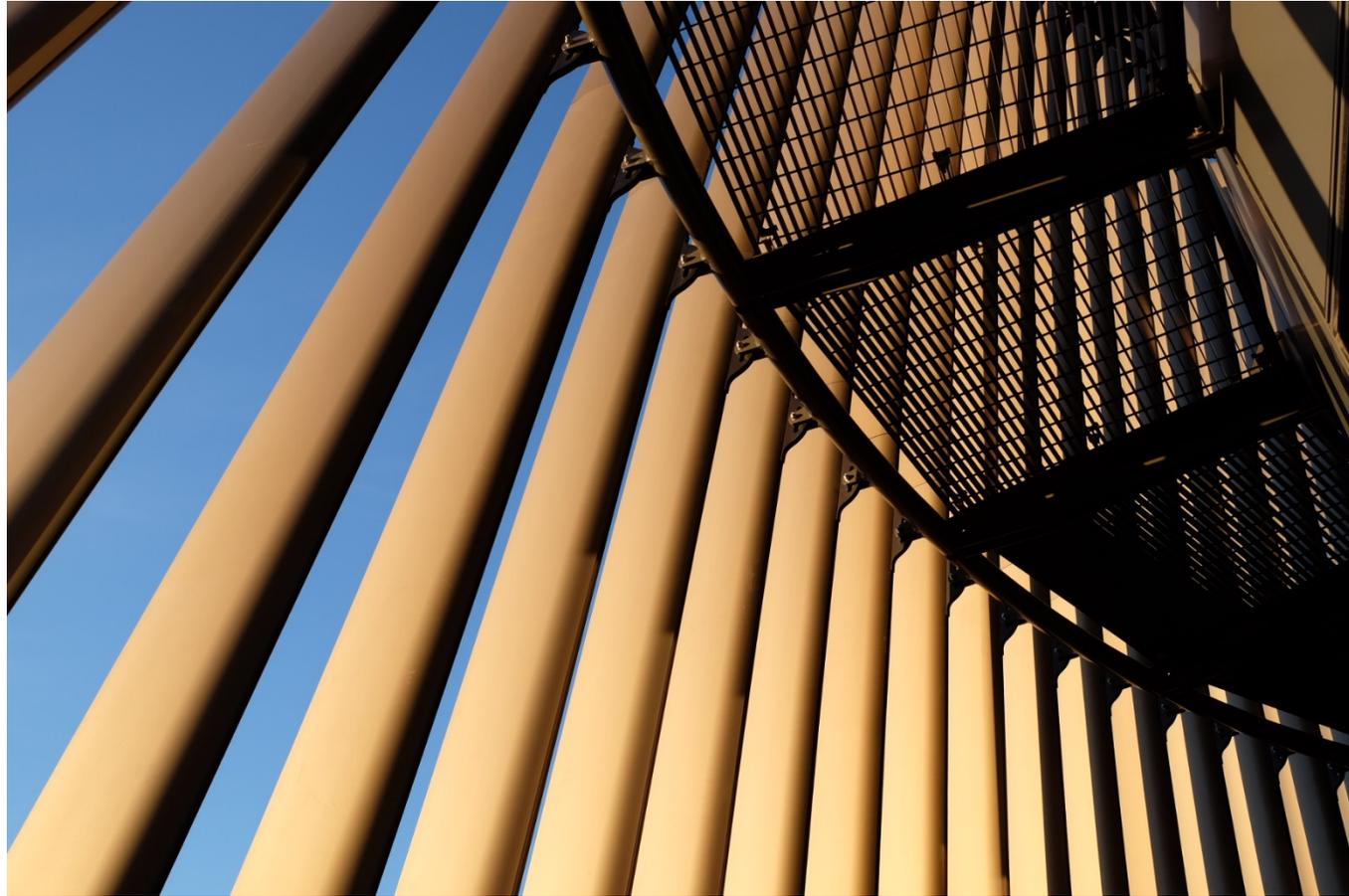
- Detailed panel by panel analysis of performance
- Exported as day/hour spreadsheet as input data for energy model
- Actualize savings from passive systems vs estimating performance

SOLAR EXPOSURE BY PANEL (SUMMER)



SOLAR EXPOSURE BY PANEL WITH SHADING (SUMMER)





A'18 AIA Conference on Architecture 2018
June 21-23, New York City

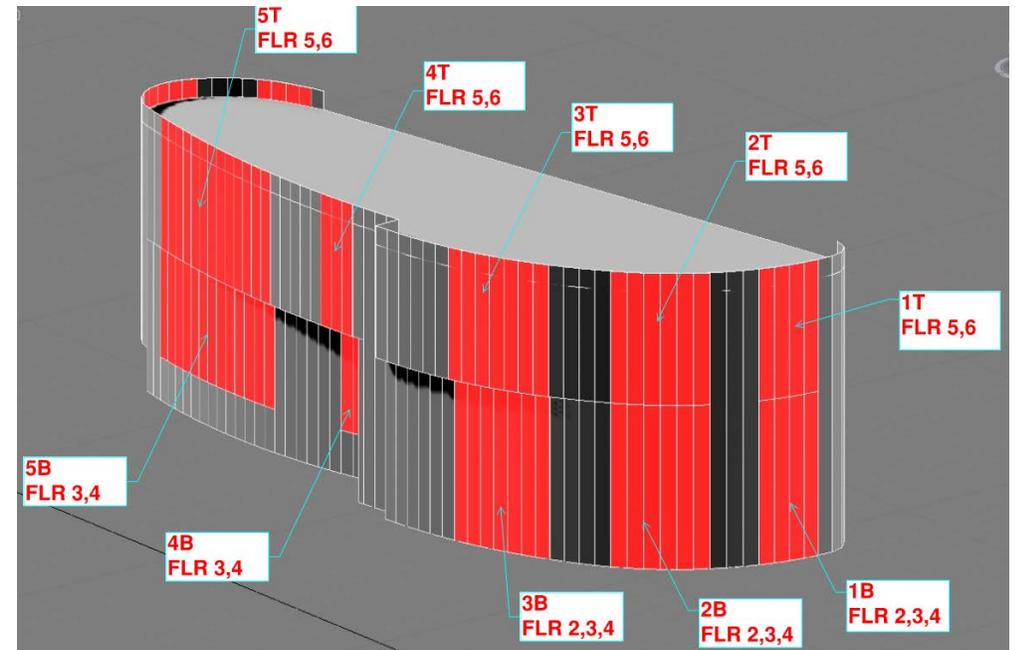
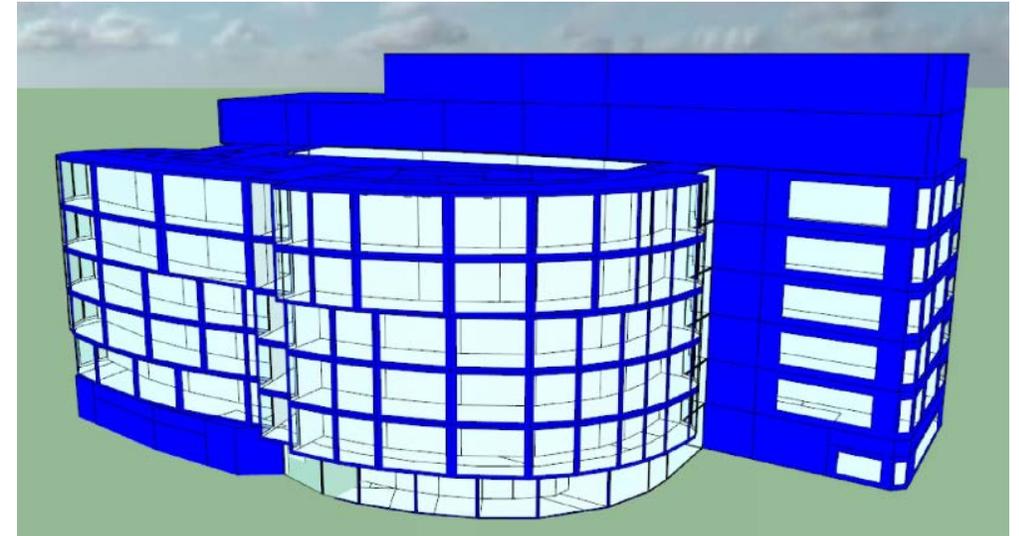
ENGINEERING TEAM INPUTS AND PROCESS | COMMON PRACTICE

- Window shape and sizes are simplified
- Shading is approximated for zones of façade

- **Advantages:**
- Ease of modelling
- Speed of analysis
- Relatively easy to modify

- **Disadvantages:**
- Loss of detail and information
- No ability to integrate interactions
- Poor visualization
- Not usable for other analyses

Simplified window modelling



Shading zones definition

ENGINEERING TEAM INPUTS AND PROCESS | ISEC PROCESS

- Window shape and size reflect design intent
- Shading is model as closely to design intent as possible
- Secondary structure and supports modeled

ADVANTAGES

- Fine detail of results for each window
- Usable for other analyses – daylighting
- Good visualization

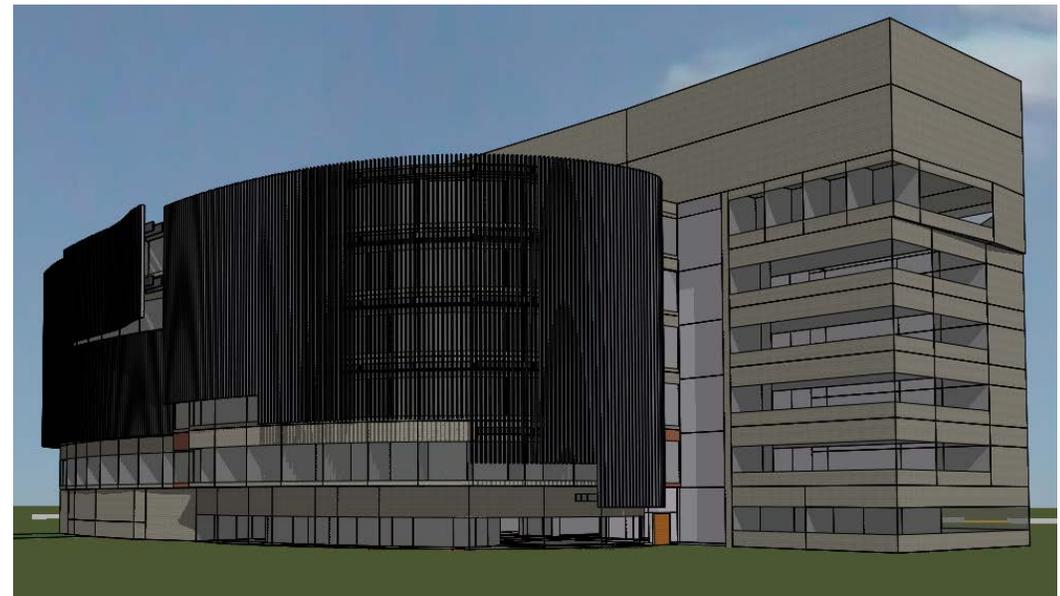
DISADVANTAGES

- Manual modelling
- Difficult to modify
- Longer run times

Architectural
Rendering



Actual IES: Virtual
Environment model



ENGINEERING TEAM INPUTS AND PROCESS

KEY FACTS AND RESULTS

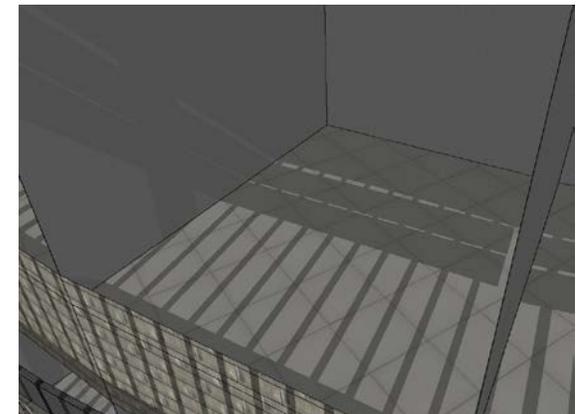
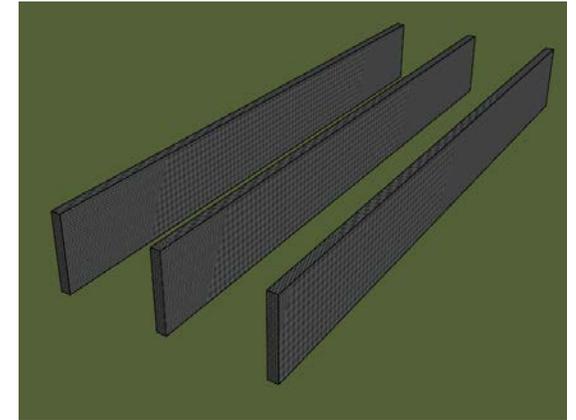
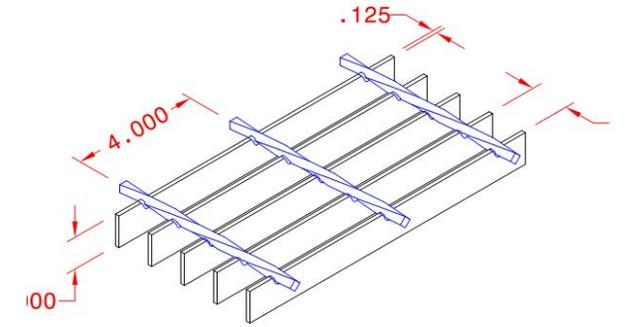
- 664 shading elements modeled
- 9 total façade types were included in model
- Detailed results allowed proposed changes to be considered quickly as impact to loads were clear

LESSON LEARNED:

- Don't forget about the supports!
- Modelling the support system showed additional shading increasing performance

NEXT STEPS:

- Increased automation for creation of model
- Integration into daylight analysis

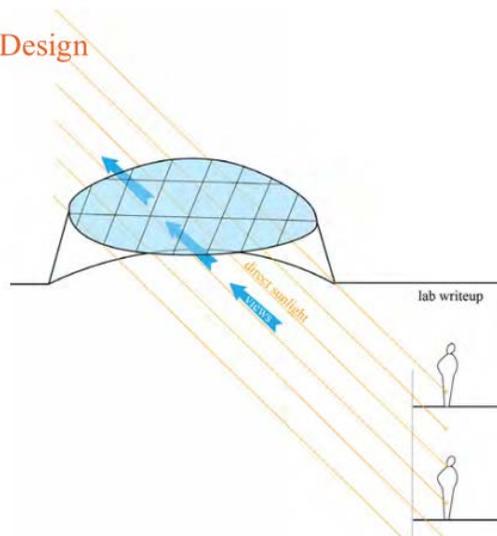


DAYLIGHTING | OFFICE SHADING & ATRIUM

- Objective of Study

- Determine optimal 3-dimensional shaping of the skylight to minimize direct sunlight penetration at lab write-up spaces while maximizing diffuse daylight transmission and views in the atrium.
- Quantify the resulting time of day/year and duration of direct sunlight in the lab write-up spaces to enable an informed decision by the owner if additional shading is required.

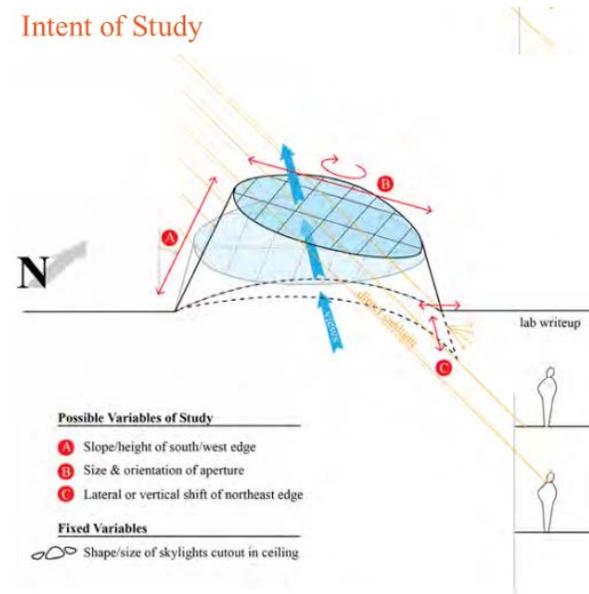
Current Design



- Challenges

- Lab write-up spaces currently experience incident direct sunlight at the top three floors.
- Providing clear views to the sky through the skylight without also providing clear views of the sun (i.e. glare)
- Given the size of the skylights, shaping the skylights alone will not be able to provide full solar control, but it can reduce such occurrences.

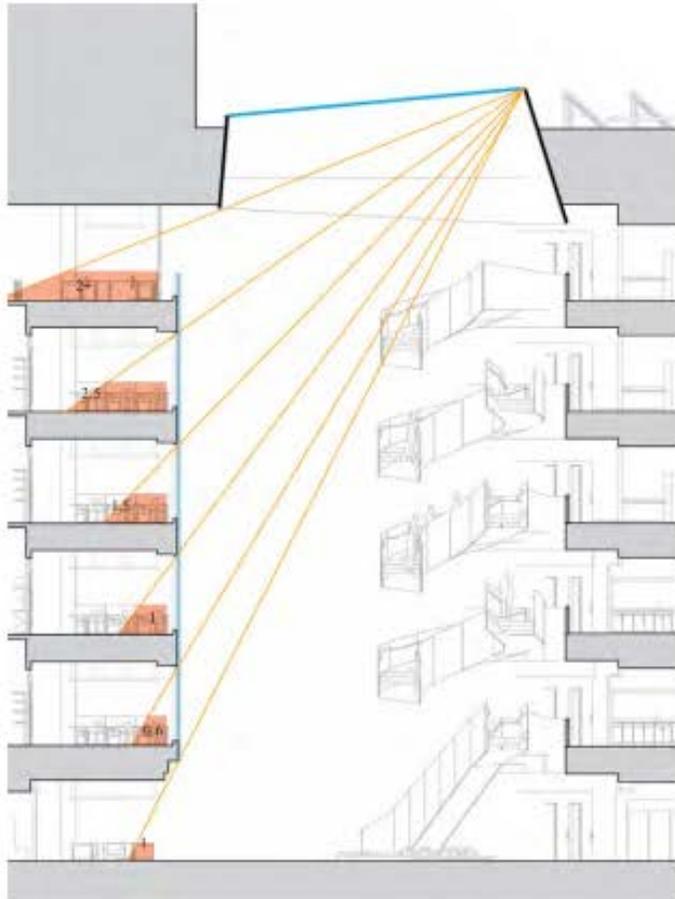
Intent of Study



DAYLIGHTING | BASELINE

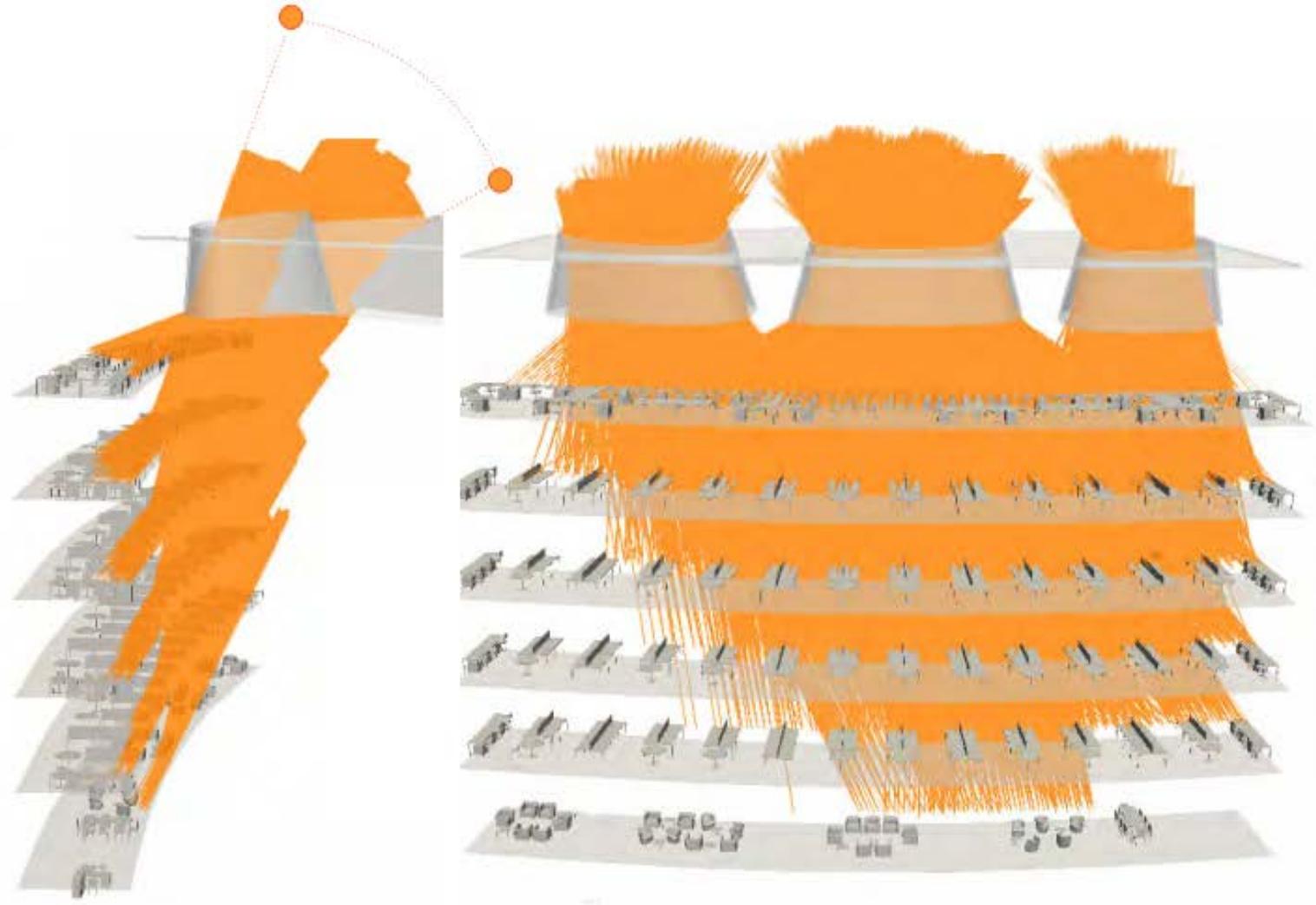
Concept Section

Indicates worst case sun penetration and number of workstations affected at each floor level



Annual Solar Ray Trace

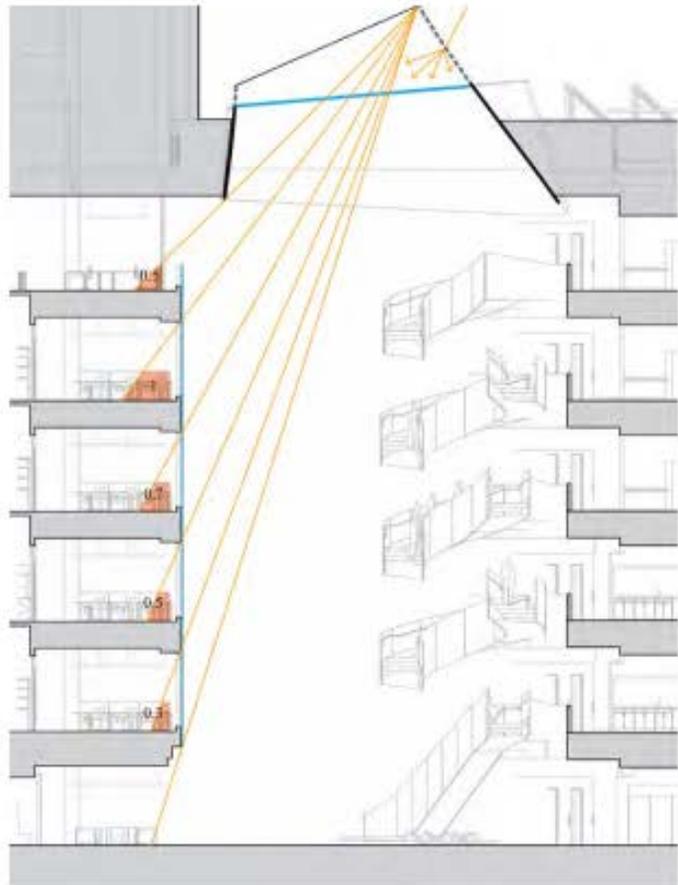
These diagrams trace rays from the every possible sun position to the lab workstations. Only unshaded rays are shown.



DAYLIGHTING | ENHANCED CONTROL DESIGN PERFORMANCE

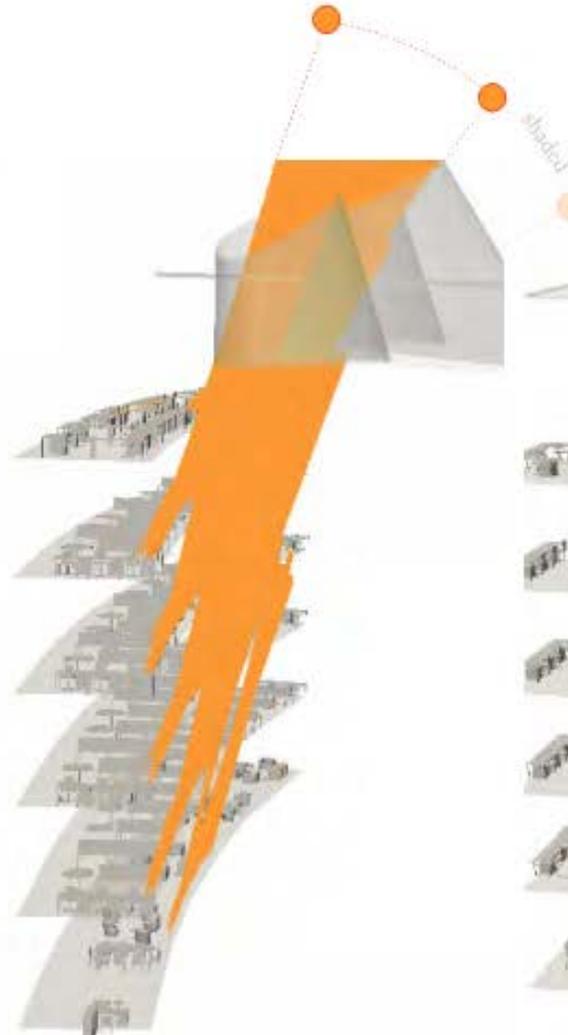
Concept Section

Indicates worst case sun penetration and number of workstations affected (in section) at each floor level. At most, only the first row of workstations is affected by direct sunlight from the skylights.

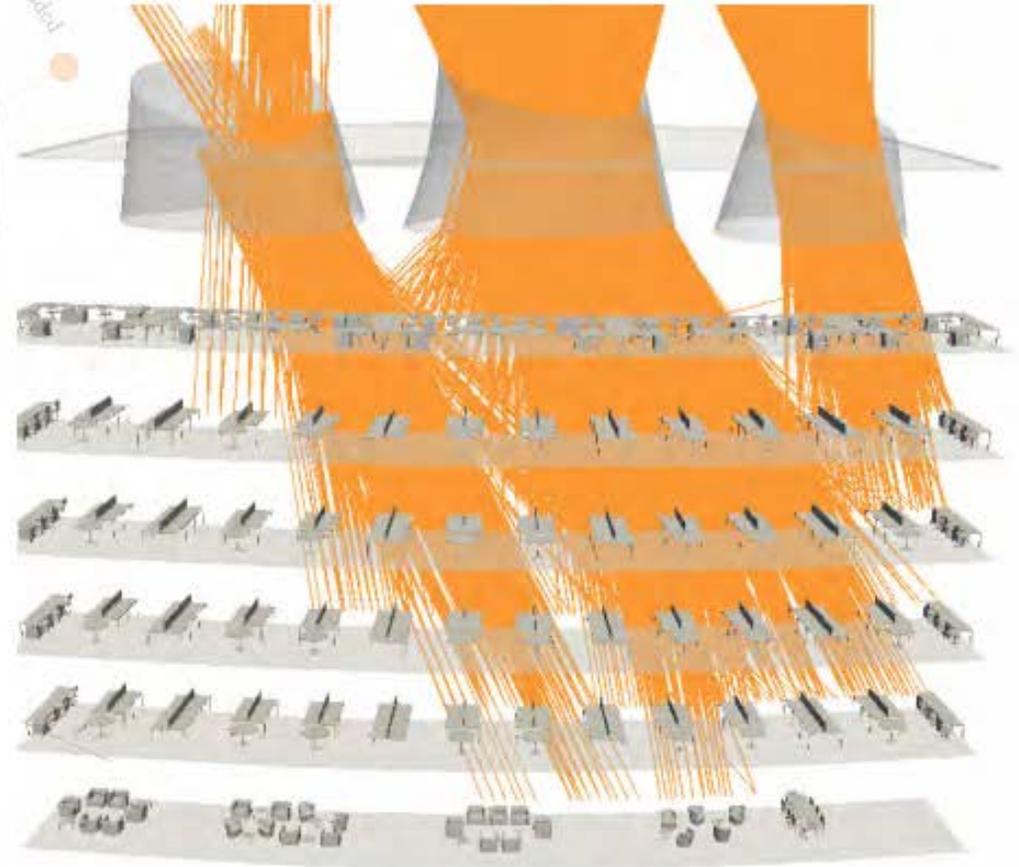


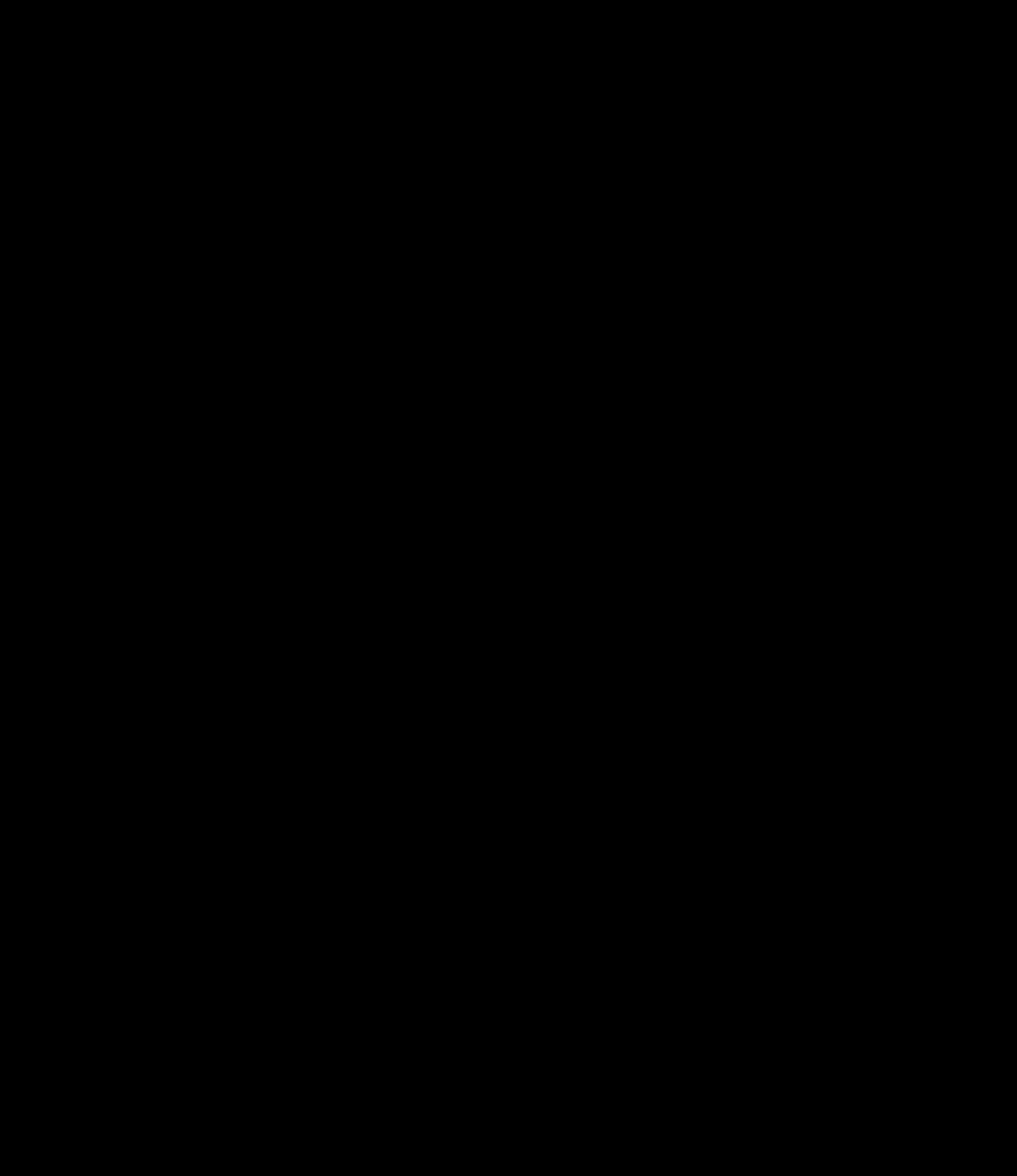
Annual Solar Ray Trace

These diagrams trace rays from every possible sun position to the lab workstations. Only unshaded rays are shown.



Skylights were shaped to block lowest sun angles. These low sun angles were responsible for the deepest sunlight penetration in the current design.



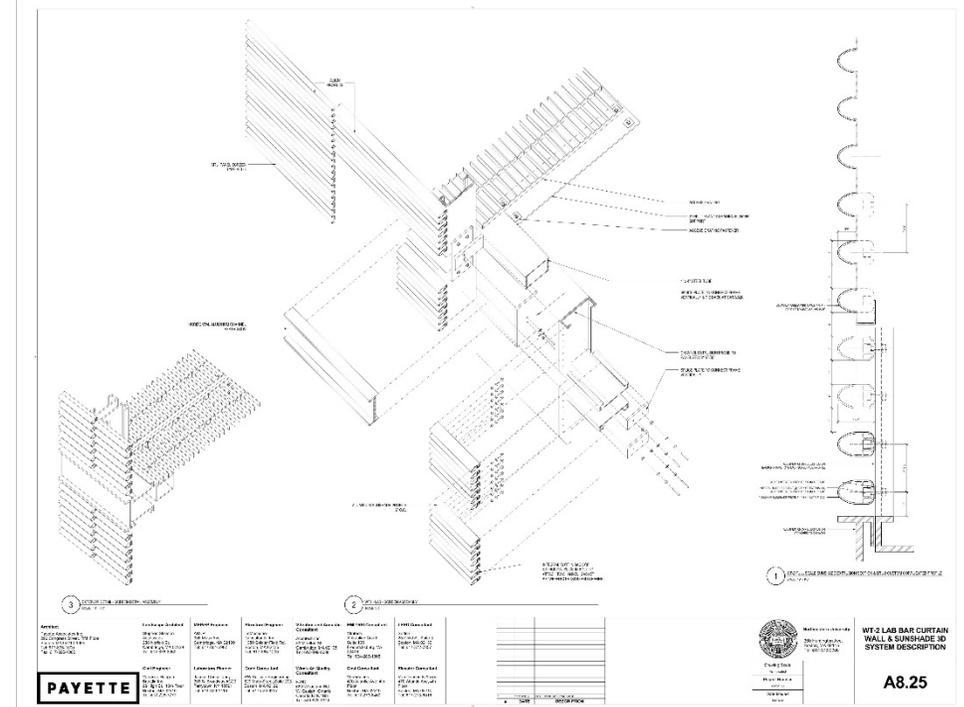
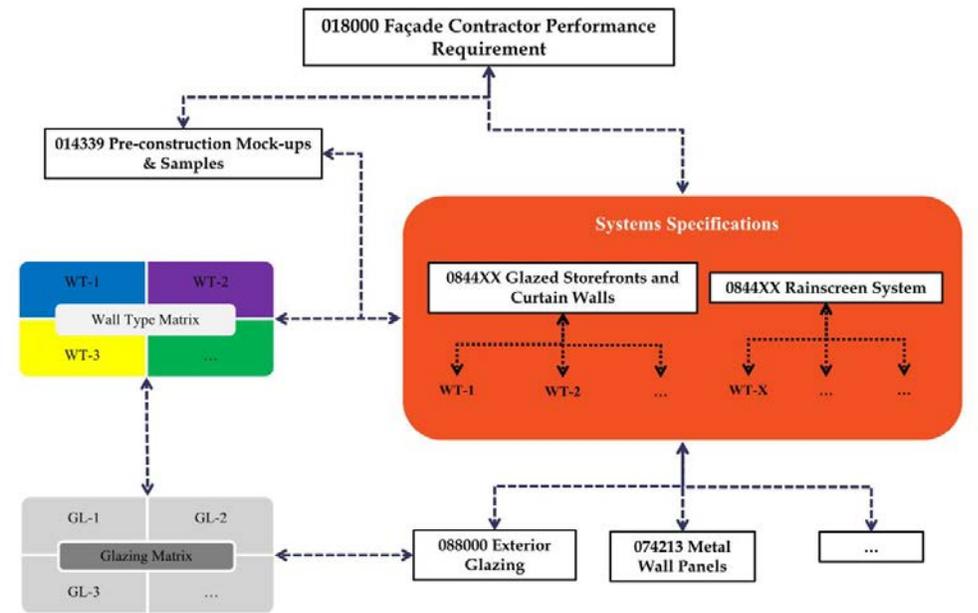


DESIGN ASSIST

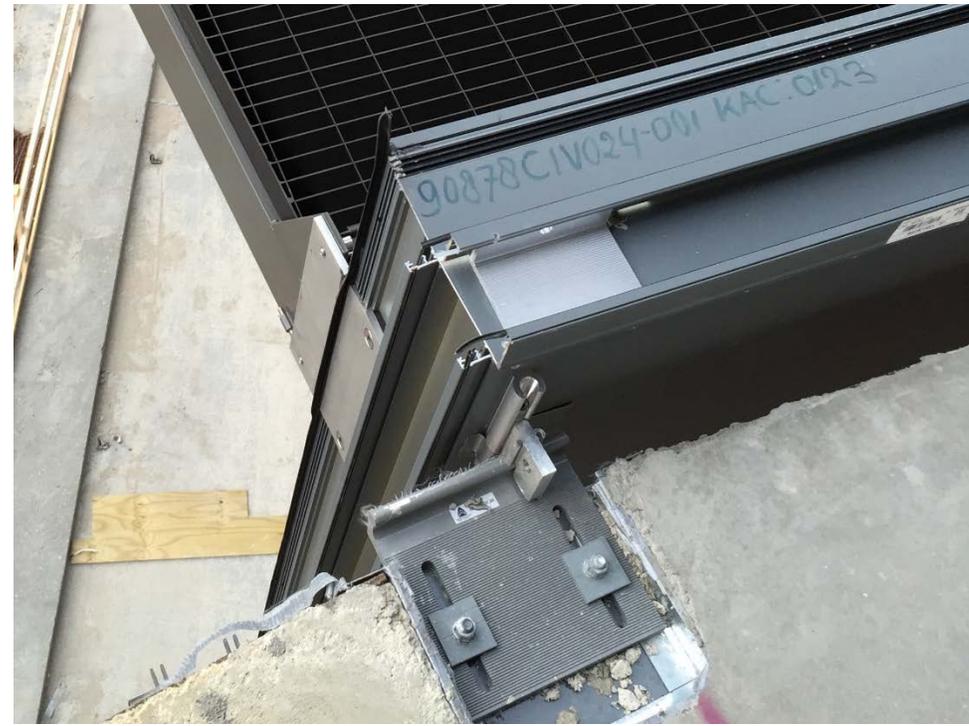
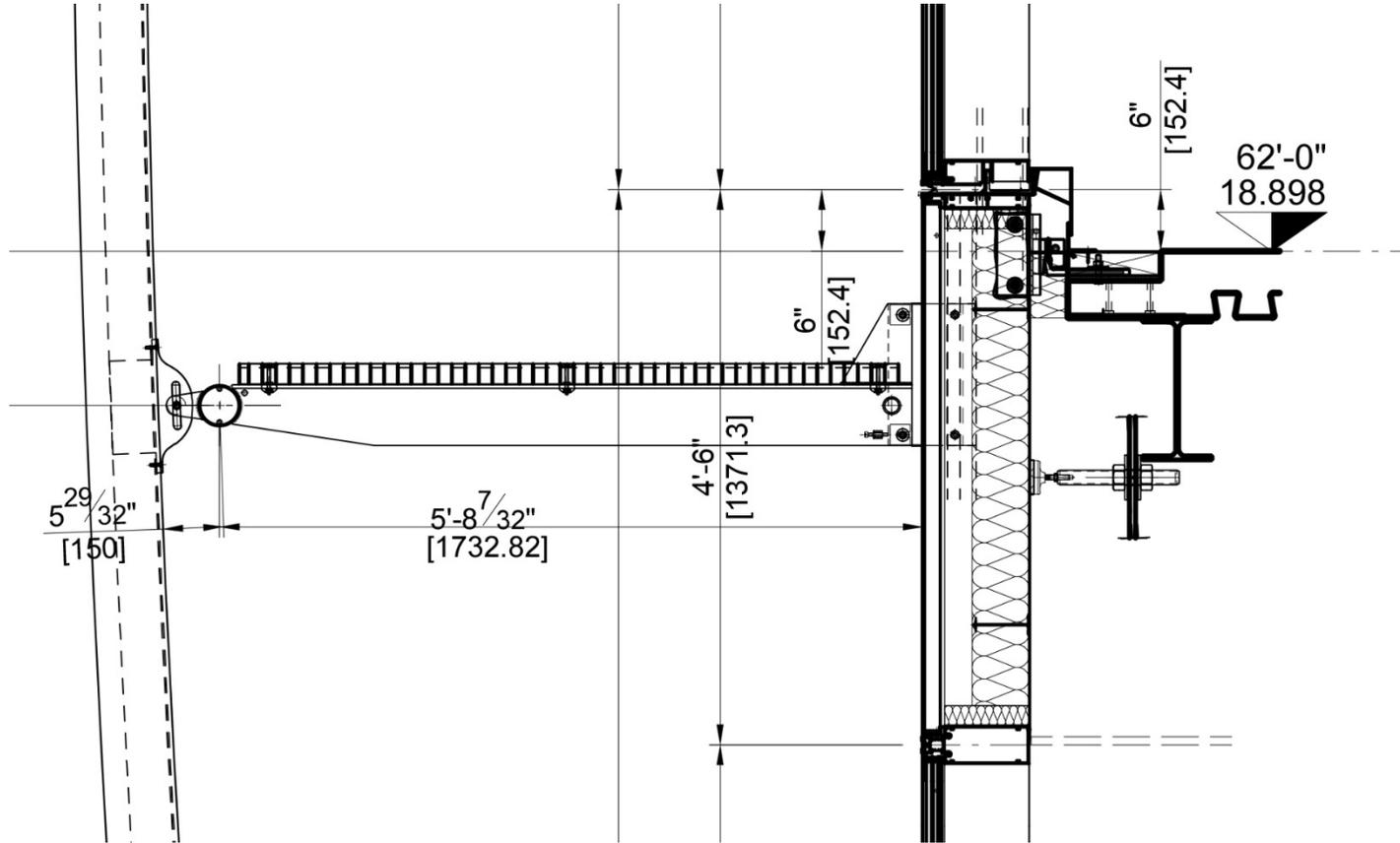
- Collaborative process between the design team and selected contractors to develop complex elements and procure long lead time elements such as glazing
- Typically engaged at the completion of Design Development
- Used to accelerate schedule with shop drawings complete at the beginning of construction
- Allows the team to be coordinating project specific details in place of drawing a generic bid package
- Loss of competitive bidding while gaining control over the quality and procurement of critical path items

DESIGN TEAM MUST SET GROUND RULES

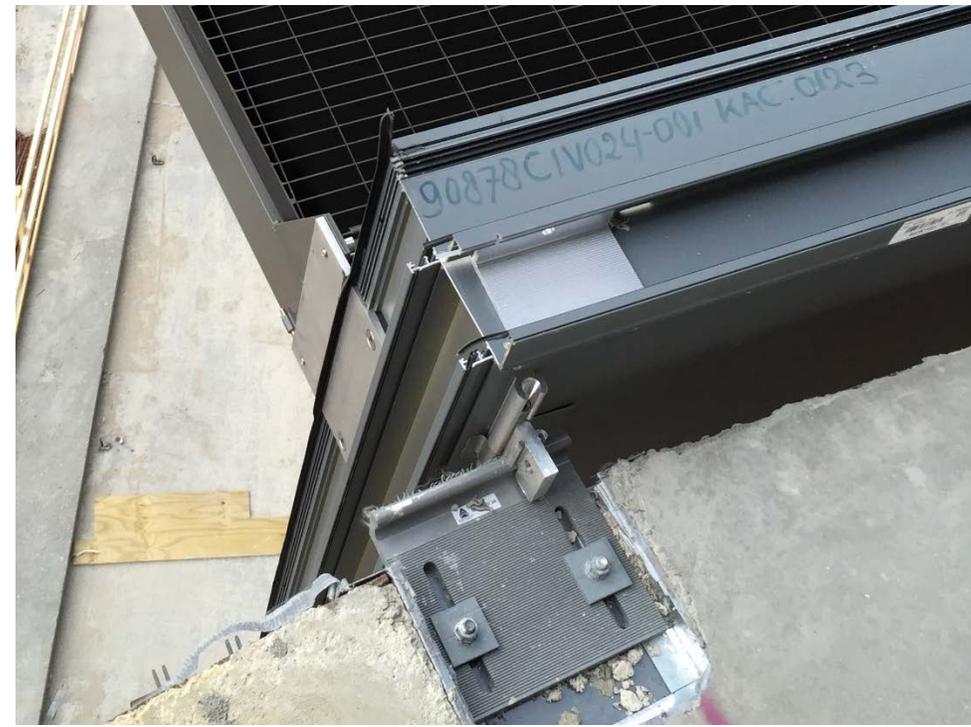
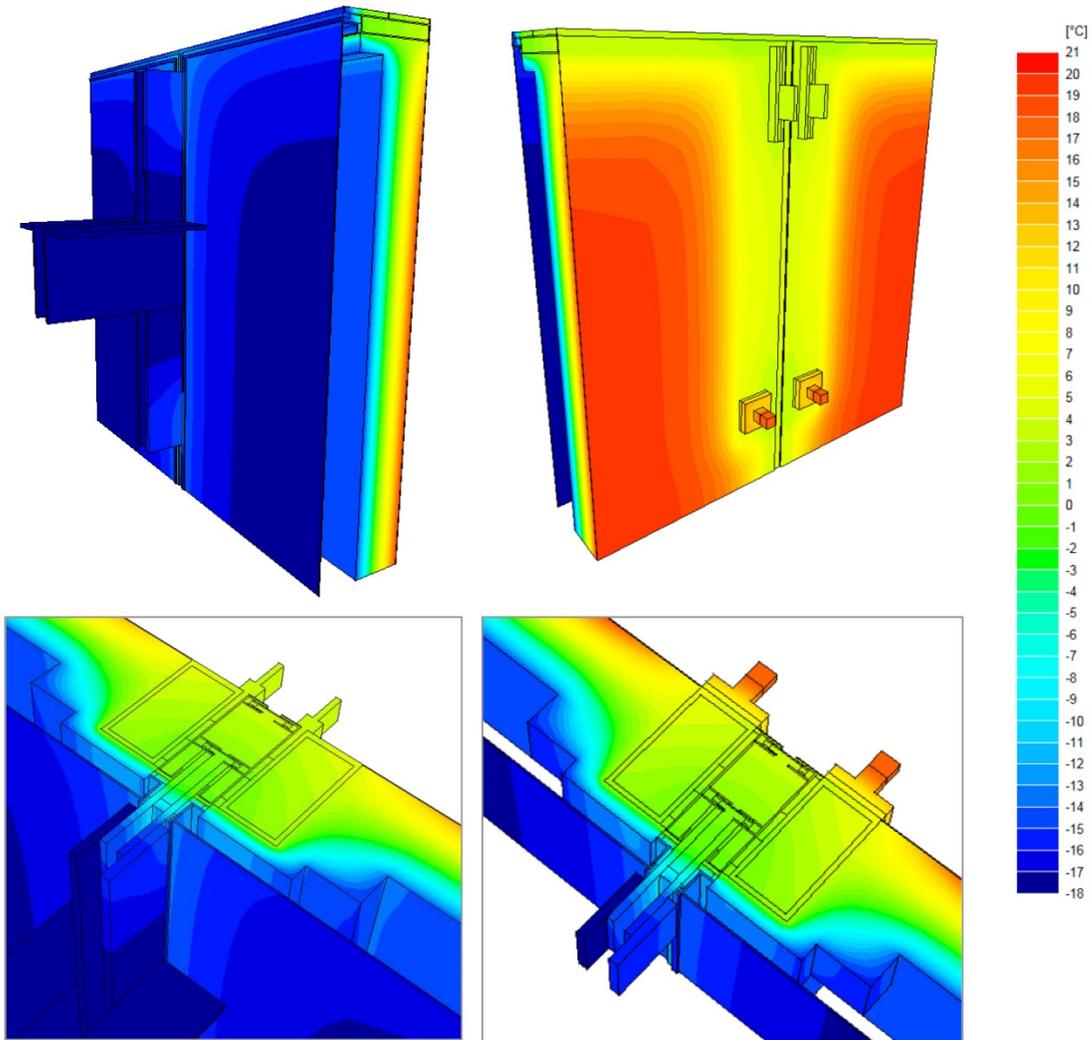
- Design Intent
- Performance Specifications (Environmental, Thermal, structural)
- Schedule & Deliverables (meetings, drawings, samples, mockups)



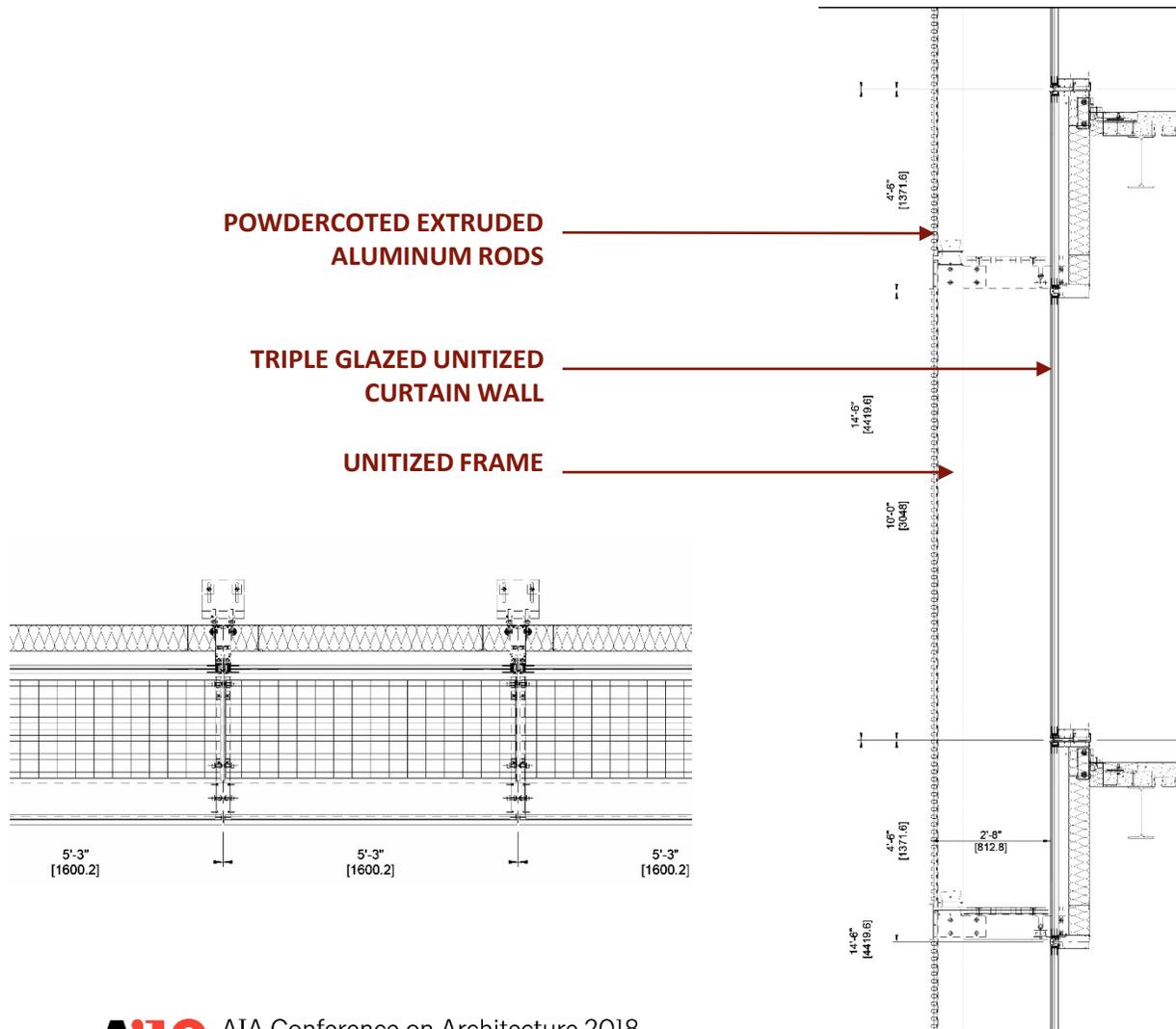
FAÇADE DETAILING | CUSTOM SOLUTIONS



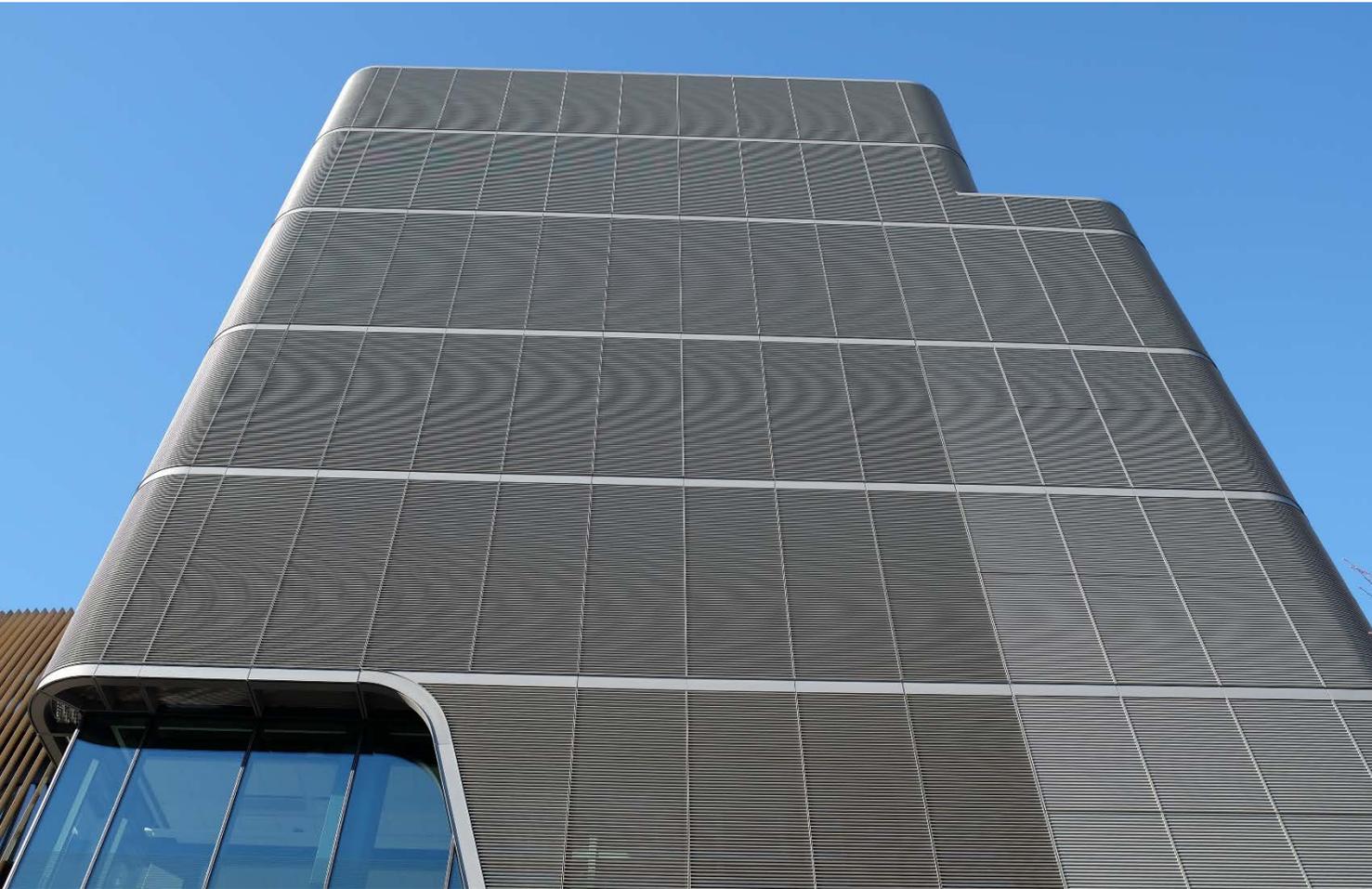
FAÇADE DETAILING | THERMAL PERFORMANCE



FAÇADE DETAILING | THERMAL OVERCOAT

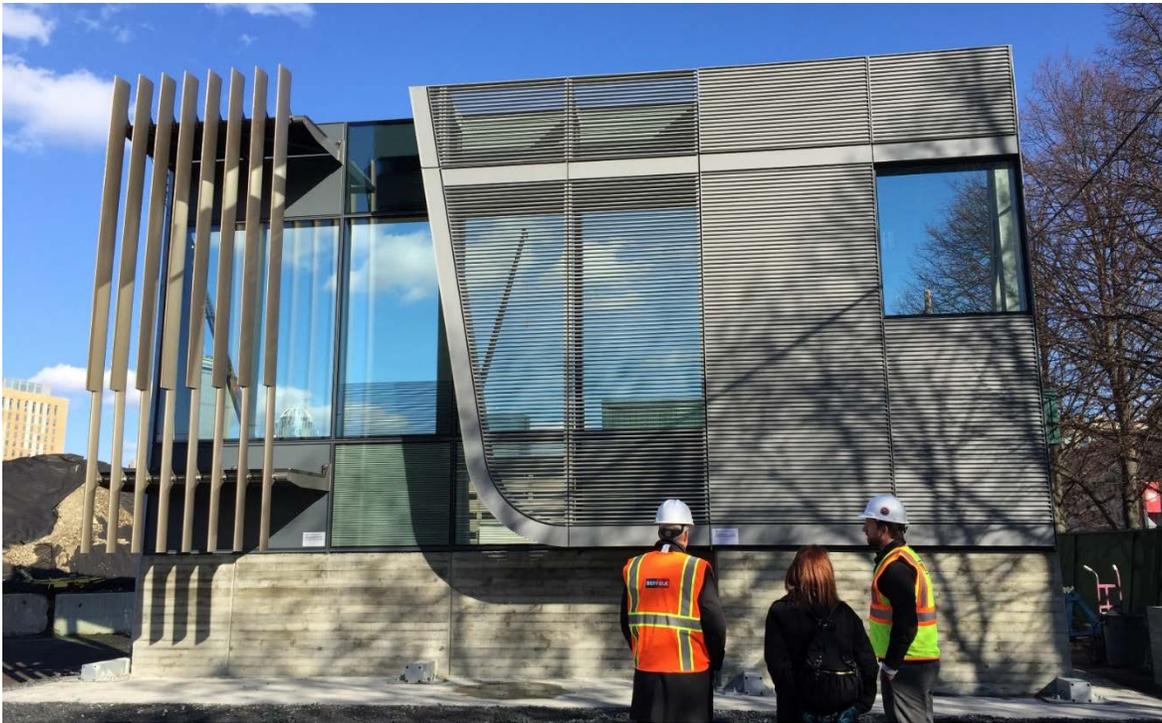


FAÇADE DETAILING | THERMAL OVERCOAT



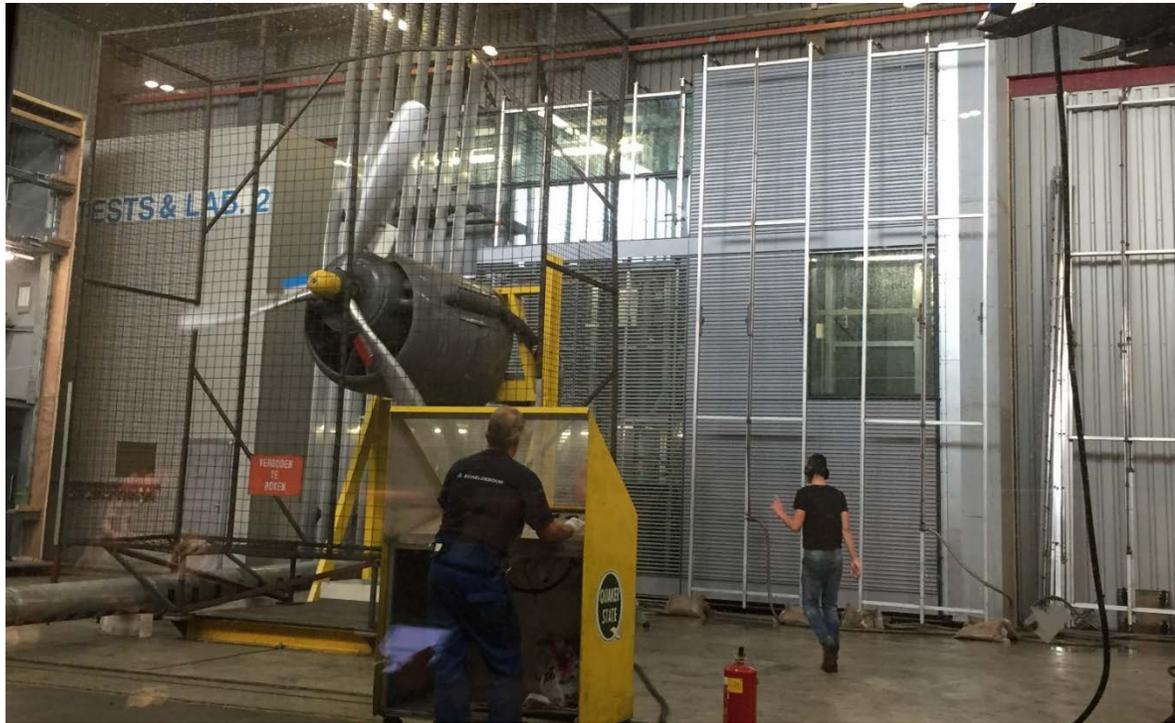
MOCKUPS: VISUAL MOCKUP

- Simulates Design Intent and Materials
- Validate Design Intent & Review Material/Color
- Client Approval
- Regulatory Approval (Boston Requirement)



MOCKUPS: PERFORMANCE MOCKUP

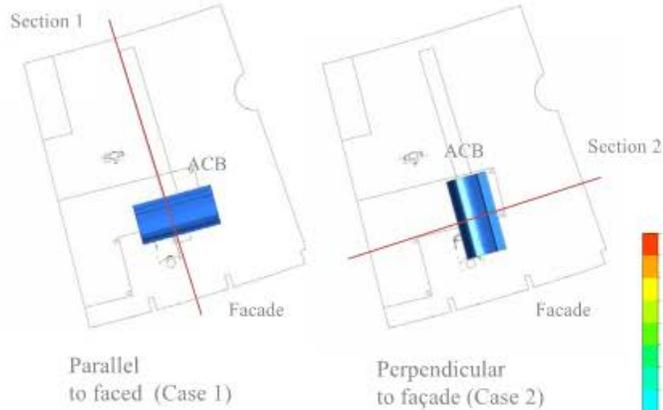
- Contractor built with Third Party Testing
- Built to test typical project details and validates constructability
- Dynamic testing validates Water tightness & Structural Performance
- Final step to release enclosure for fabrication





414

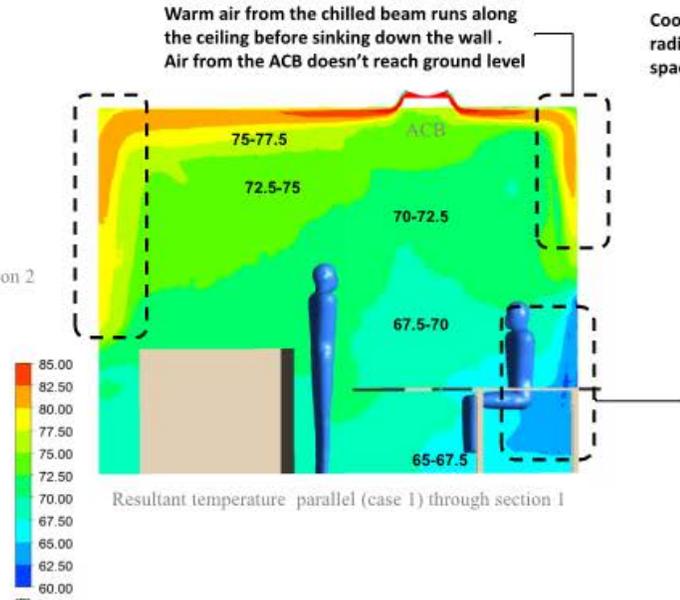
Two configurations of chilled beam (ACB) layouts have been modeled, as illustrated in the diagrams, in order to determine the impact the orientation has on the thermal comfort in the space during winter conditions.



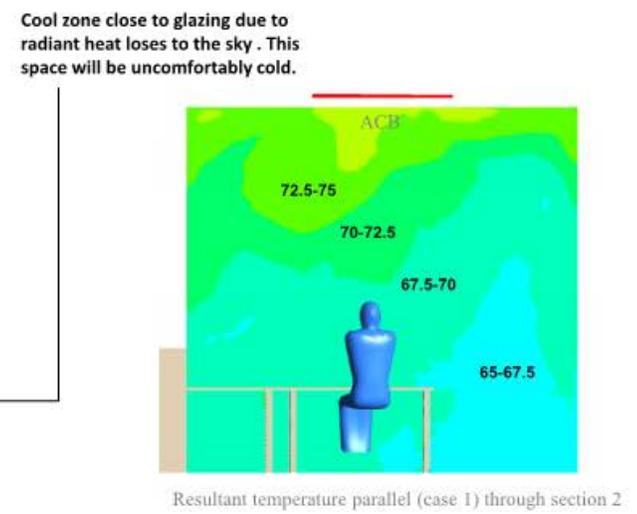
The modeling assumptions are as follows:

External Temperature	7.4F (99.6% TMY Coldest Month)
ACB	4 x 2 feet , Total Supply: 362 CFM at 55F
Glazing	Double Glazing Frame+ glazing U-value: 0.42 Btu/hr-ft ² F Centre glass U-value= 0.27 Btu/hr-ft ² F

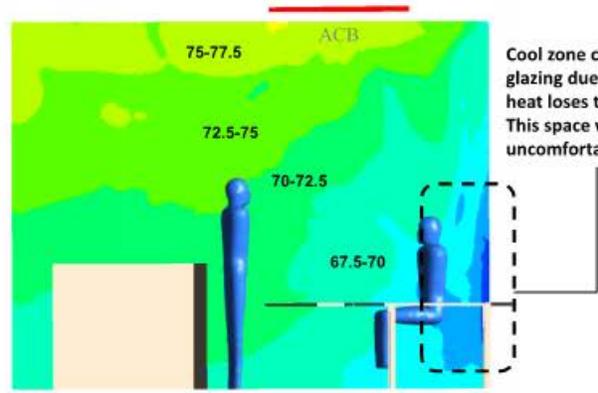
Both configurations show that resultant temperatures are low close to the façade. The second case with the chilled beam perpendicular to the façade shows the warm air penetrating lower into the space due to the geometry of the space. Flow from the chilled beams runs along the ceiling on the shorter axis so it has more momentum as it sinks to the floor. Thermal comfort is achieved away from the façade with both cases. Closer to the façade the space is cooler. The cold glazing surface results in radiant heat loss in this area.



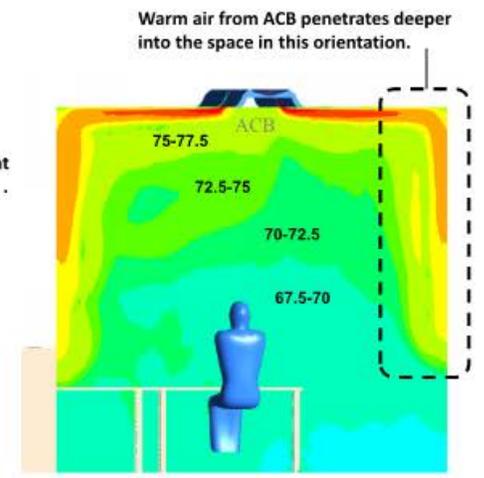
Resultant temperature parallel (case 1) through section 1



Resultant temperature parallel (case 1) through section 2



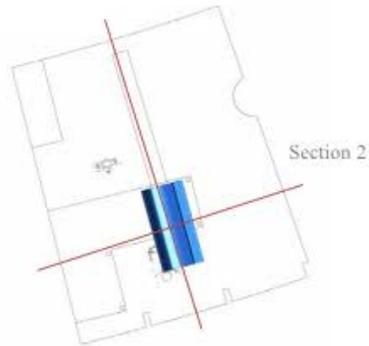
Resultant temperature perpendicular (case 2) through section 1



Resultant temperature perpendicular (case 2) through section 2

The perpendicular chilled beam layout (2) was modeled with two external winter conditions in order to assess the performance of the systems during the 99.6th percentile coldest temperature (7.4F) and the 99th percentile coldest temperature (12.4F).

Section 1

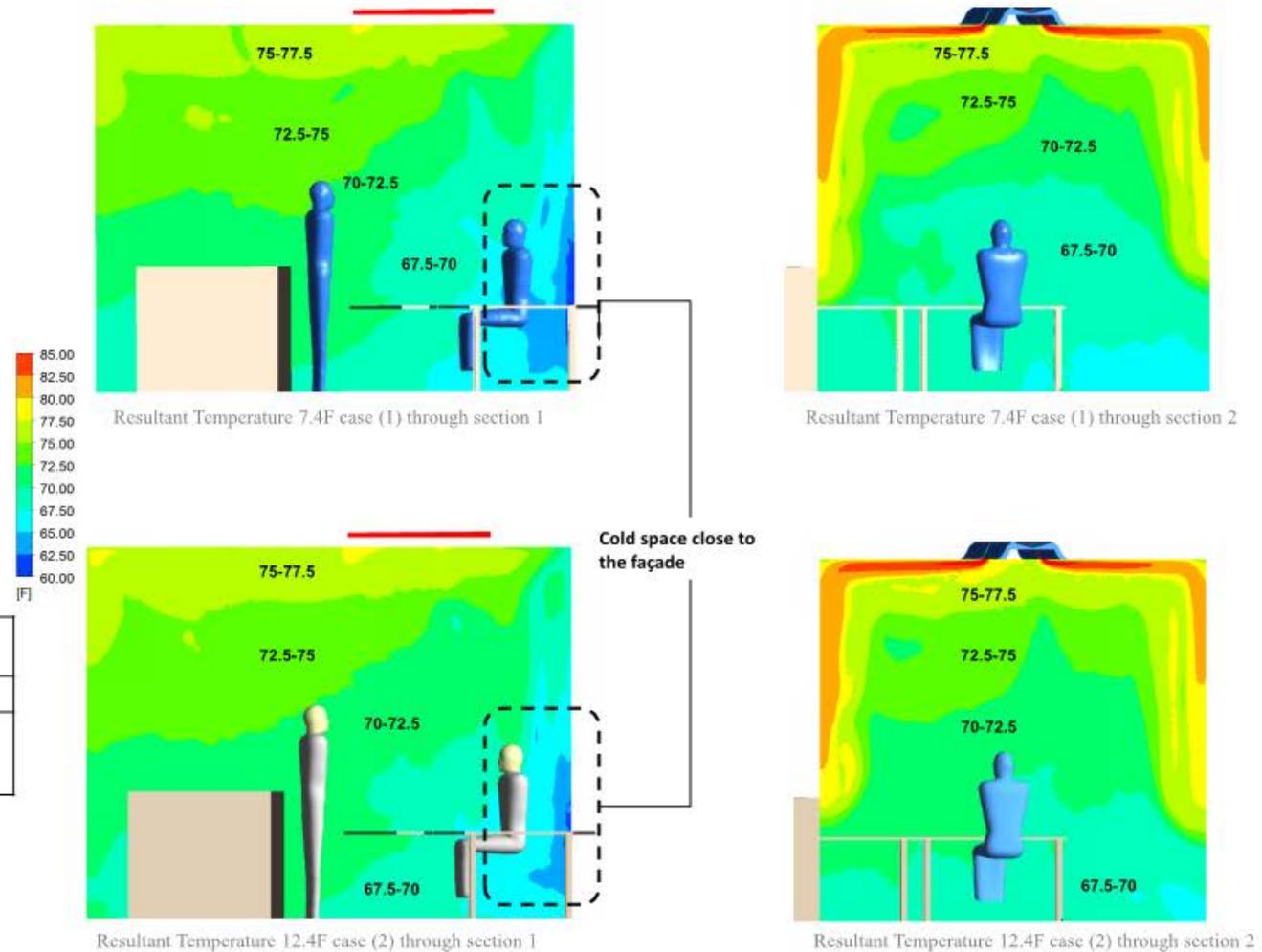


Perpendicular layout

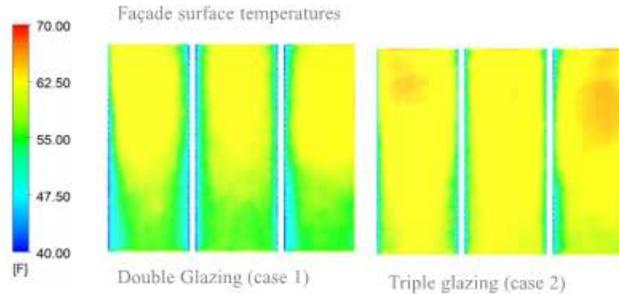
The modeling assumptions are as follows:

External Temperature	Case 1: 7.4F (99.6% TMY Coldest Month) Case 2: 12.4F (99% TMY Coldest Month)
ACB	4 x 2 feet , Total Supply: 362 CFM at 55F
Glazing	Double Glazing Frame+ glazing U-value: 0.42 Btu/hr-ft ² F Centre glass U-value= 0.27 Btu/hr-ft ² F

Even with a less conservative winter temperature the zone close to the cold glazed façade is uncomfortable. The critical factor is the radiant losses as a result of the cool glazing surface . The area a few feet closer to the cool surface will be cold.



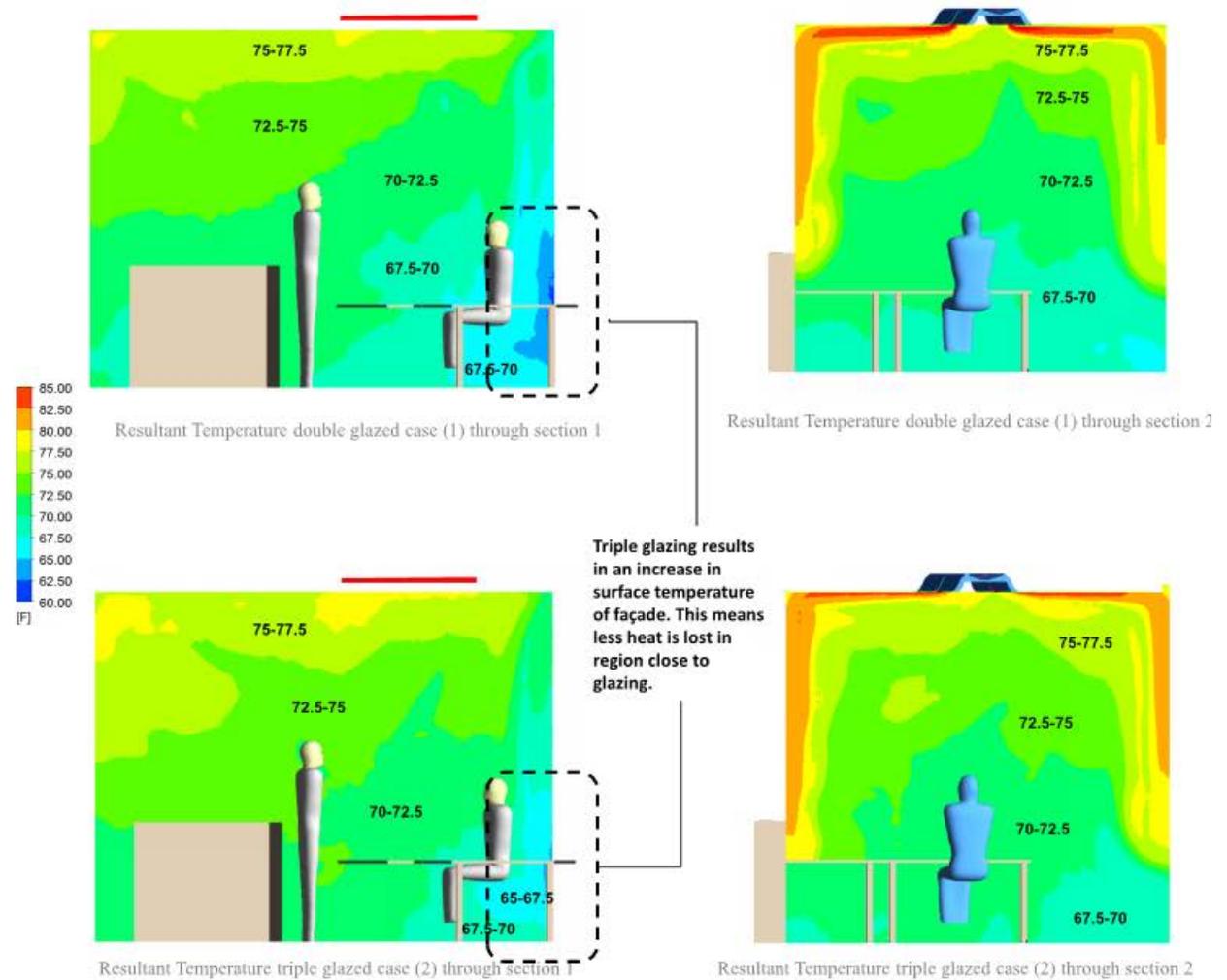
This study examines the difference in performance of a double glazed façade compared to a triple glazed façade.



The modeling assumptions are as follows:

External Temperature	12.4F (99% TMY Coldest Month)
ACB	4 x 2 feet , Total Supply: 362 CFM at 55F
Glazing	<p>Double Glazing Frame+ glazing U-value: 0.42 Btu/hr-ft²F Centre glass U-value= 0.27 Btu/hr-ft²F</p> <p>Case 2: Triple Glazing Frame+ glazing U-value: 0.36 Btu/hr-ft²F Centre glass U-value= 0.21 Btu/hr-ft²F</p>

The triple glazed facade shows an improvement in resultant temperatures close to the facade as well as overall in the space. This is due to a warmer surface temperature on the triple glazed façade which results in the space being less exposed to radiant heat loss.



1 Introduction

2 Form-Giving Sunshades

Northeastern University

Interdisciplinary Science and Engineering Complex

3 Minimalist Design

Amherst College, New Science Center

4 Orchestration of Standard Components

Tufts University, Science and Engineering Complex

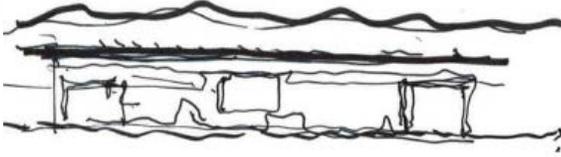
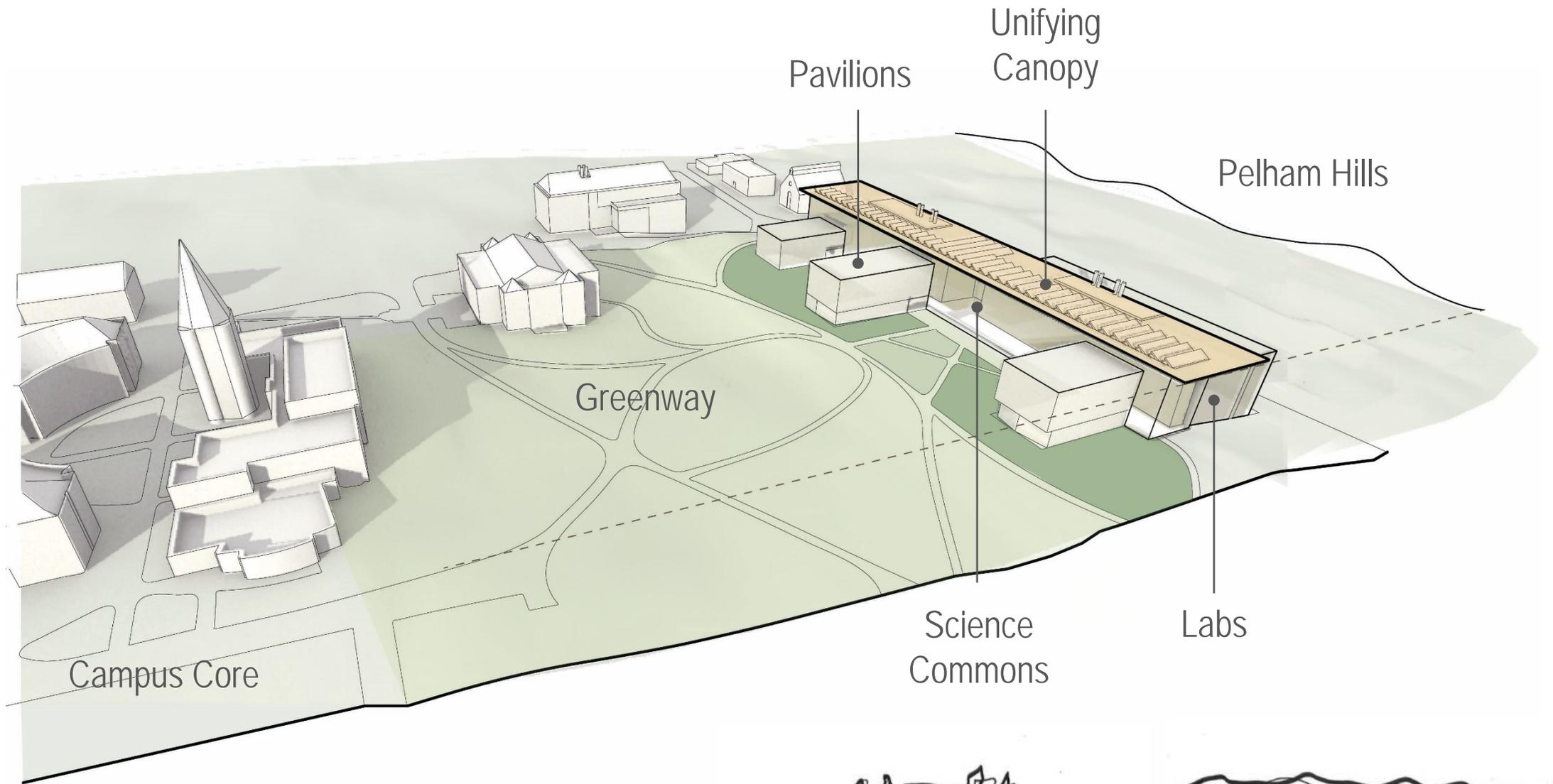
5 Moderated Discussion | Q&A



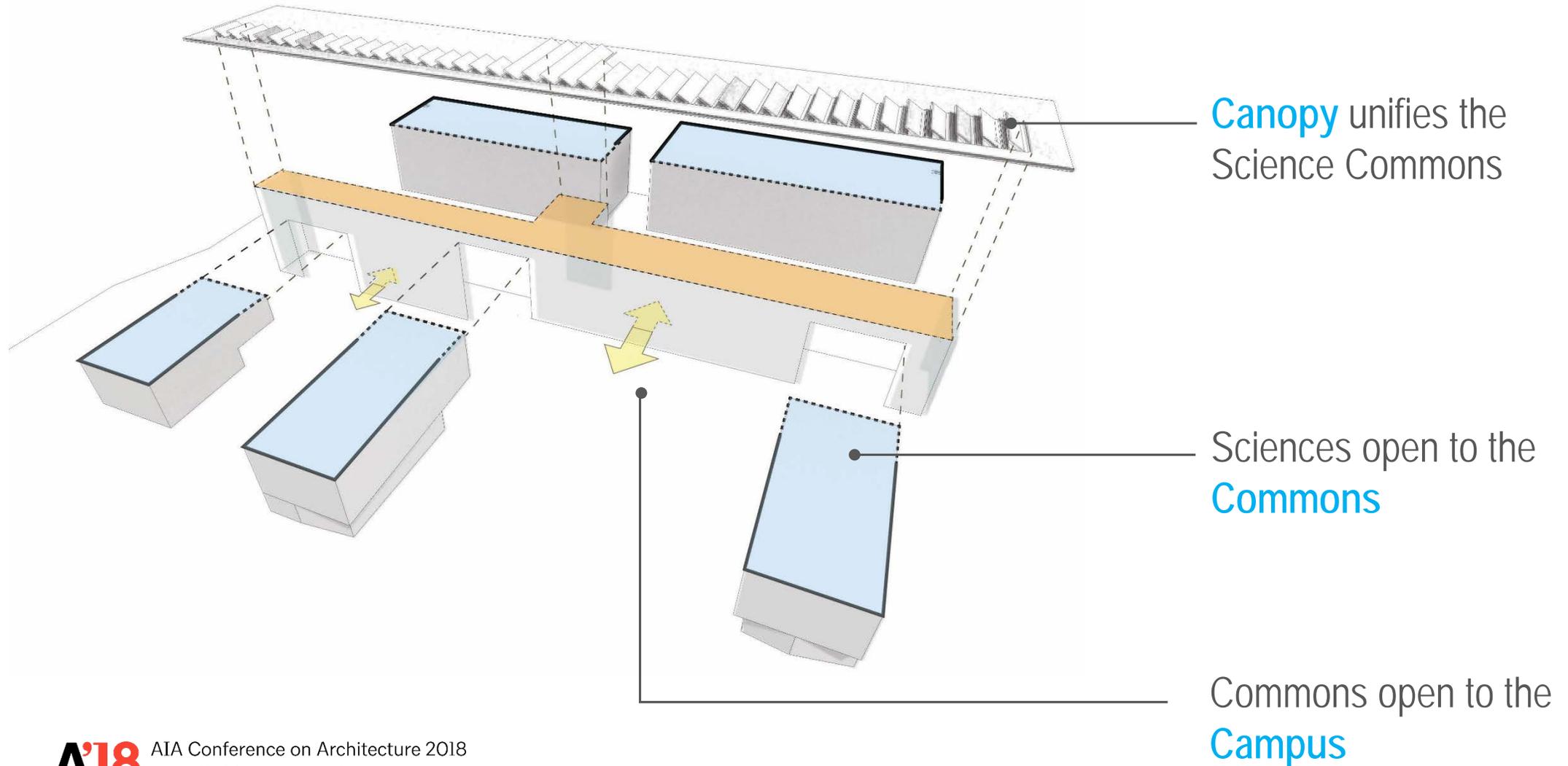
A'18 AIA Conference on Architecture 2018
June 21-23, New York City

Amherst College, New Science Center



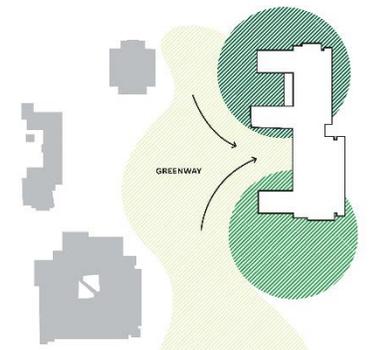
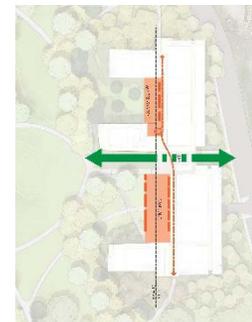


The Science Center defines **a community for the sciences**
a destination for the entire campus

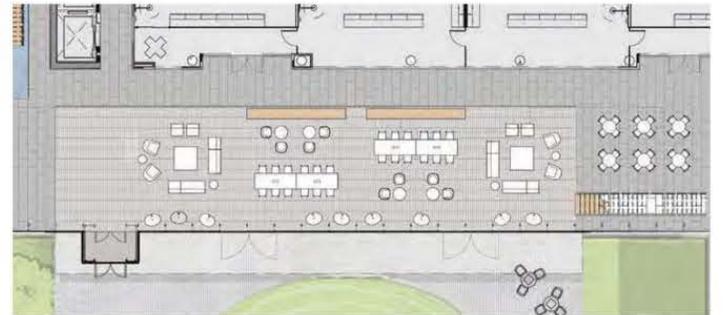
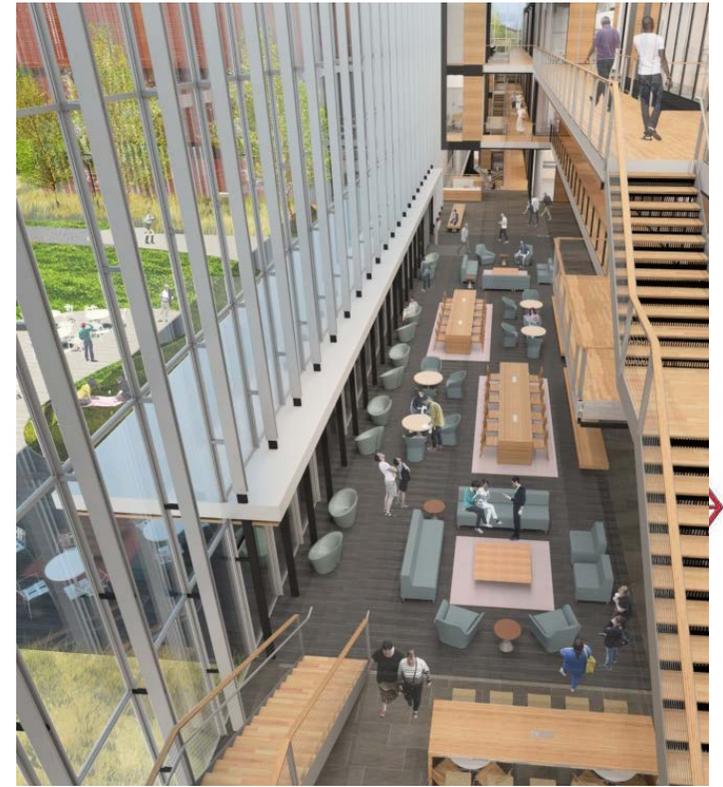


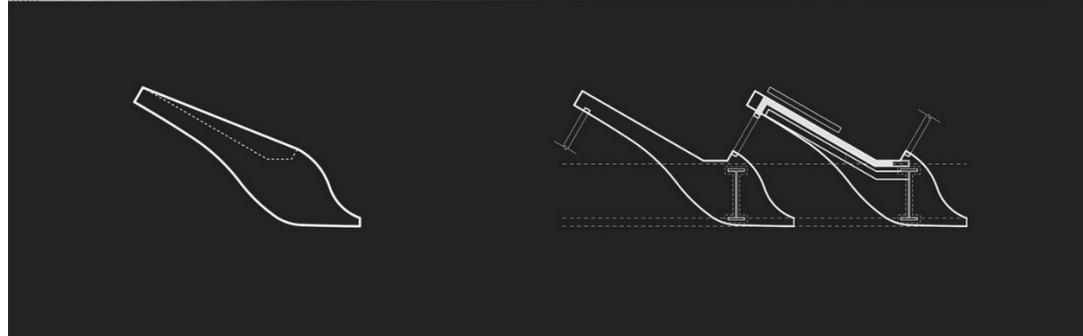
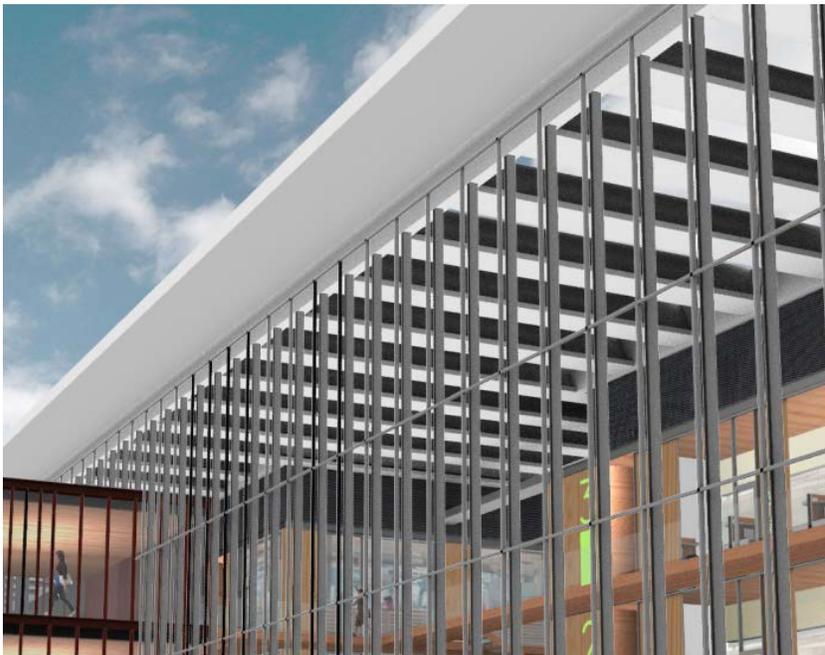


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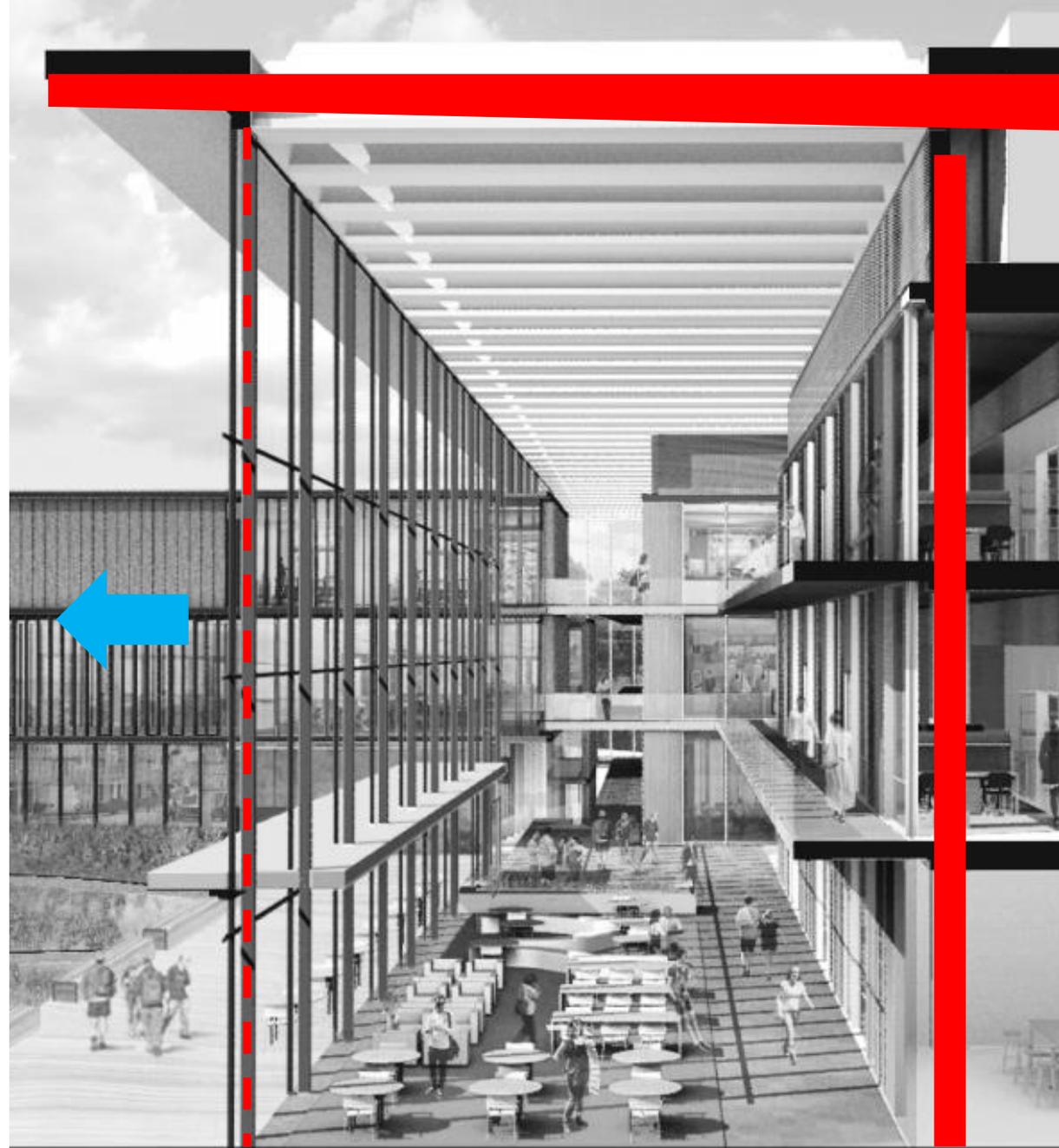
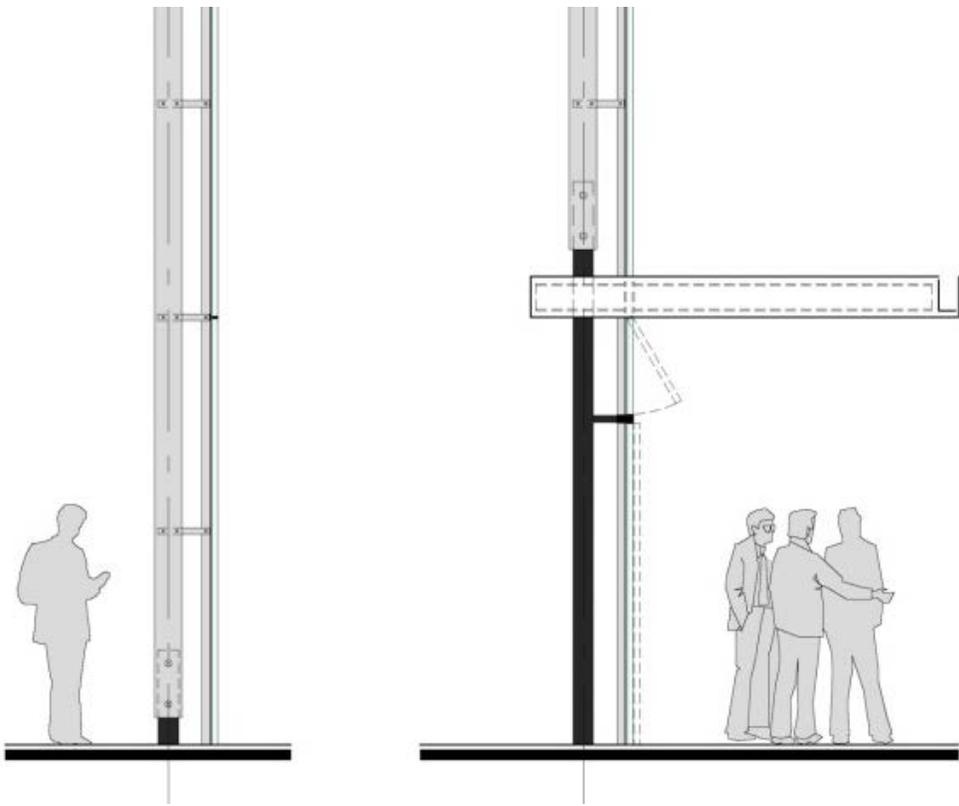








A'18 AIA Conference on Architecture 2018
June 21-23, New York City





Transparency

- Low Iron Glass
- Neutral Color Coatings
- Anti-Reflective Glass



Annual Heating

- Triple Insulating Glass
- Coated Polyester
Suspended Films
- Gas-filled Interspace
- Second low-e (surf #4)
- Warm edge spacer



56% VLT

15% VLR (Outside)

- Low Iron Glass
- Neutral Color Coatings
- Anti-Reflective Glass



0.16 COG U-Value

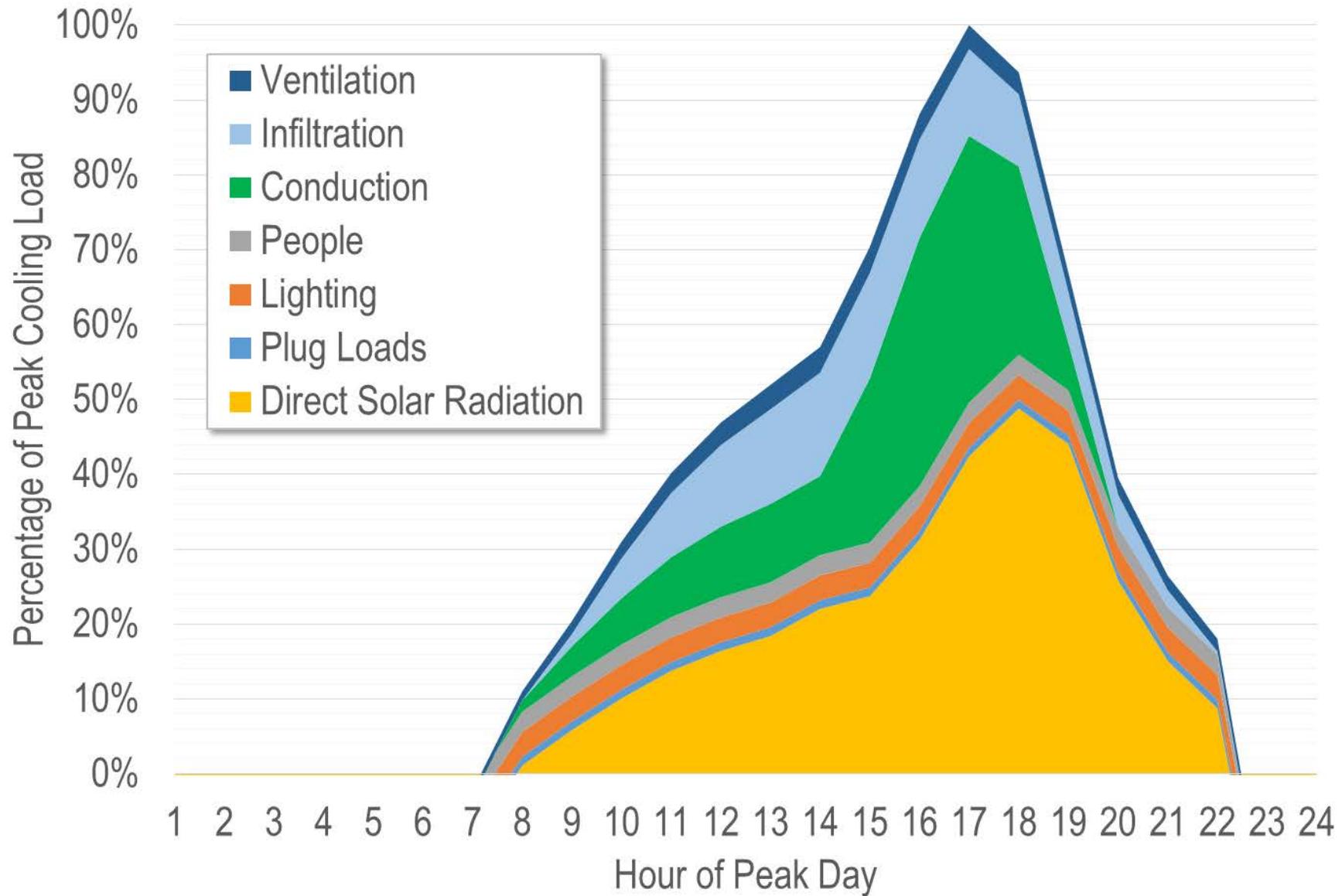
- Triple Insulating Glass
- Coated Polyester Suspended Films
- Gas-filled Interspace
- Second low-e (surf #4)
- Warm edge spacer



66% VLT

14% VLR (Outside)

0.16 COG U-Value





Transparency

- Low Iron Glass
- Neutral Color Coatings
- Anti-Reflective Glass

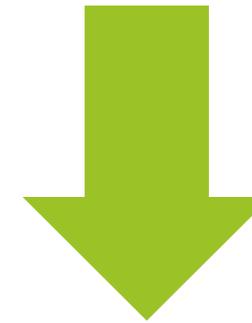


Heating Energy

- Triple Insulating Glass
- Coated Polyester Suspended Films
- Gas-filled Interspace
- Second low-e (surf #4)
- Warm edge spacer



Peak Cooling



0.28 SHGC



VLT: **56%**
 VLR (Outside): **15%**



COG U-Value: **0.16**
(0.25 Assembly)



0.28 SHGC

22% Increase in Peak Cooling Load



0.35 SHGC



56% VLT

15% VLR (Outside)

- Low Iron Glass
- Neutral Color Coatings
- Anti-Reflective Glass



0.16 COG U-Value

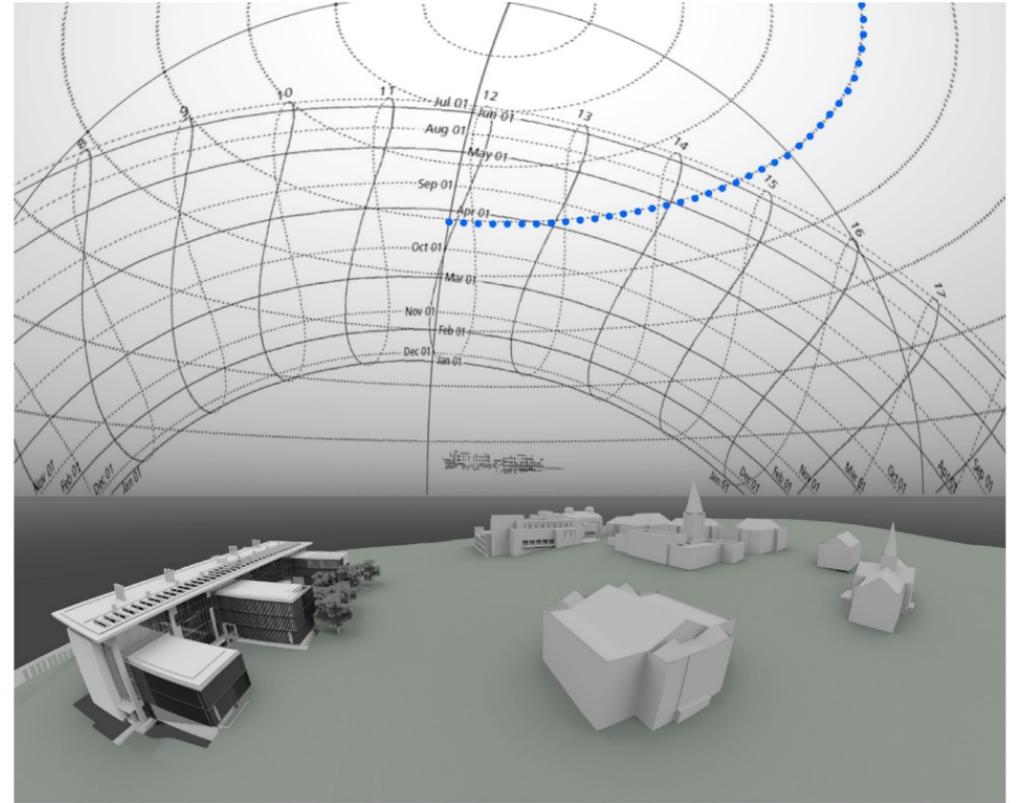
0.25 Assembly

- Triple Insulating Glass
- Coated Polyester Suspended Films
- Gas-filled Interspace
- Second low-e (surf #4)
- Warm edge spacer



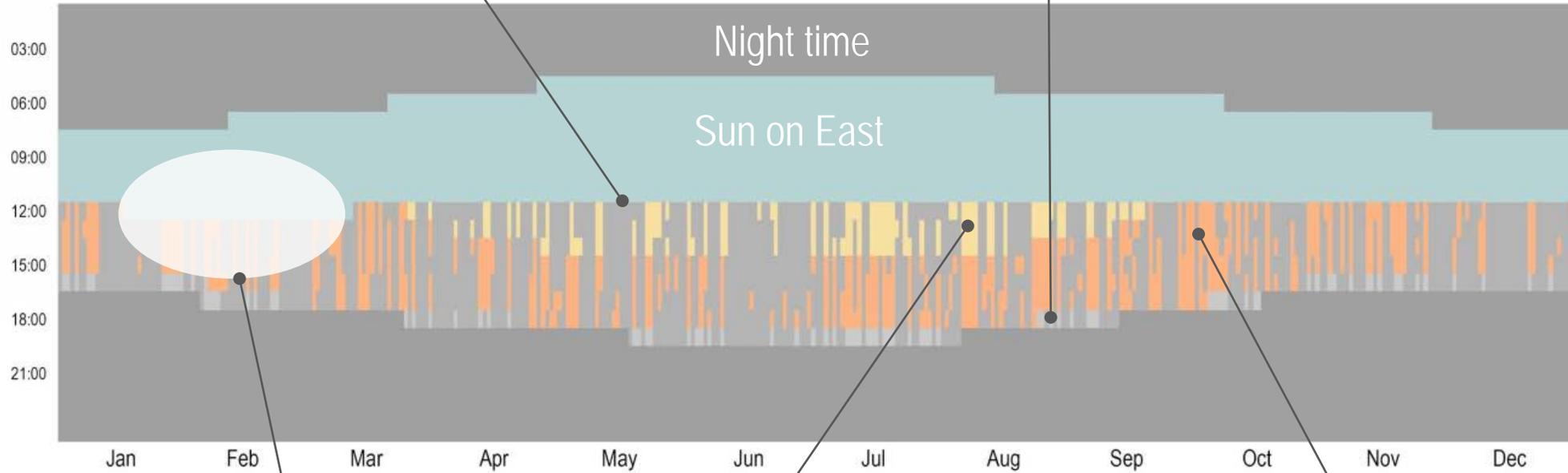
0.28 SHGC

- Low-e (surf #2)
- Ceramic Frit
- Interior Shading Systems



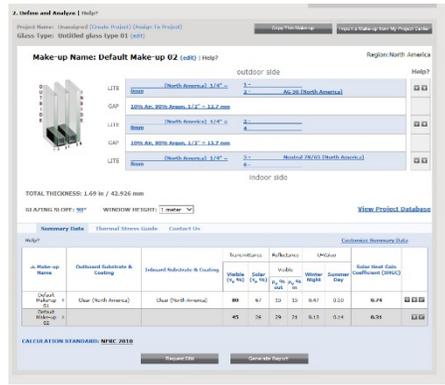
Overcast skies (63% of afternoon hours)

Topography shading



High solar gain (energy)
155 hours
7% afternoon hours

Low sun angles (glare)
569 hours
26% afternoon hours



Select Glazing Configuration:

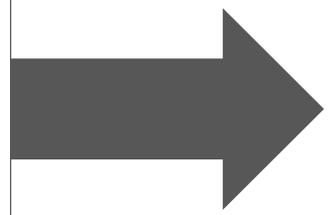
Single
 Double
 Triple

Imperial
 Metric
 Installation Angle °

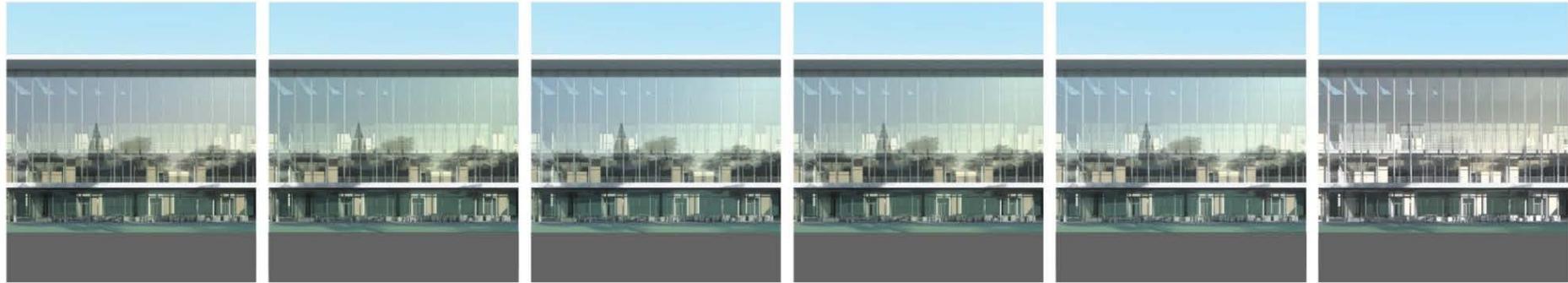
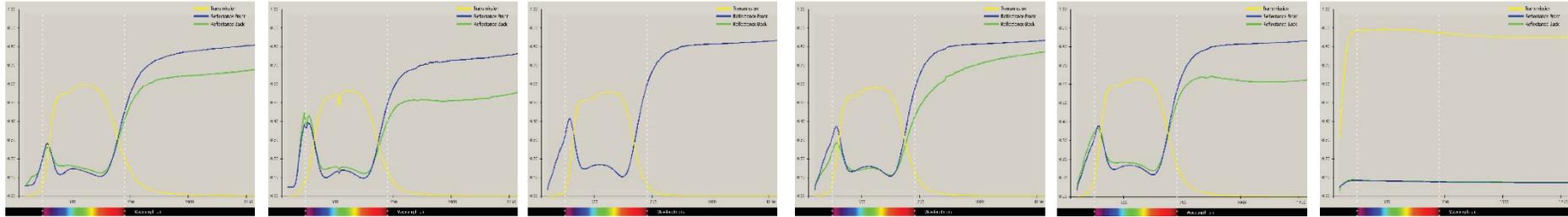
Layer 1 Outside
 Manufacturer: [Dropdown]
 Laminate
 Non Laminate
 Thickness: <--Select Thickness-->
 Glass Selection: <--Select-->

Cavity 1 (Air, 1/2" (12.7mm))
 Layer 2 Middle
 Cavity 2 (Air, 1/2" (12.7mm))
 Layer 3 Inside

Calculate



Mfg.	U-Value (Winter)	U-Value (Summer)	SHGC	Relative Heat Gain	VLT	VLR (Outside)
MFG 1	0.12	0.12	0.26	60.9	56%	16%
MFG 1	0.15	0.16	0.26	61.6	55%	16%
MFG 1	0.12	0.12	0.24	56.1	48%	14%
MFG 1	0.15	0.15	0.24	56.7	48%	14%
MFG 1	0.12	0.12	0.35	83.3	61%	14%
MFG 1	0.16	0.16	0.36	83.9	61%	14%
MFG 1	0.12	0.12	0.27	64.5	58%	15%
MFG 1	0.15	0.16	0.27	65.1	56%	15%
MFG 1	0.12	0.12	0.25	59.5	54%	14%
MFG 1	0.15	0.16	0.25	60.2	54%	14%
MFG 1	0.14	0.14	0.26	62.4	57%	18%
MFG 1	0	0	0	0	0%	0%
MFG 1	0.15	0.14	0.26	62.0	57%	18%
MFG 1	0.18	0.17	0.26	62.4	57%	18%
MFG 1	0	0	0	0	0%	0%
MFG 1	0	0	0	0	0%	0%
MFG 1	0	0	0	0	0%	0%
MFG 1	0	0	0	0	0%	0%
MFG 1	0.14	0.14	0.36	85.8	60%	17%
MFG 1	0	0	0	0	0%	0%
MFG 1	0	0	0	0	0%	0%
MFG 1	0.18	0.17	0.36	84.9	60%	17%
MFG 1	0.17	0.17	0.27	65.5	61%	16%
MFG 2	0.13	0.13	0.24	58.0	53%	12%
MFG 2	0.16	0.16	0.25	59.0	53%	12%
MFG 2	0.16	0.16	0.26	62.0	59%	14%
MFG 2						
MFG 2	0.13	0.13	0.32	76.0	60%	14%
MFG 2	0.16	0.16	0.32	77.0	60%	14%
MFG 2						
MFG 2						
MFG 2	0.16	0.17	0.37	87.0	66%	14%
MFG 3	0.12	0.12	0.23		44%	15%
MFG 3	0.15	0.16	0.23		44%	15%
MFG 3	0.12	0.13	0.33		53%	15%
MFG 3	0.16	0.16	0.33		53%	24%
MFG 3	0.14	0.15	0.58		70%	16%
MFG 3	0.17	0.18	0.58		70%	16%
MFG 3	0.13	0.13	0.24		56%	13%
MFG 3	0.16	0.17	0.24		56%	13%



MFG 1
Coating 1

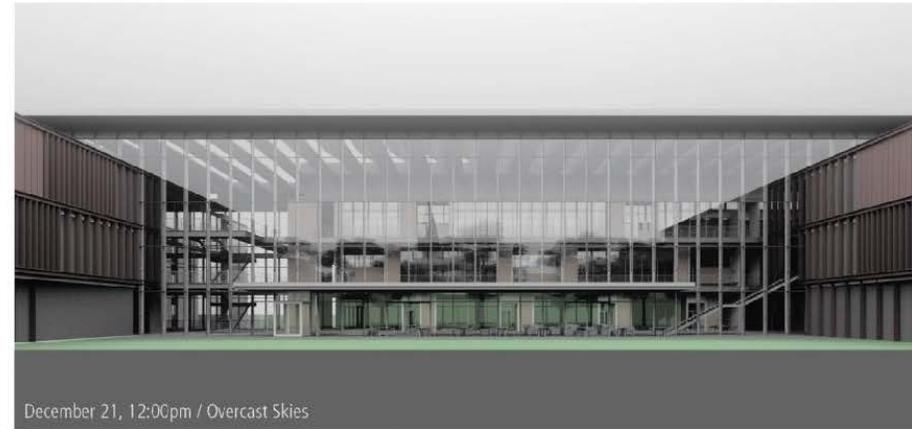
MFG 2
Coating 1

MFG 3
Coating 1

MFG 3
Coating 2

MFG 3
Coating 3

(Control)
Single
Low Iron



Control Single Pane Low Iron



Basis of Design Triple-Glazed, Low Iron, Two Low-e Coatings



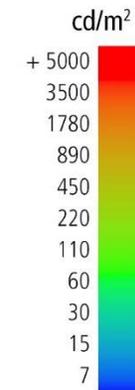
66% VLT
14% VLR (Outside)
0.16 COG U-Value
0.35 SHGC



56% VLT
15% VLR (Outside)
0.15 COG U-Value
0.27 SHGC



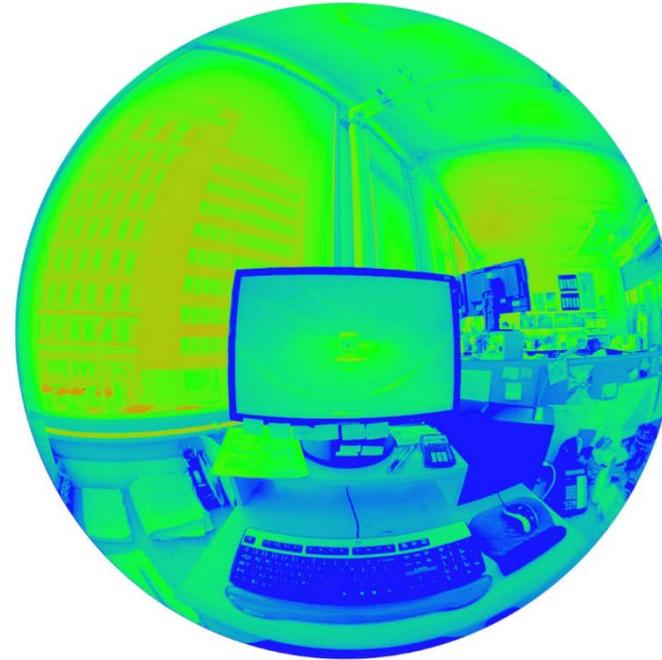
HDR Computational Image
Workstation View
White Exterior Building in **Direct Sun**



Daylight Glare Probability: **0.31**



HDR Computational Image
Workstation View
Diffusing Shade Fabric Deployed



Daylight Glare Probability: 0.16

Commons



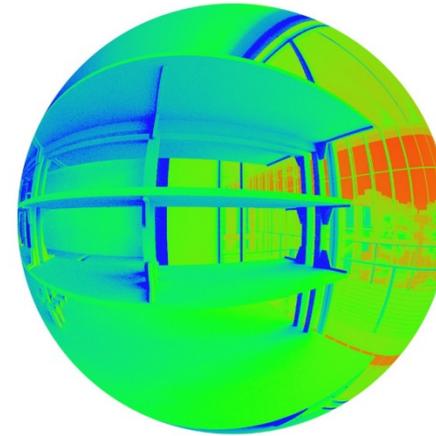
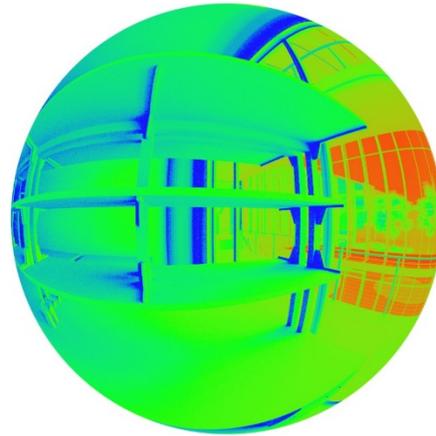
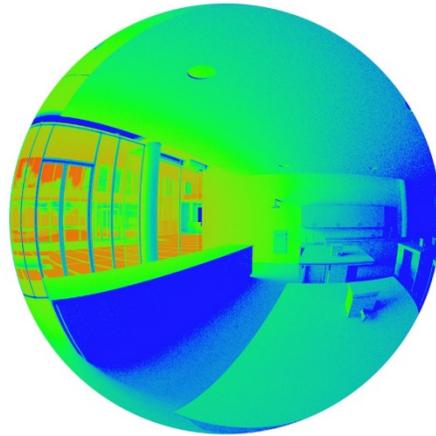
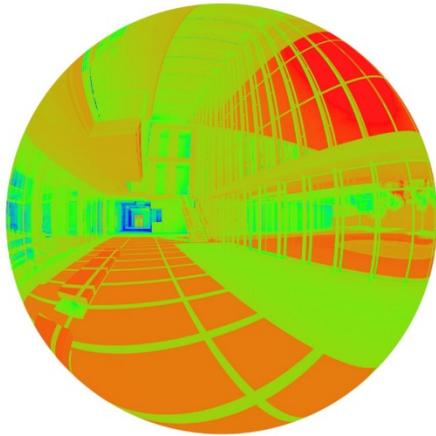
Level 1 Classroom

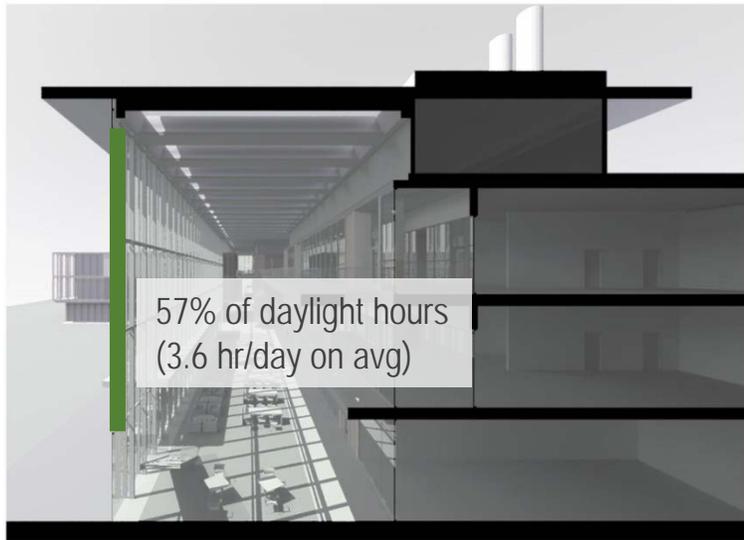


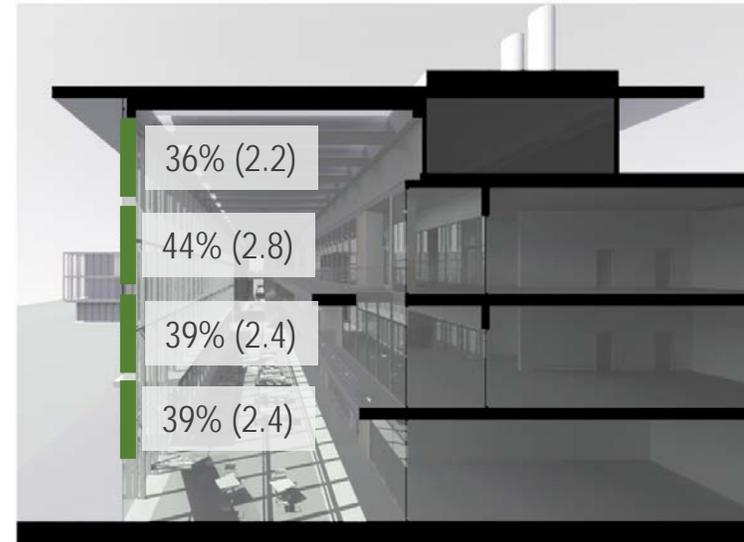
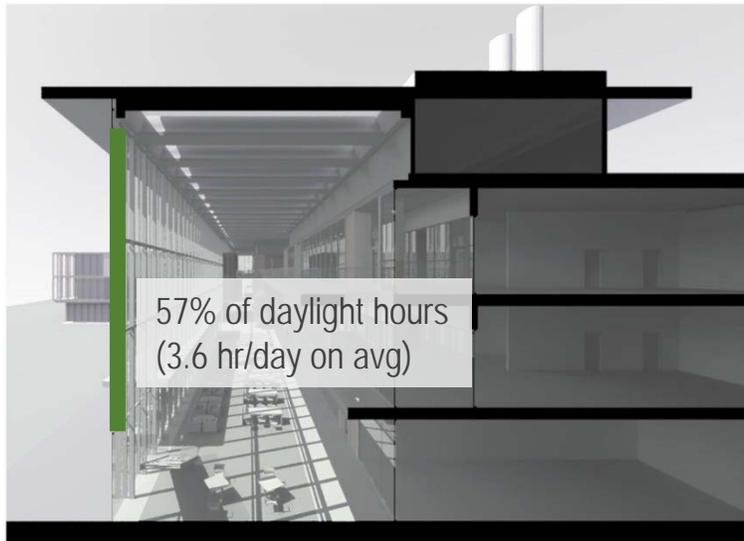
Level 2 Lab

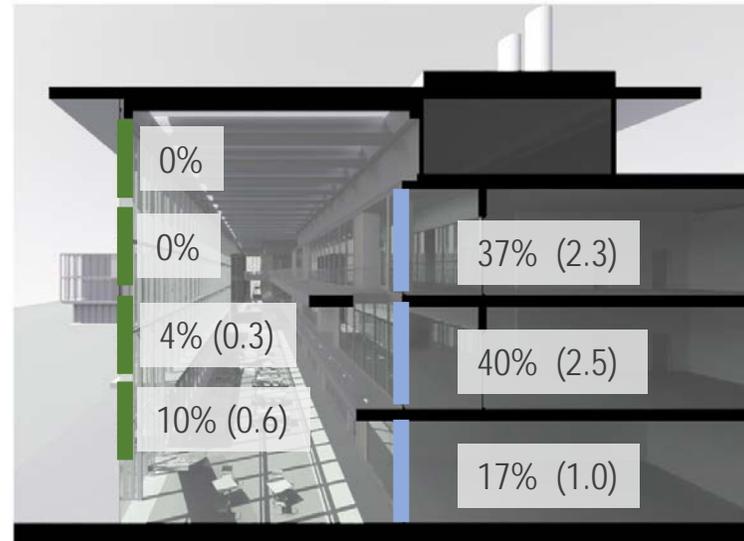
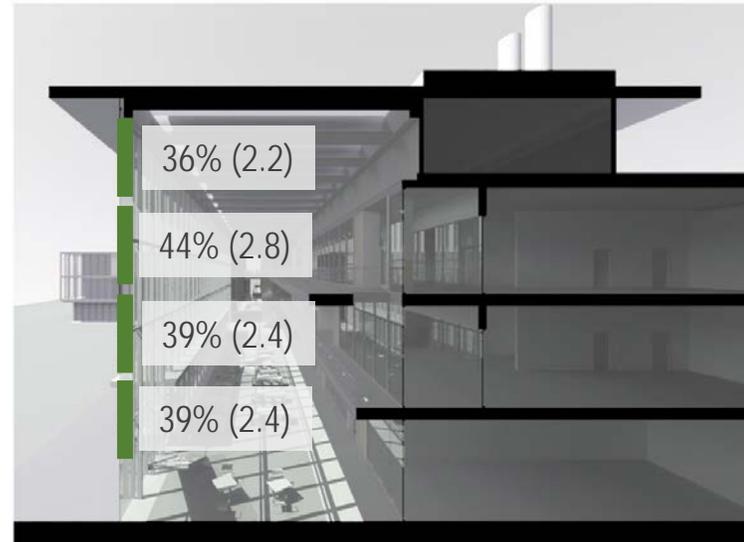
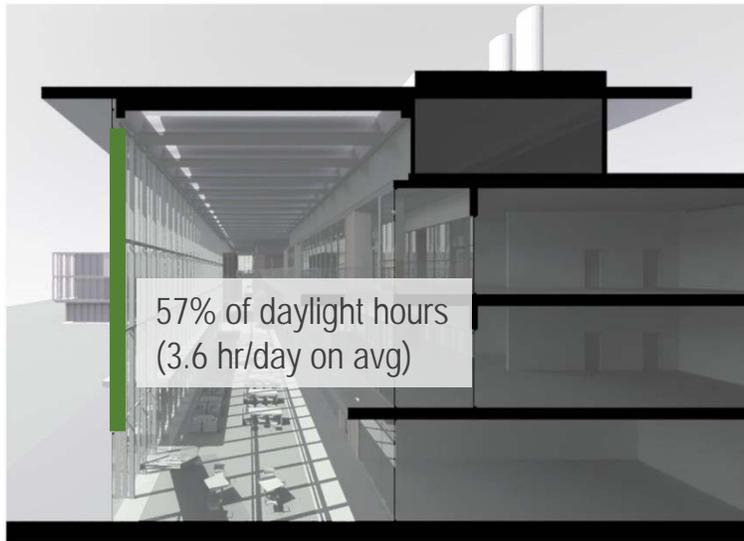


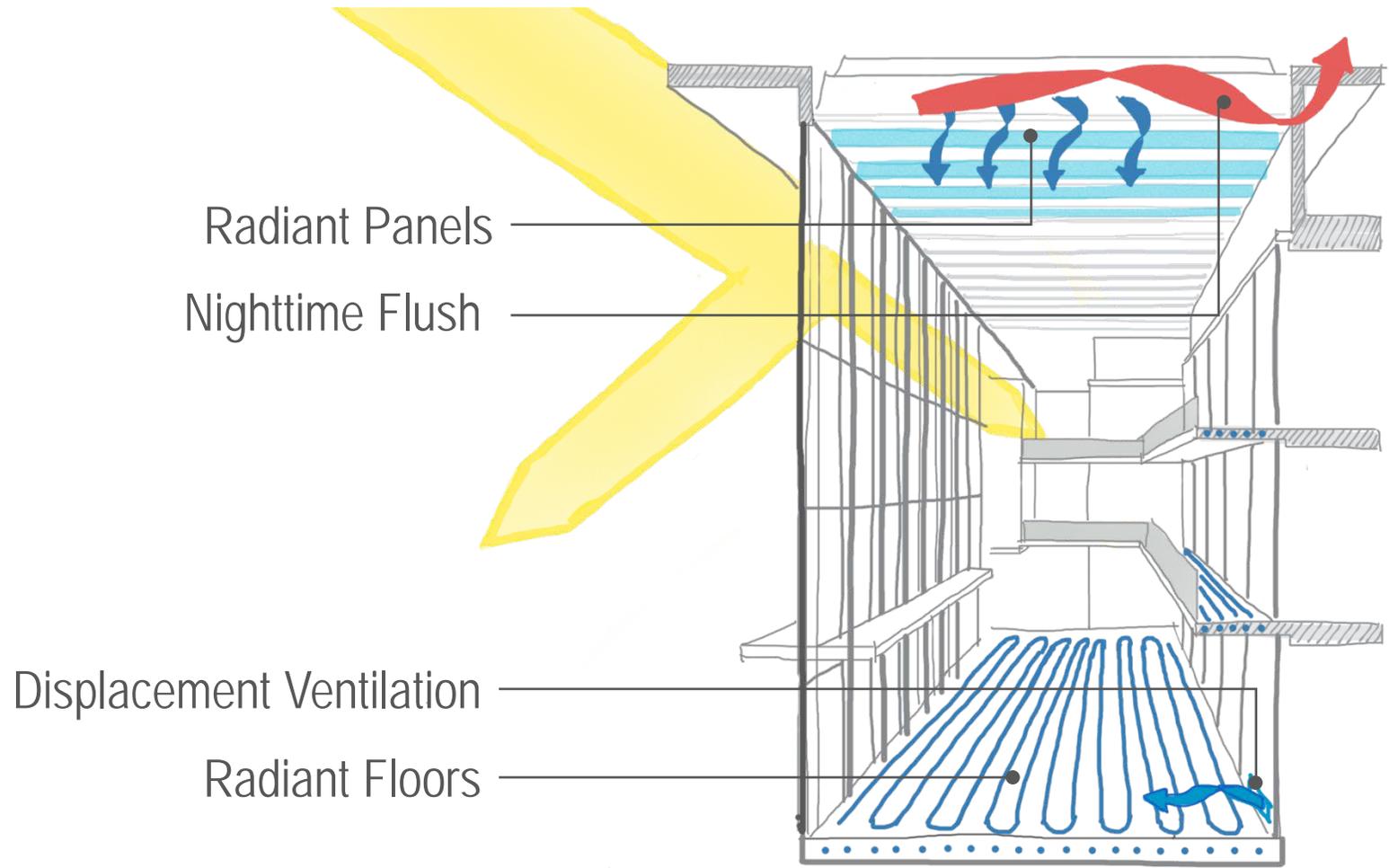
Level 3 Lab

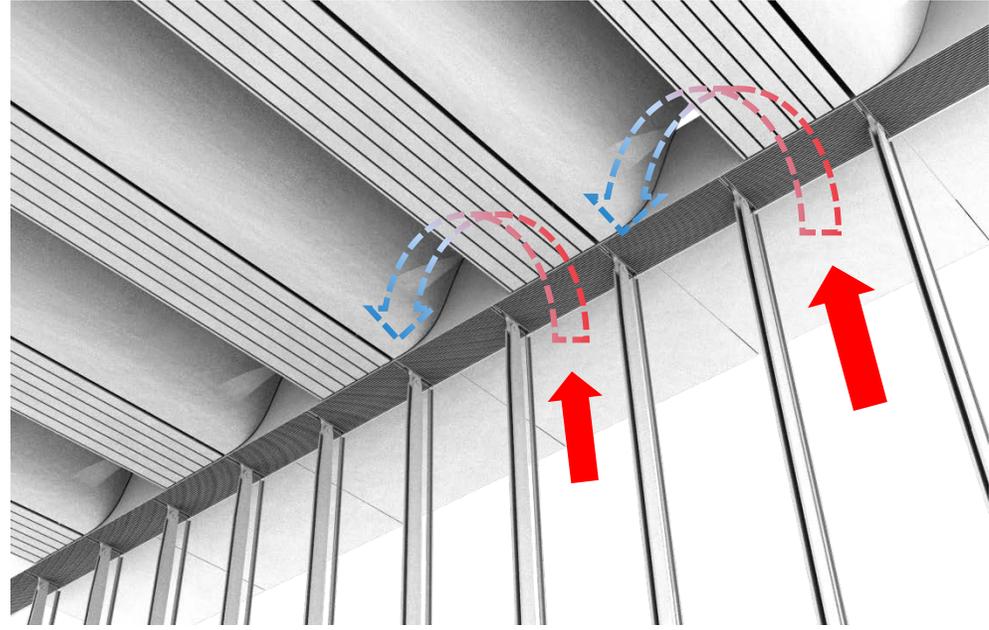
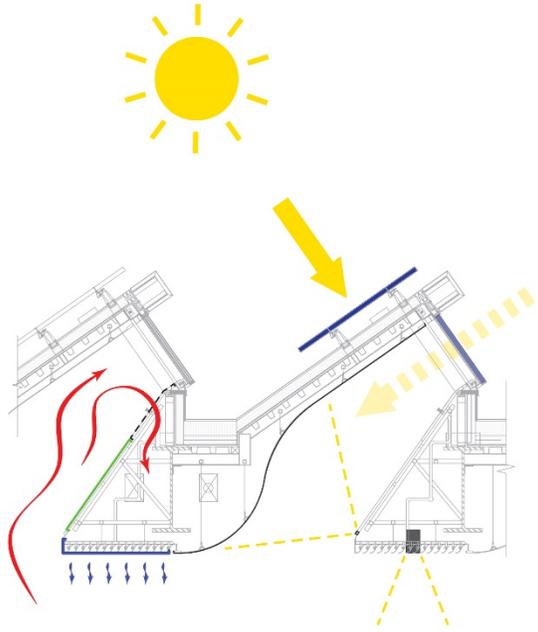




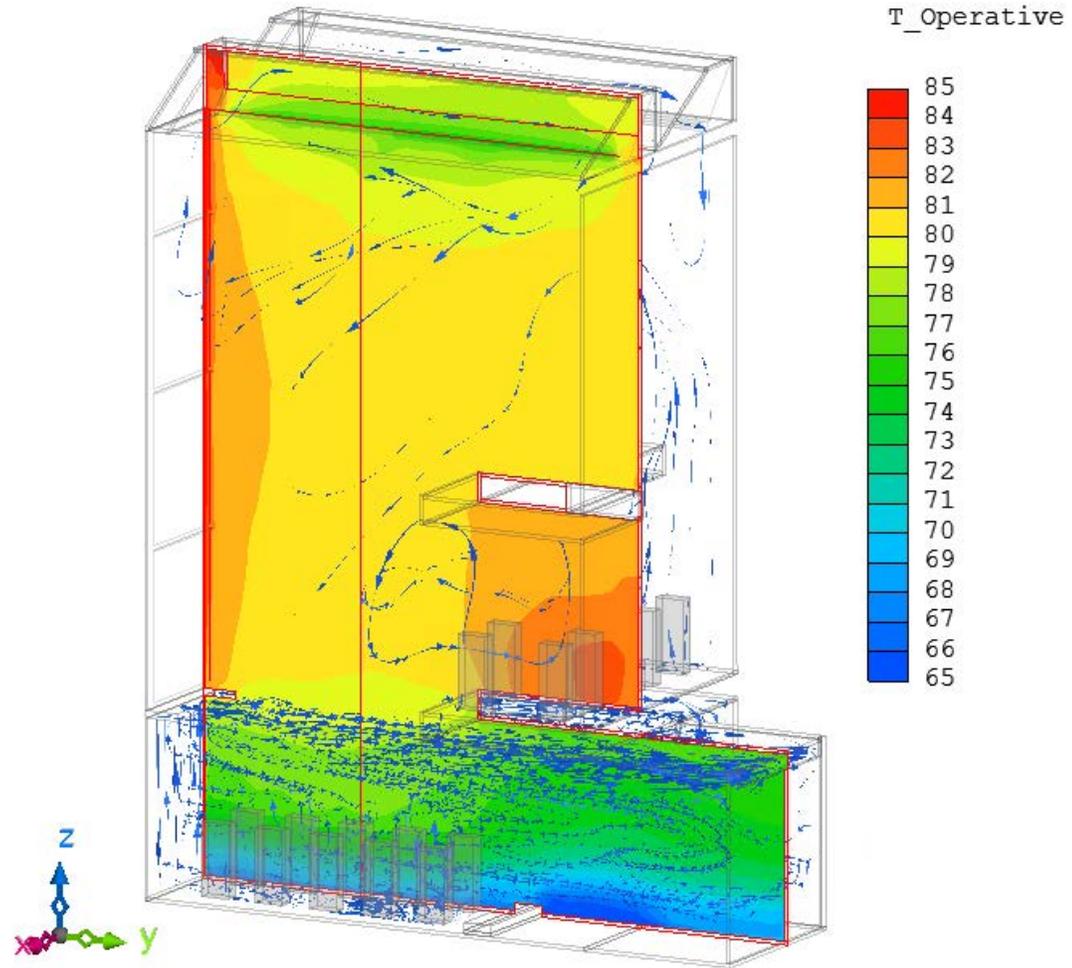






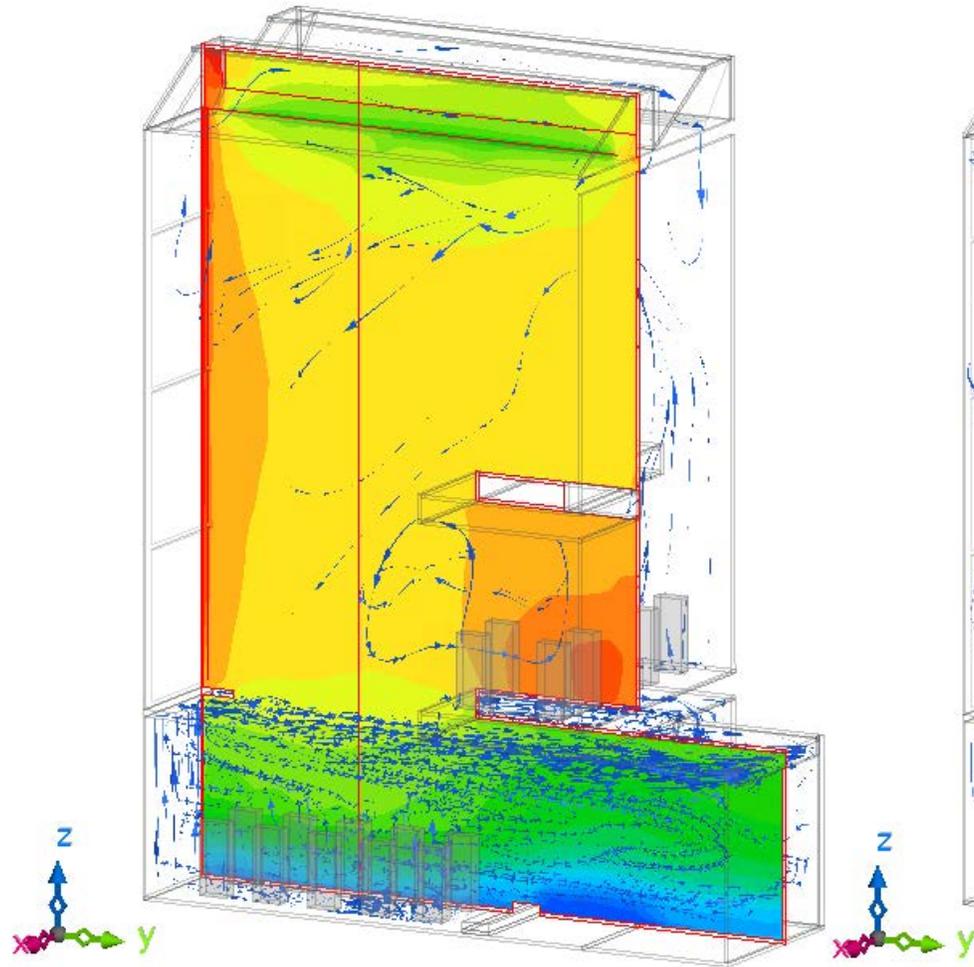


Mostly Radiant System

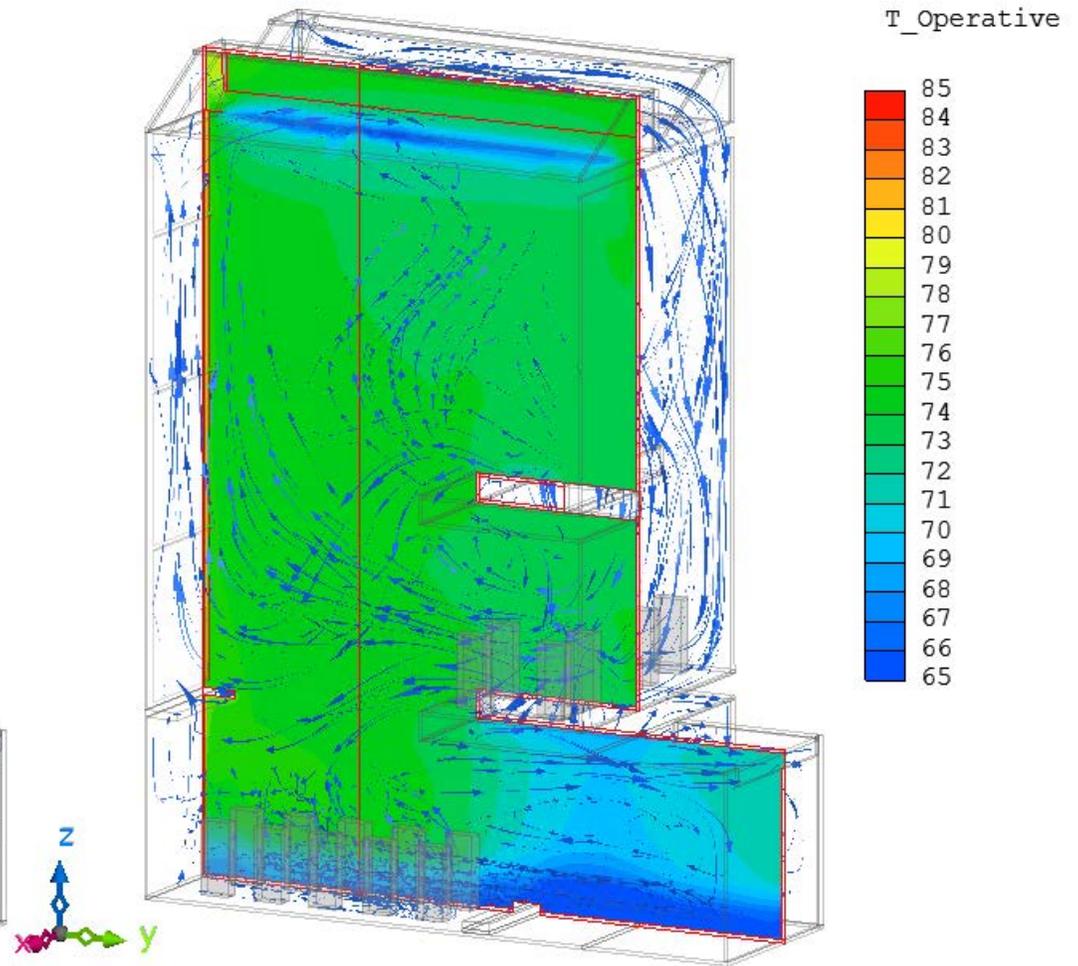




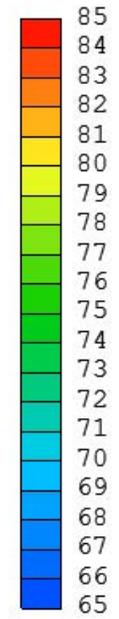
Mostly Radiant System



Mostly Convective System



T_{Operative}



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Tufts University, Science and Engineering Complex

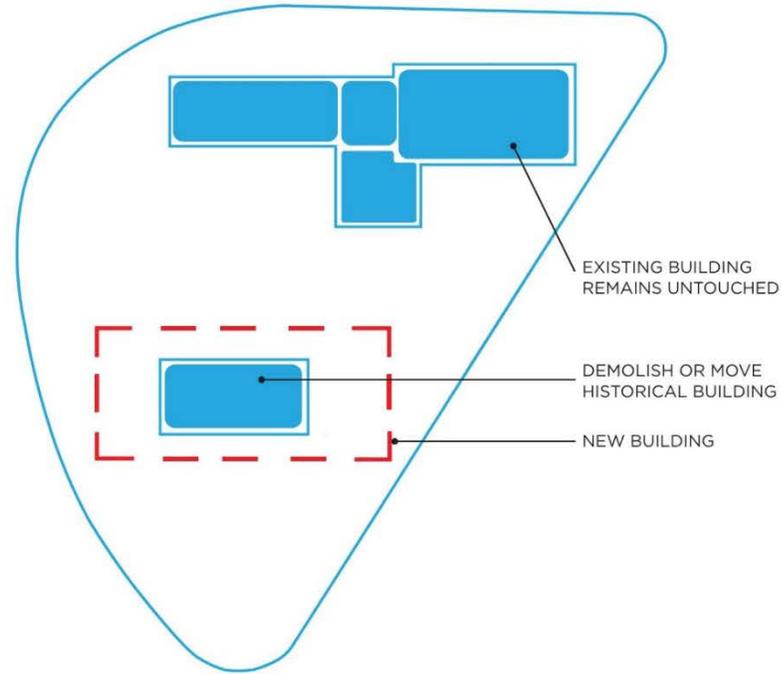
5 Moderated Discussion | Q&A



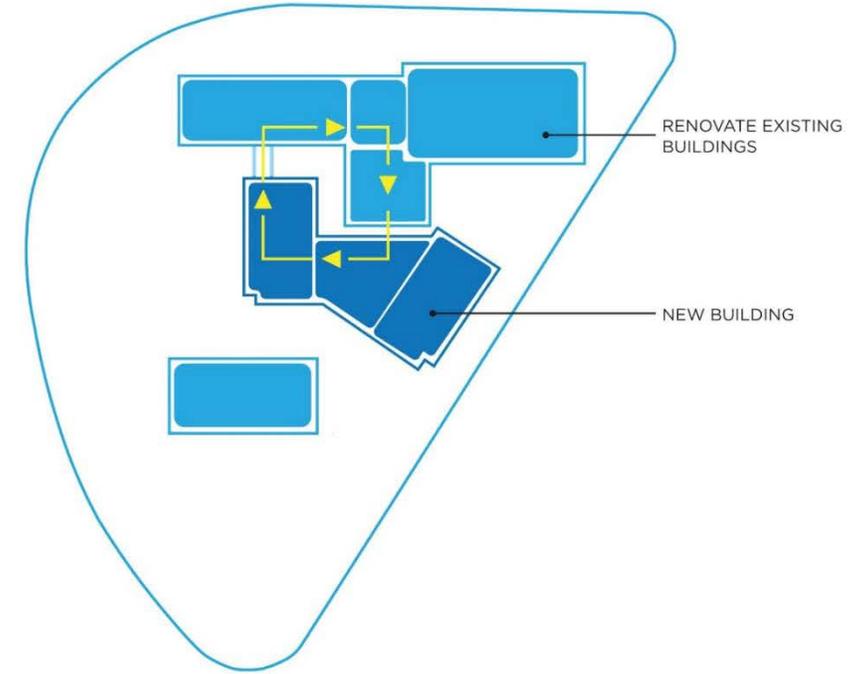
A'18 AIA Conference on Architecture 2018
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Tufts University Science & Engineering Complex

NEW — OLD = DISPARATE PARTS

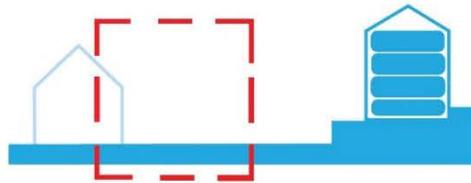


NEW + OLD = REVITALIZATION



INITIAL CLIENT BRIEF

110,000 SF NEW — 30,000 SF EXISTING = 70,000 SF NET

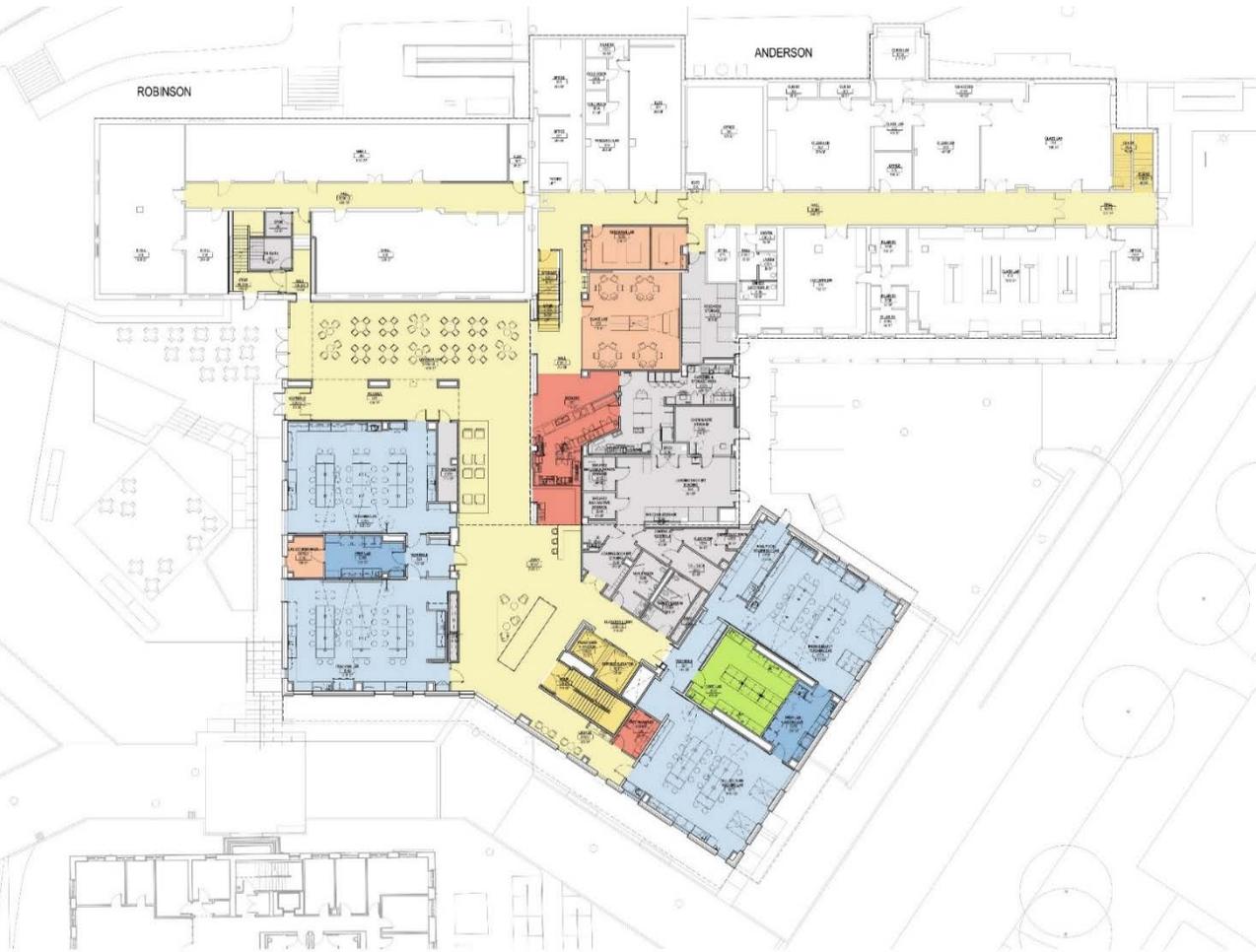


DESIGN SOLUTION

77,000 SF NEW + 100,000 SF EXISTING = 177,000 SF NET







Integrated Strategy: Breathing New Life

112 KBTU/SF

per year in energy use intensity, which is equal to the energy use of 606 homes

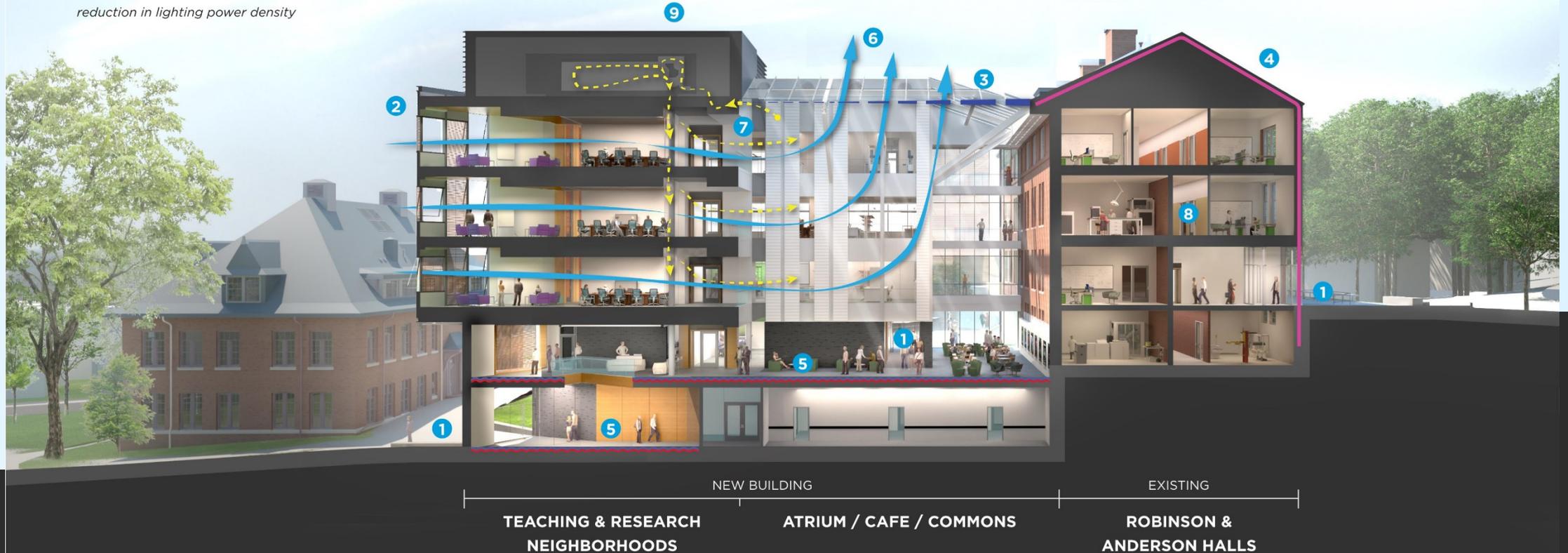
77%

reduction in energy use

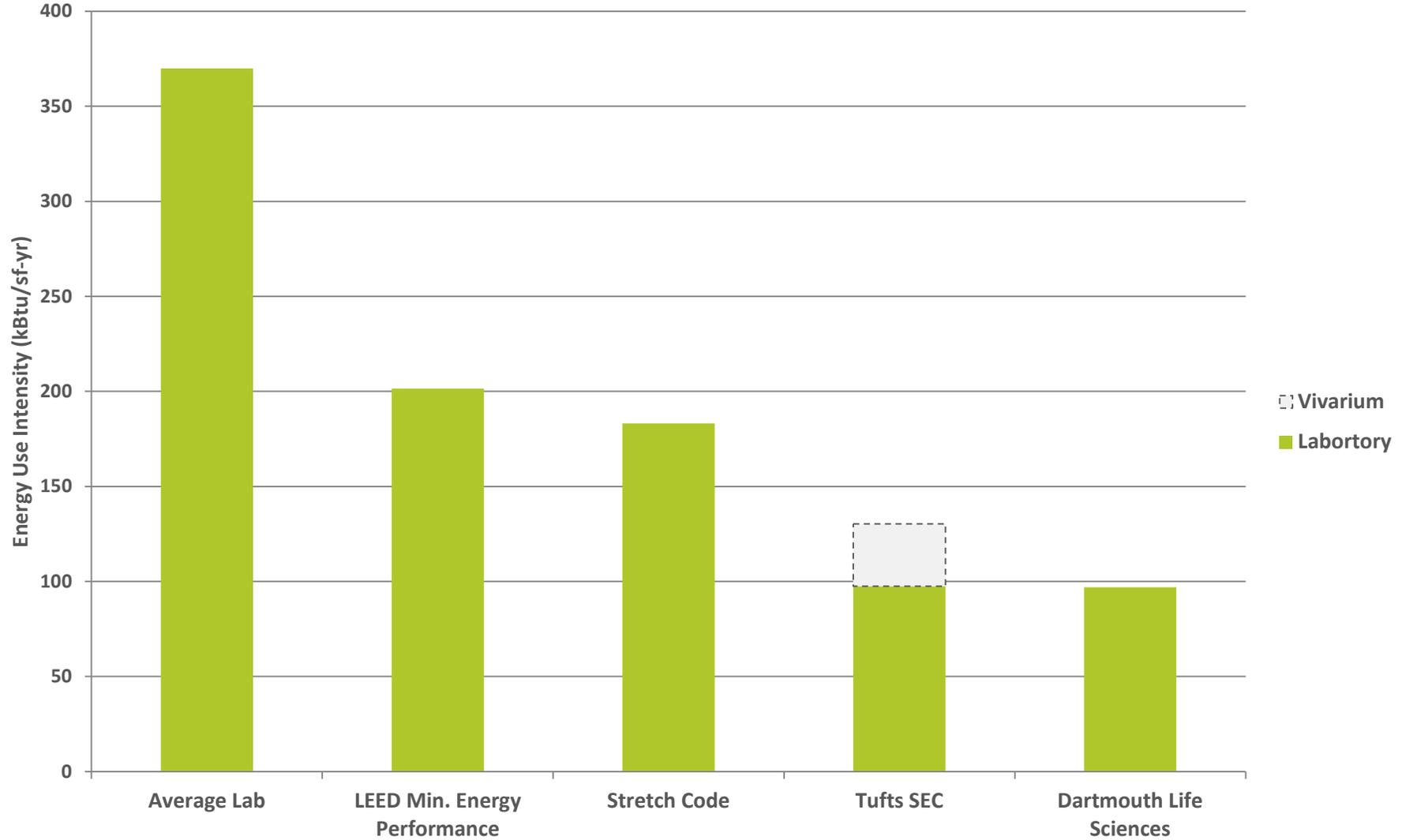
30%

reduction in lighting power density

- 1 Entrances on multiple levels create walk-up building
- 2 Triple glazed exterior reduces solar heat gain and eliminates need for perimeter heating
- 3 Progressively opaque roof glazing reduces glare and creates even light distribution
- 4 Existing building envelope is thermally improved
- 5 Radiant heating & cooling of interior floors
- 6 Fan assisted natural ventilation (dual purpose with atrium smoke evacuation)
- 7 Laboratory supply air is first cascaded through atrium to minimize pre-heat
- 8 Existing load bearing masonry is exposed, preserved, celebrated
- 9 PV Panel-Ready Roof with electrical infrastructure installed



Energy Use Intensity (kBtu/sf-year)

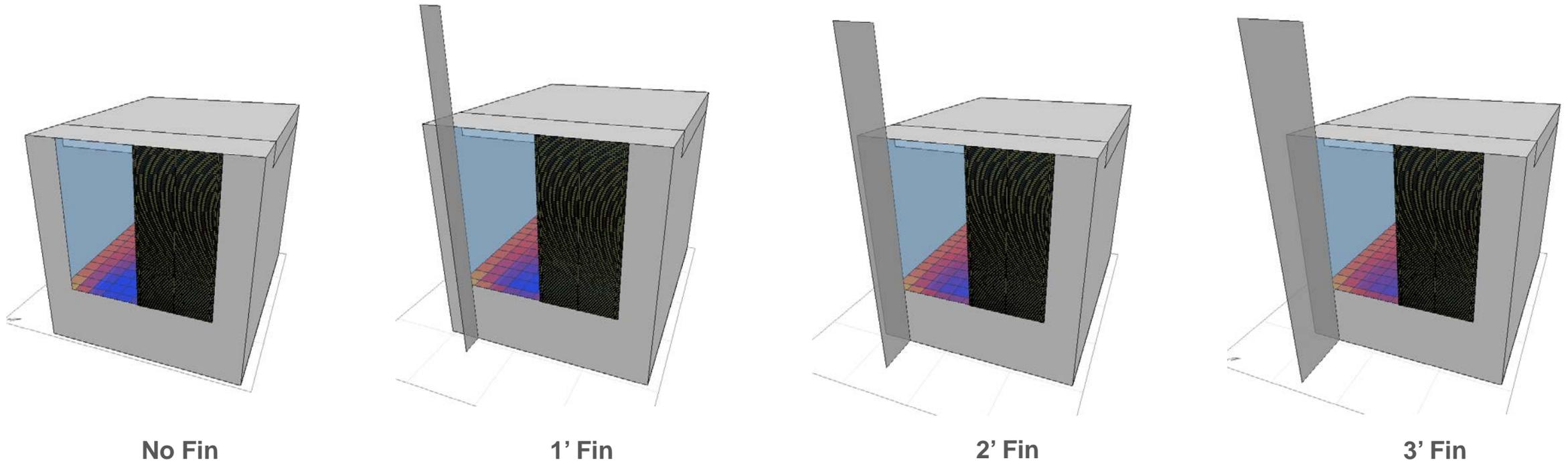




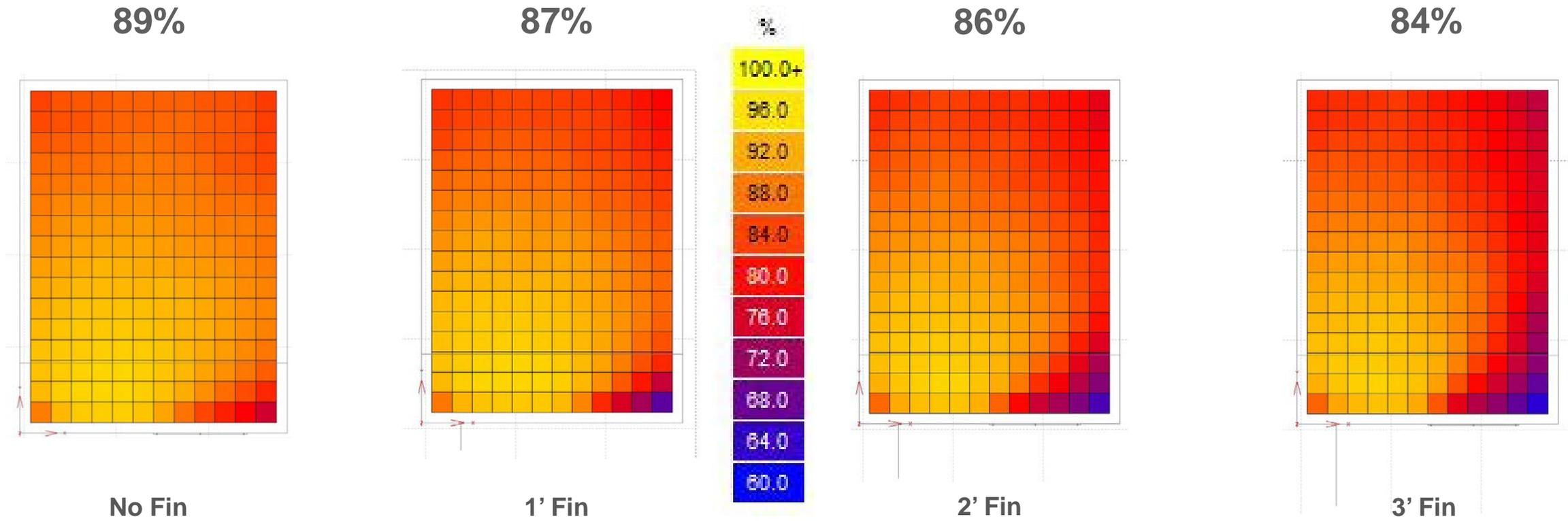
A'18 AIA Conference on Architecture 2018
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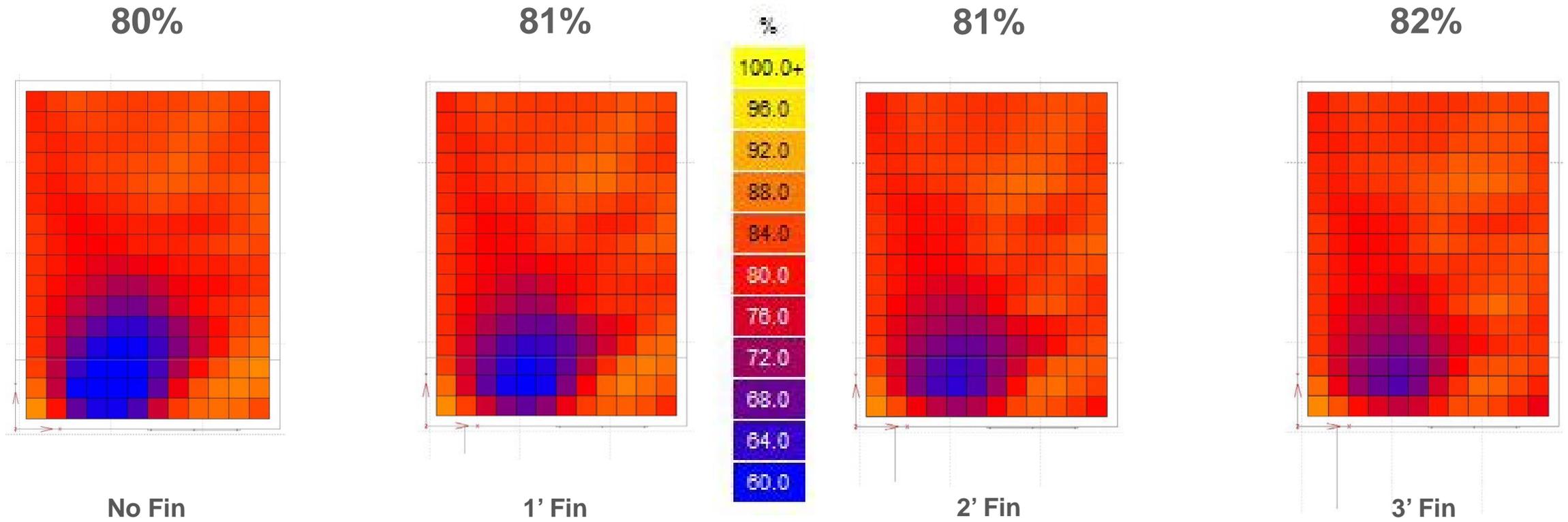
Office Daylight Analysis – 50% Clear : 50% Filtered



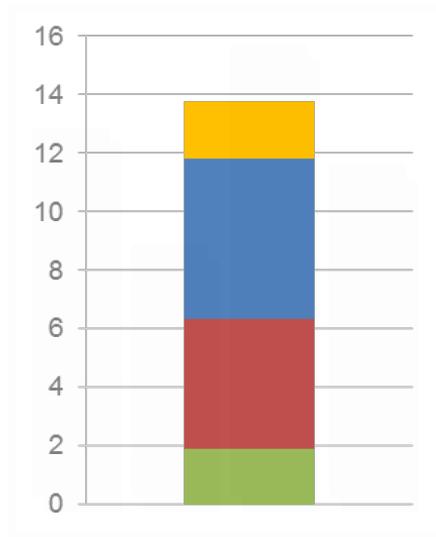
Continuous Daylight Autonomy (Percent of year lights can be dimmed or off at target of 30fc between 8am & 6pm)



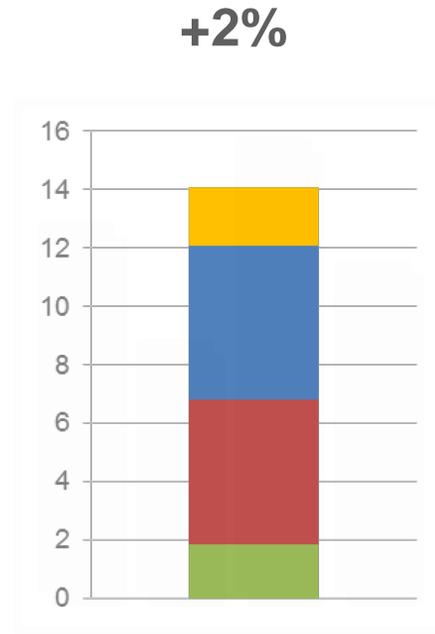
Continuous Daylight Autonomy (Percent of year lights can be dimmed or off at target of 30fc between 8am & 6pm)



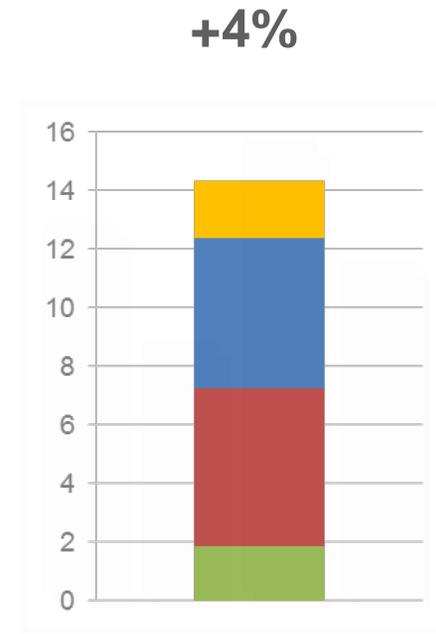
Annual Lighting and HVAC Energy Use



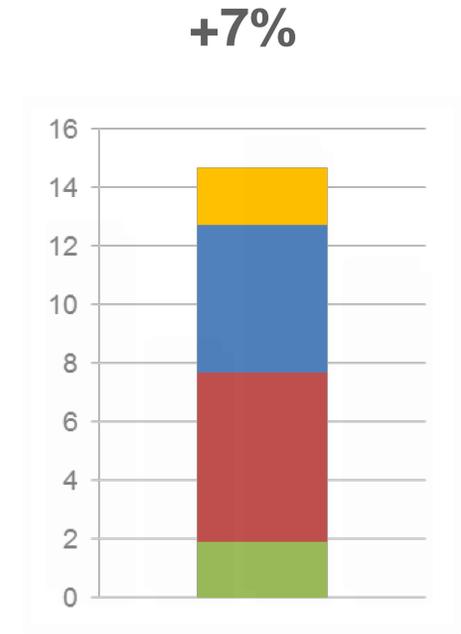
No Fin



1' Fin



2' Fin

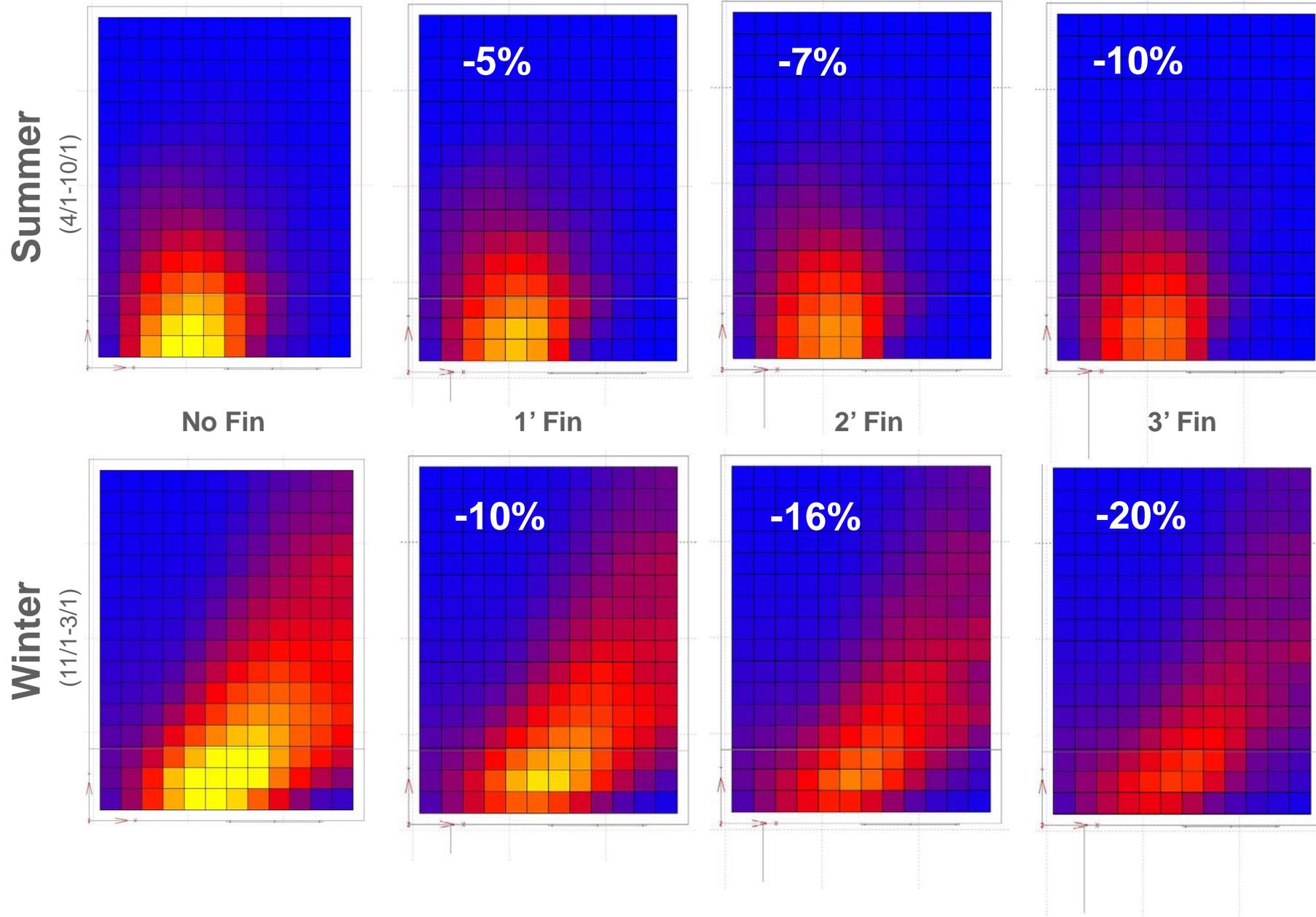


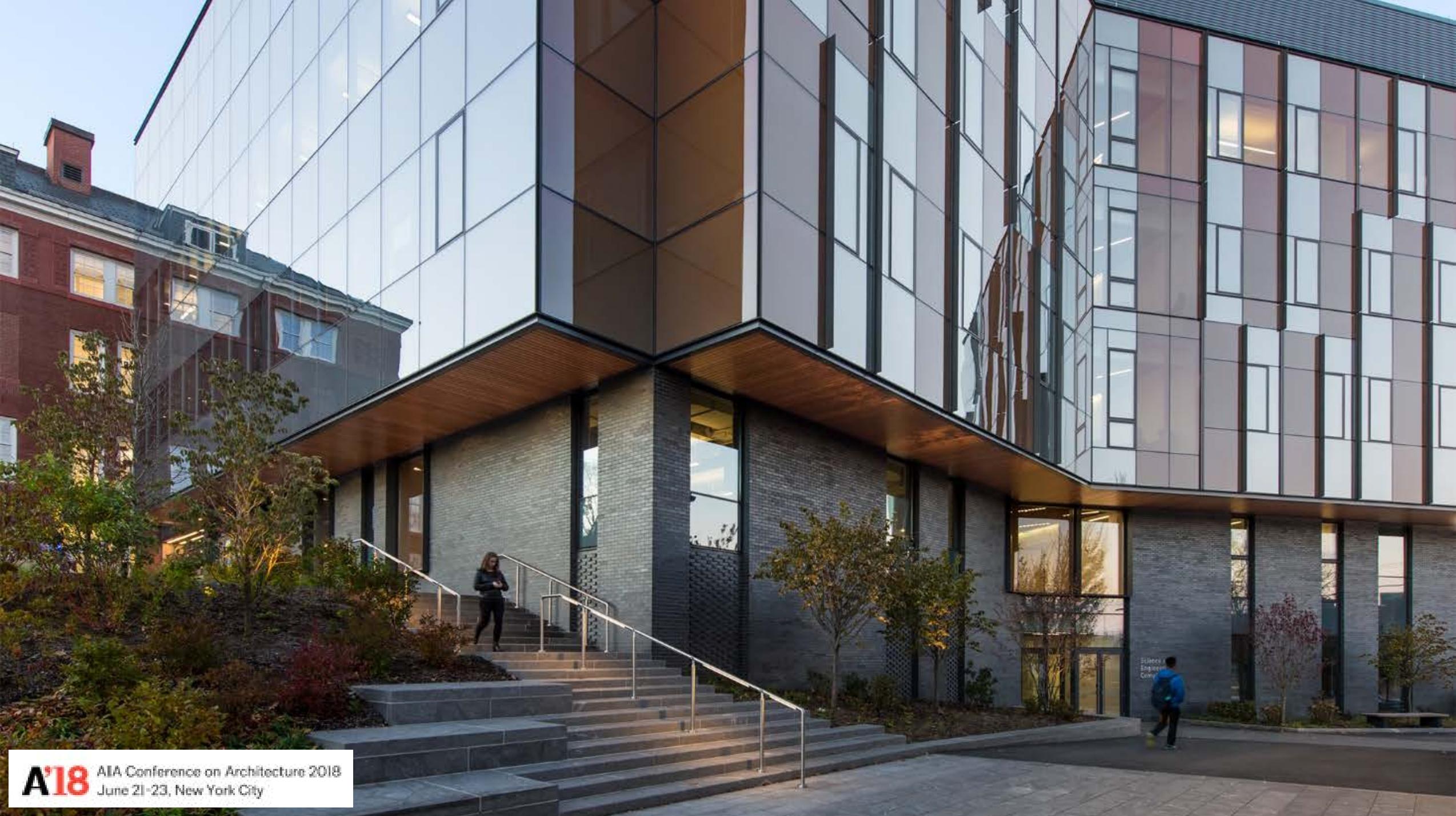
3' Fin



Solar Radiation

(Cumulative radiation between 8am & 6pm over specified time period)







ITEM DESCRIPTION	QUANTITY	UNITS	SELL \$/UNIT	PRICE
Ground Floor Curtainwalls (CW Type 1)	10,500.00	sqft		
Lobby Curtainwall (portals)	3,500.00	sqft		
Utilized Curtainwall (CW Type 2)	35,725.00	sqft		
Balcony Curtainwalls	1,000.00	sqft		
Utilized Curtainwall (CW Type 1)	41,750.00	sqft		
Punched Curtainwalls	13,250.00	sqft		
Terracotta Type 1 (Wall Type 1)	38,500.00	sqft		
Terracotta Type 2 (Wall Type 2)	37,750.00	sqft		
Rainscreen Metal Wall and Soffit Panels	5,225.00	sqft		
Penthouse Panels (Wall Type 3)	16,000.00	sqft		
Louvers	2,500.00	sqft		
Painted Aluminum Column Cover	1.00	lot		
Medium Size Aluminum Doors	7.00	leafs		
Revolving Doors	2.00	units		
Terrace Doors	3.00	leafs		
Garage Vestibule Doors	6.00	leafs		
Balcony Railings	0.00	lnft		
Visual Mock-up	1.00	lot		
Design Assist Fee	1.00	lot		

NOTES
This is a hold # pending vendor input

TOTAL BUDGET SELL PRICE

NOTES / CLARIFICATIONS

Ground Floor Curtainwalls

Slick built aluminum curtainwall
Kawneer 1600 SS System 2 1/2" x 101/2" deep with 6" extended exterior "fin" covers
System is designed to accommodate 1/2" live load slab edge movement
2-coat, 70% Kynar painted finish, custom color
Typical mullion spacing to me 50", maximum span 200" between anchor points (attach to every floor)
Attachment to floor slab assumed to be embeded anchor
Anywhere the head of the curtainwall comes up to the under side of a floors slab, additional steel (by others) is required.
Vision glass is 1" Clear Low-E insulated (Guardian SN68 or equal by PPG or Viracon)
Spandrel glass is included as vision glass with an 1/8" painted aluminum shadow box, 3" mineral fiber insulation and galvanized backpan

Lobby Curtainwall

VS-1 Mullion System
2-coat, 70% Kynar painted finish, custom color
Typical mullion spacing to me 50", maximum span 200" between anchor points (attach to every floor)
Steel wind girt (by others) will be required at the second floor elevation
Anywhere the head of the curtainwall comes up to the under side of a floors slab, additional steel (by others) is required.
Vision glass is 1" Clear Low-E insulated (Guardian SN68 or equal by PPG or Viracon)
Spandrel glass is included as vision glass with an 1/8" painted aluminum shadow box, 3" mineral fiber insulation and galvanized backpan

Utilized Curtainwall

Preglazed utilized curtainwall - 4 side SSG
IBG PG 2500 System, 3 1/4" verticals, 2 1/2" horizontals, 5 1/2" stack, 6 1/2" deep
System is designed to accommodate 1/2" live load slab edge movement
2-coat, 70% Kynar painted finish, custom color
Typical mullion spacing to me 50", maximum span 180" between anchor points (attach to every floor)
Vision glass is 1" Clear Low-E insulated (Guardian SN68 or equal by PPG or Viracon)
Spandrel area is a 6" projected composite panel with 3" mineral fiber insulation and galvanized backpan
Internal reinforcement of composite panels is included as required
Typically at the slab edge IBG includes fire safing, smoke seal and a sill trim to cover the firesafing

Balcony Curtainwall

Slick built aluminum curtainwall - captured horizontals SSG verticals
Kawneer 1600 SS System 2 1/2" x 101/2" deep
2-coat, 70% Kynar painted finish, custom color
Typical mullion spacing to me 50", maximum span 200" between anchor points (attach to every floor)
Vision glass is 1" Clear Low-E insulated (Guardian SN68 or equal by PPG or Viracon)
Spandrel glass is included as vision glass with an 1/8" painted aluminum shadow box, 3" mineral fiber insulation and galvanized backpan

Utilized Curtainwall

Preglazed utilized curtainwall - 4 side SSG
IBG PG 2500 System, 3 1/4" verticals, 2 1/2" horizontals, 5 1/2" stack, 6 1/2" deep
System is designed to accommodate 1/2" live load slab edge movement
2-coat, 70% Kynar painted finish, custom color
Typical mullion spacing to me 50", maximum span 180" between anchor points (attach to every floor)
Vision glass is 1" Clear Low-E insulated (Guardian SN68 or equal by PPG or Viracon)
Spandrel glass is included as vision glass with an 1/8" painted aluminum shadow box, 3" mineral fiber insulation and galvanized backpan
Typically at the slab edge IBG includes fire safing, smoke seal and a sill trim to cover the firesafing
A head trim (similar to the sill trim noted above) has been included to close the space between the curtainwall and shaftwall

Punched Curtainwalls

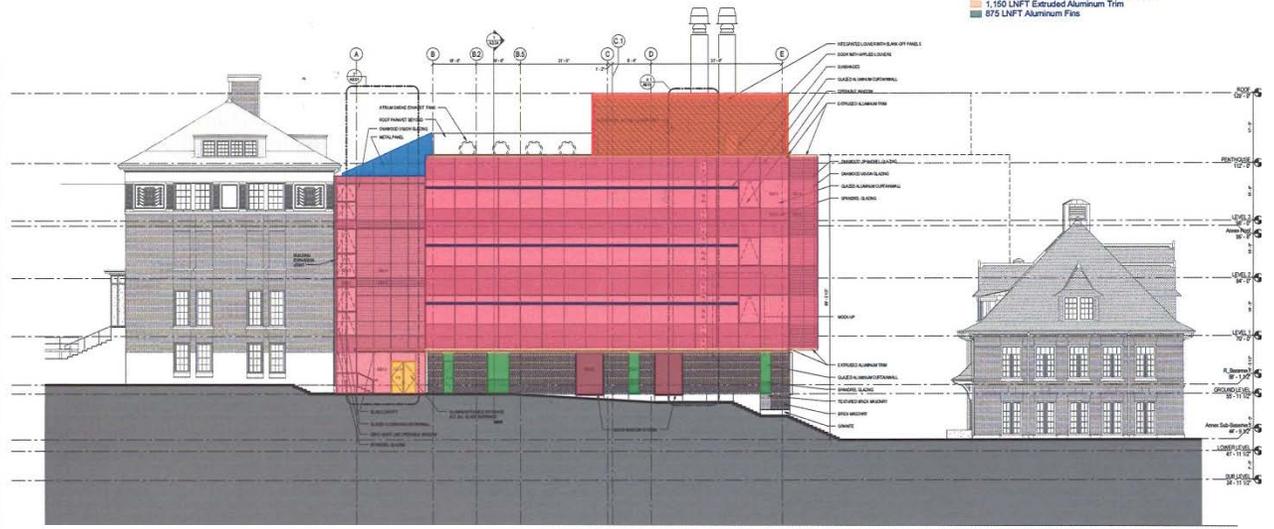
Preglazed flange window - captured perimeter and horizontals, SSG intermediate vertical
Kawneer 1600 SS System 2 2 1/2" X 6" with integral perimeter flange for attachment and AVB tie in
2-coat, 70% Kynar painted finish, custom color
Vision glass is 1" Clear Low-E insulated (Guardian SN68 or equal by PPG or Viracon)

Terracotta Type 1

30mm standard Shildan color and shape terracotta tile and attachment system
Maximum tile size is 16" x 60"
5" mineral fiber insulation and thermally broken girt system
Note: AVB, Densglass, and LGMF are by others

LEGEND

- 1,000 SQFT Ground Floor Curtain Wall - 4 Sided SSG
- 600 SQFT Punched Curtain Wall - 4 Sided SSG
- 18, 875 SQFT Multi-Floor Curtain Wall - Utilized
- 825 SQFT Wood Bay Windows
- 3,150 SQFT Sidelights
- 225 LNFT Sunshades (AND 225 LNFT Lightshells)
- 1,200 SQFT Aluminum Flute Panel
- 5,850 SQFT Corrugated Panel
- 2,250 SQFT Louver Screens
- 1,700 SQFT Louvers
- Entrances (6 leafs aluminum, 4 leafs all glass)
- 1,150 LNFT Extruded Aluminum Trim
- 875 LNFT Aluminum Fins

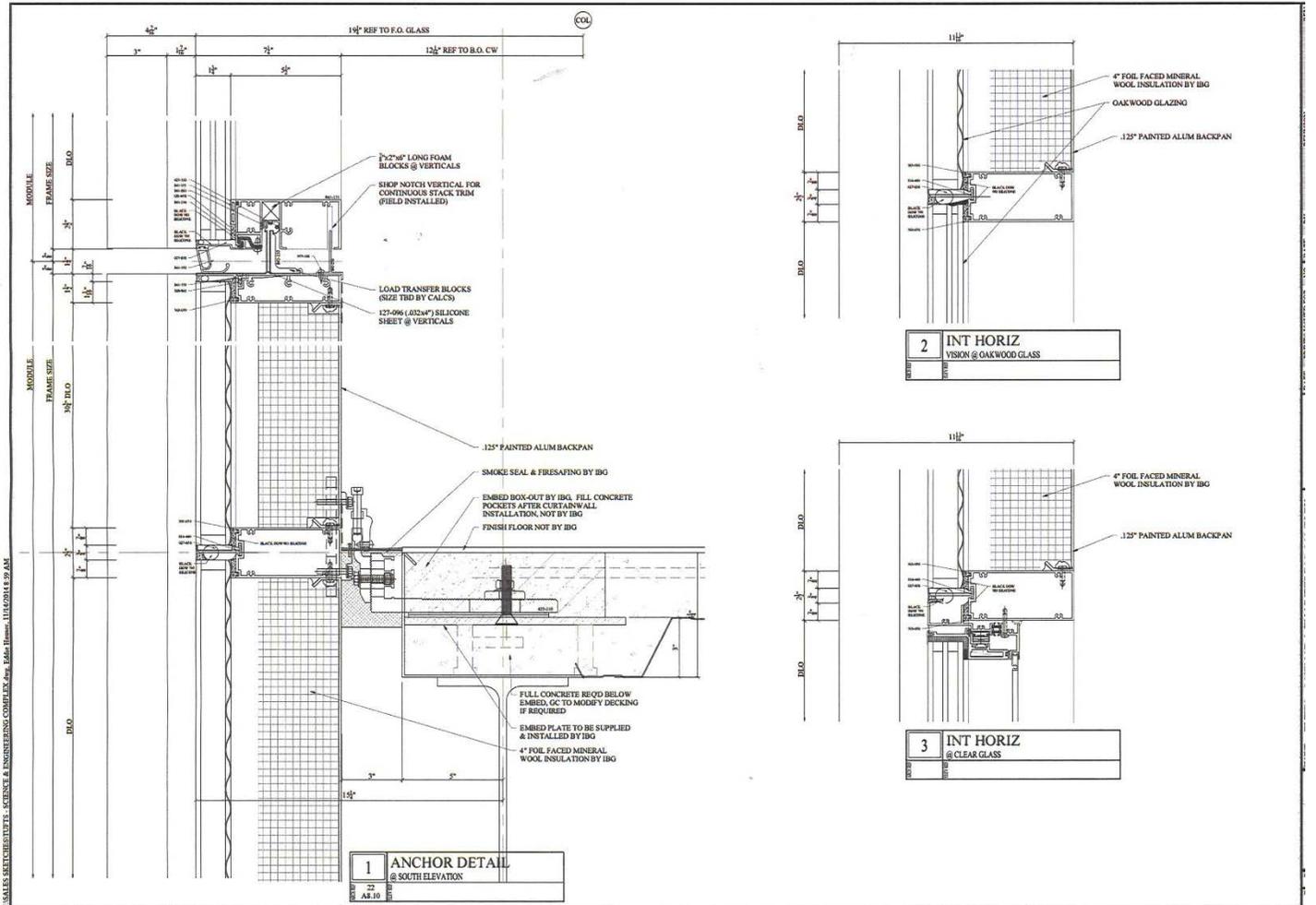


Tufts Science and Engineering Complex

CHANGE COST TRACKING
6/2/2015

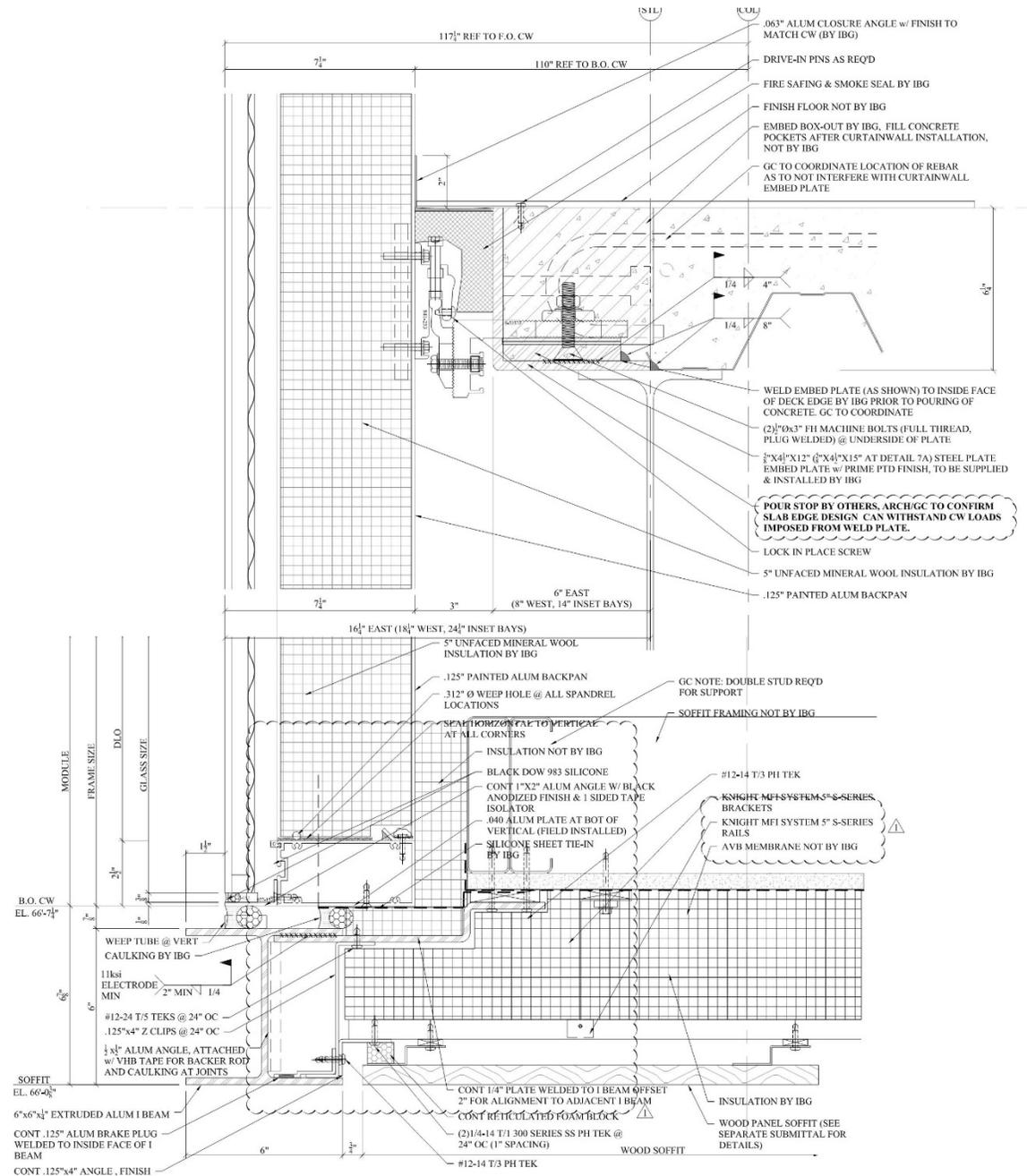
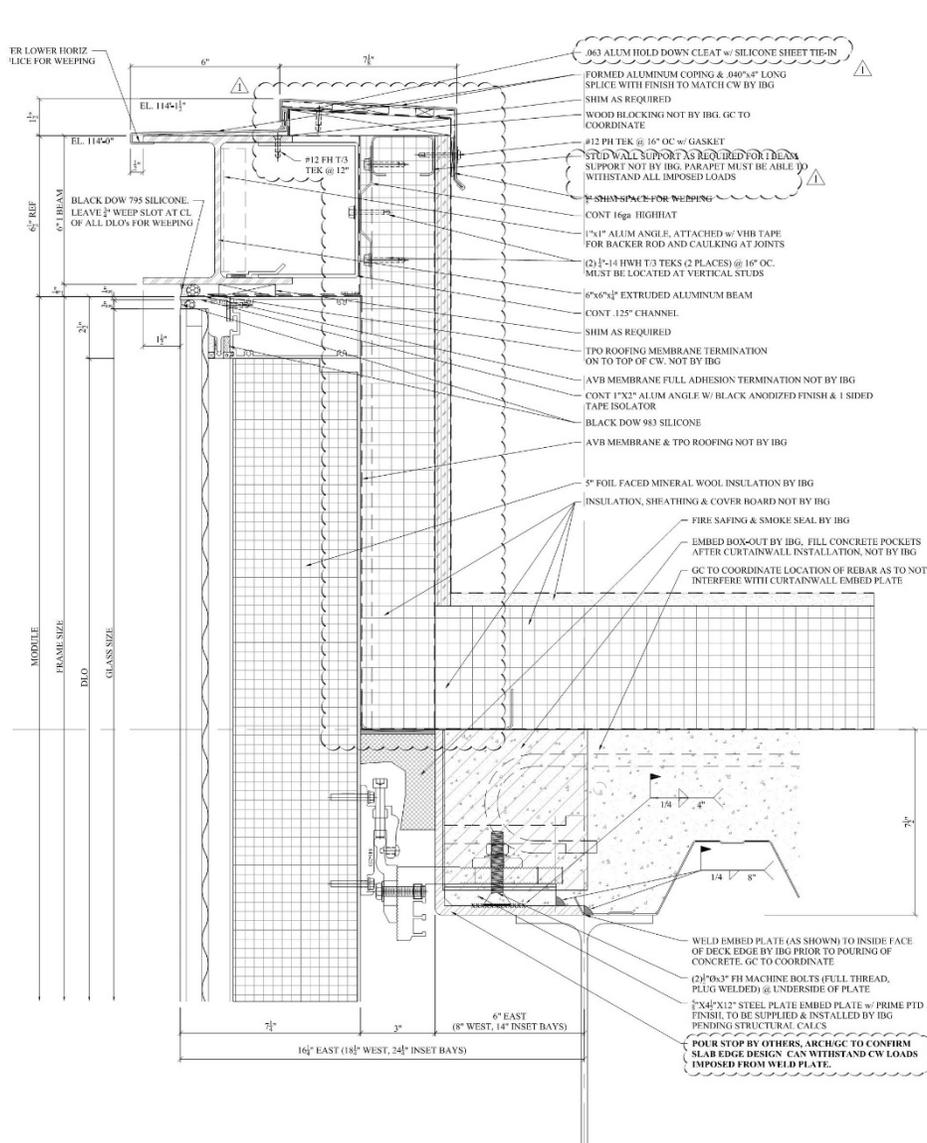
Line #	Description	Accepted	NOTES	Accepted Costs
1	IBG/TCCO Contract Agreement 12-19-14	Y		
2				
3	TCCO/IBG Generated VE			
4	VE#49 Delete Annex Roof Screen	N	See changes noted below	
5	VE#50 Delete Wood Soffits	N		
6	VE#50 Add Composite Panel Soffits	N		
7	VE#52 Change exterior vestibule doors to non thermal	N		
8	VE#55 Delete Sunshades	Y	Shown on 4-17-14 CD Set	
9	VE#55 Delete Light Shelves	Y	Shown on 4-17-14 CD Set	
10	VE#57 Simplify Bay Windows (change to aluminum)	Y	Final value pending	
11	VE#159 Delete Curtainwall behind Brick Screens	N	Deleted on 12-22-14 Check Set	
12	VE#170 Change aluminum plate panels to composite	Y	Shown as composite on 12-22-14 Check Set	
13	VE#171 Delete sealing of girts at the penthouse	N	GC/Arch/Owner confirm	
14	VE#174 Delete Curtainwall at North Loading Dock Corner	N	See changes noted below	
15	VE#205 Double glazing at Skylight ILO triple	N		
16				
17	2-20-15 PDF Posting			
18	Add 5 top hung operable windows	N	See changes noted below	
19	Add 14 power window operators	N	See changes noted below	
20	Add 2 power operated casement windows	N	See changes noted below	
21	Add 4 exterior doors	N	See changes noted below	
22	Add 4 auto door operators (OOH5)	N	See changes noted below	
23	Reduce Oka at the bridge	N	See changes noted below	
24	Simplify Bay Windows (change to aluminum)	Y	Shown on 4-17-14 CD Set	
25	Reduce galvanize backpan scope	N	See changes noted below	
26	Revise spec on wood soffit products (white oak or hemlock)	TBD	See changes noted below	
27	Revise spec on wood soffit products (red oak)	TBD	See changes noted below	
28				
29				
30	2-24-15 PDF Posting			
31	Delete 6 operable windows	N	See changes noted below	
32	Delete 6 power window operators	N	See changes noted below	
33	Delete glass canopy and gutter	Y	Shown on 4-17-14 CD Set	
34				
35				
36	4-17-15 CD Set with Addendums 1-4			
37	Add 150 sqft of ground floor curtainwall	Y		
38	Delete 4 operable windows in above	Y		
39	Add 3 powered operators to operables in above	Y		
40	Add 4 swing doors in above	Y		
41	Add 8 automatic operators in above	Y		
42	Delete 4 operable windows in punched ground floor curtainwalls	Y		
43	Delete 4 powered operators in punched ground floor curtainwalls	Y		
44	Delete 335 sqft unutilized curtainwall	Y		
45	Delete 5 operables in above	Y		
46	Skylight changes (cost from manufacturer)	Y	gutters are not by IBG, but fascia is	
47	Net deduct of 99 sqft of composite panel	Y		
48	Net add of 889 sqft of corrugated panel	Y		
49	Net deduct of 711 sqft of louver	Y		
50	Add 174 sqft of corrugated panel at areaway	Y		
51	Delete standard aluminum door and frame at Robinson	Y		
52	Add Fire rated door and frame at Robinson	Y		
53				
54				
55	TCCO ITB dated 4-27-15			
56	#15	Y		
57	#18	Y		
58	#37	Y		
59	#40	Y		
60				
61				

CURRENT AGREED UPON CONTRACT PRICE
NET CHANGE TO CONTRACT AGREEMENT



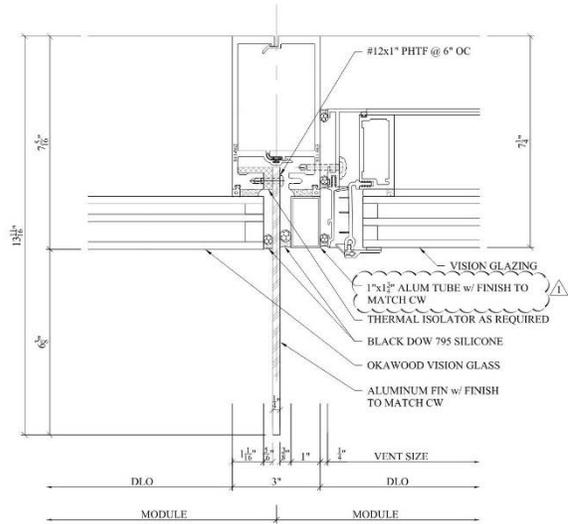


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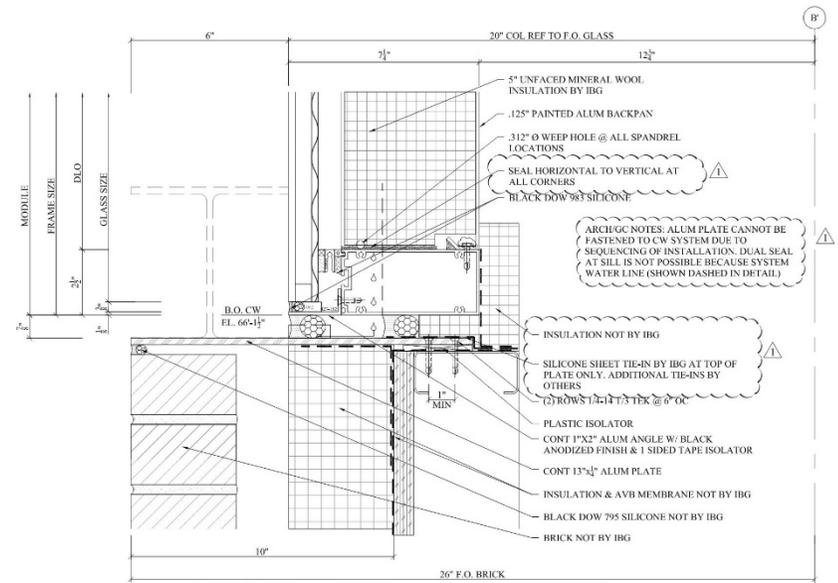
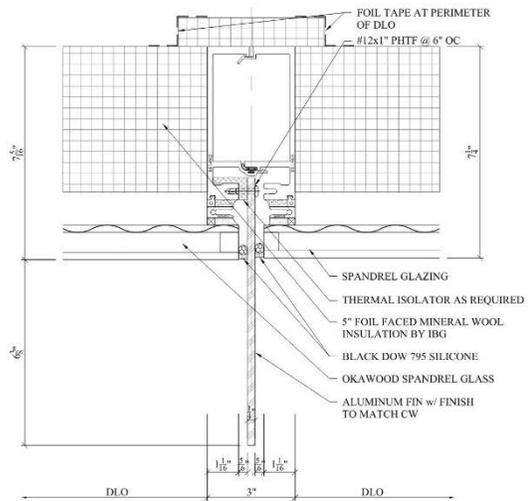




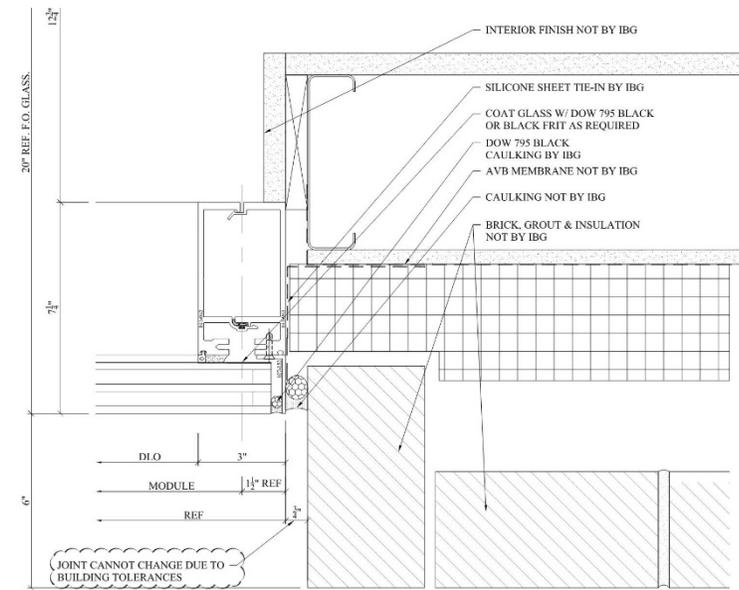




9	UNITIZED - INT SSG VERT WITH FIN @ VENT
<small>REV</small> 21 <small>DATE</small> AS.11	<small>REV</small> CW6,7



26	UNITIZED - SILL PLATE @ BRICK
<small>REV</small> NA	<small>REV</small> CW12



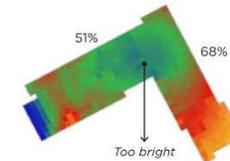
18	UNITIZED - JAMB @ BRICK
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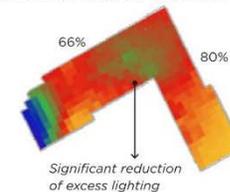
USEFUL DAYLIGHT ILLUMINANCE (10 – 200 FC)

% occupied hours with light levels above 50fc (at least 50% of the time)

CLEAR ROOM GLAZING

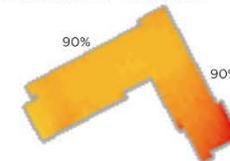


PROGRESSIVELY OPAQUE GLAZING

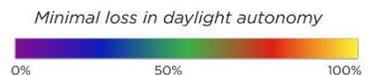
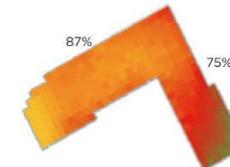


DAYLIGHT AUTONOMY (50 FC)

CLEAR ROOF GLAZING



PROGRESSIVELY OPAQUE GLAZING

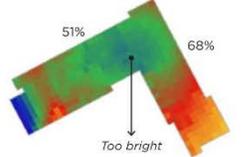




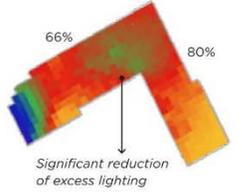
USEFUL DAYLIGHT ILLUMINANCE (10 – 200 FC)

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CLEAR ROOM GLAZING

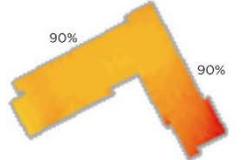


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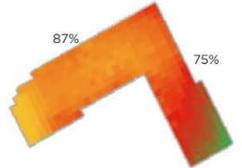


DAYLIGHT AUTONOMY (50 FC)

CLEAR ROOF GLAZING

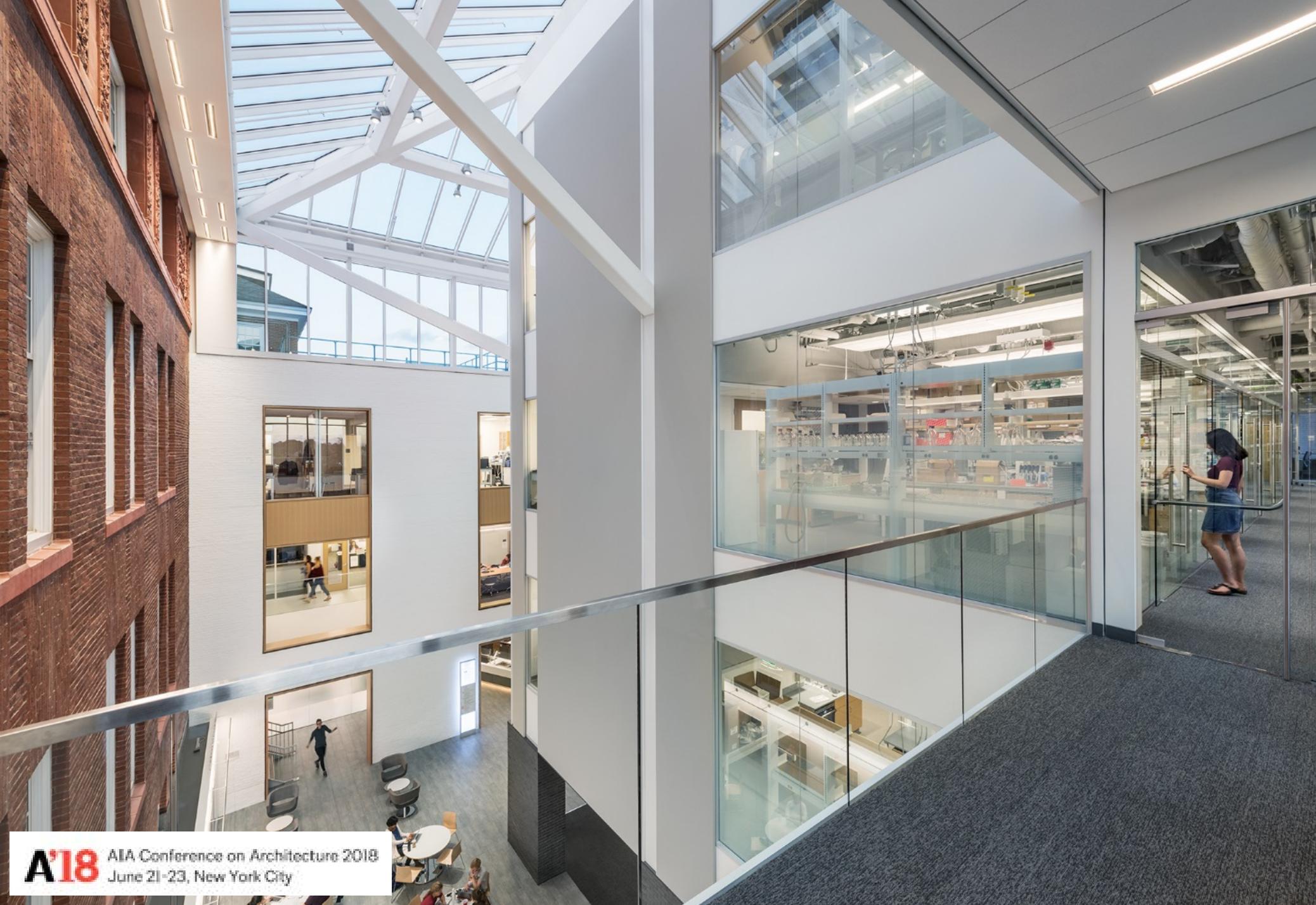


PROGRESSIVELY OPAQUE GLAZING



Minimal loss in daylight autonomy

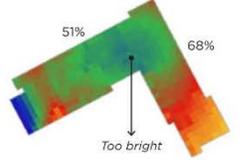




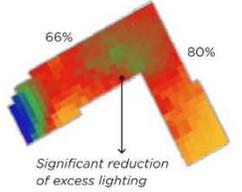
USEFUL DAYLIGHT ILLUMINANCE (10 – 200 FC)

% occupied hours with light levels above 50fc (at least 50% of the time)

CLEAR ROOM GLAZING

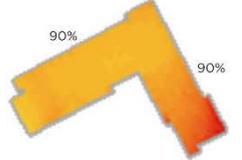


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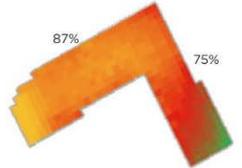


DAYLIGHT AUTONOMY (50 FC)

CLEAR ROOF GLAZING



PROGRESSIVELY OPAQUE GLAZING



Minimal loss in daylight autonomy

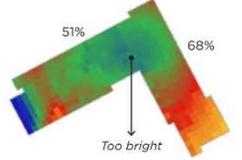




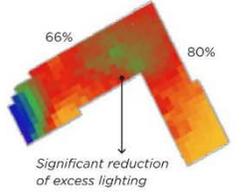
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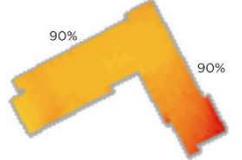


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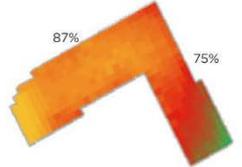


DAYLIGHT AUTONOMY (50 FC)

CLEAR ROOM GLAZING



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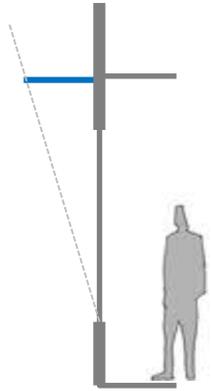
Minimal loss in daylight autonomy



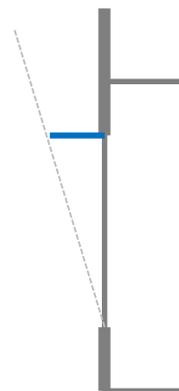


Laboratory Write-up - Daylighting

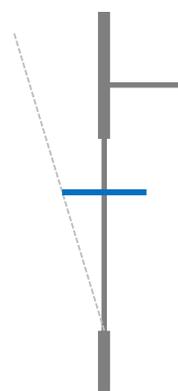
Height above floor



14' AFF

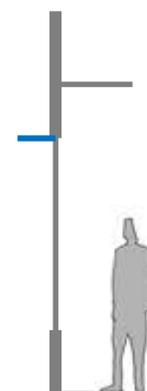


10' AFF

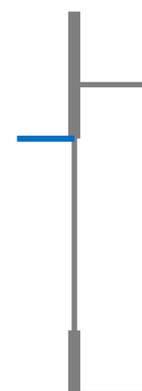


8' AFF

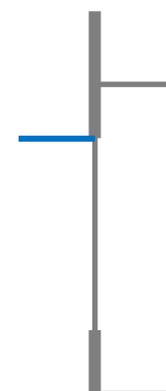
Projection



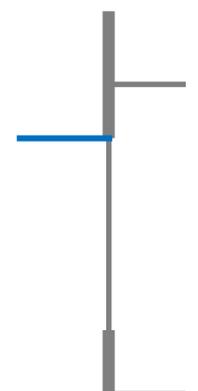
1'



2'



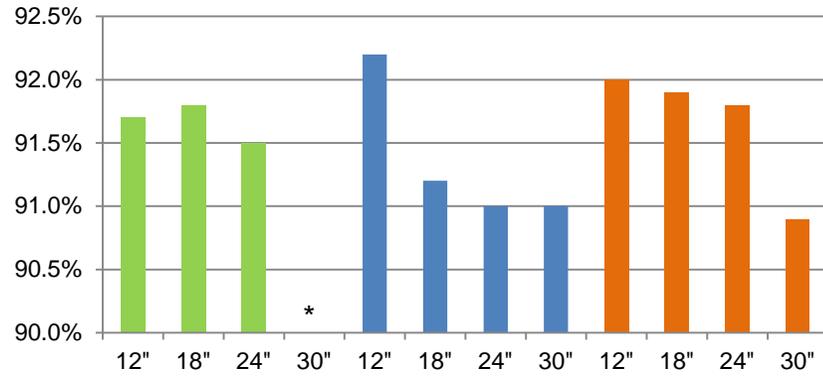
3'



4'

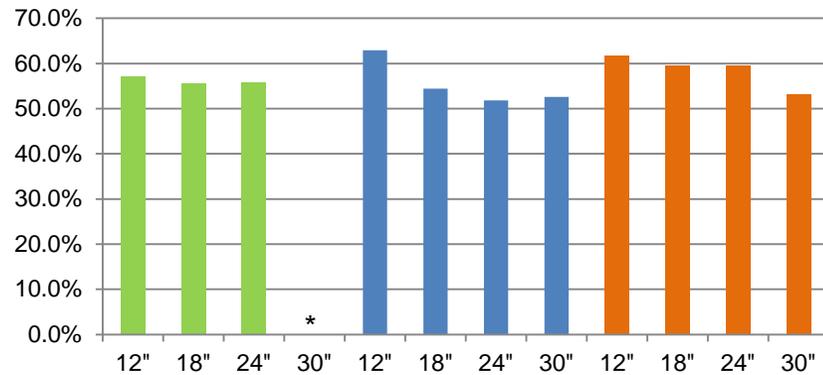
Daylight Autonomy

Writeup area

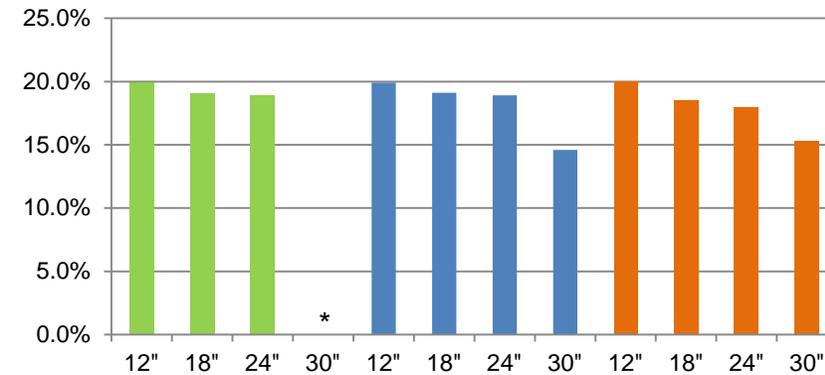


- 14' FROM FLOOR LEVEL
- 10' FROM FLOOR LEVEL
- 8' FROM FLOOR LEVEL (W/ LIGHT SHELF)

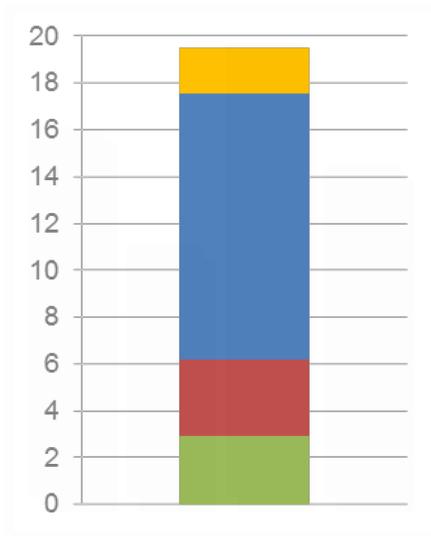
Lab (front)



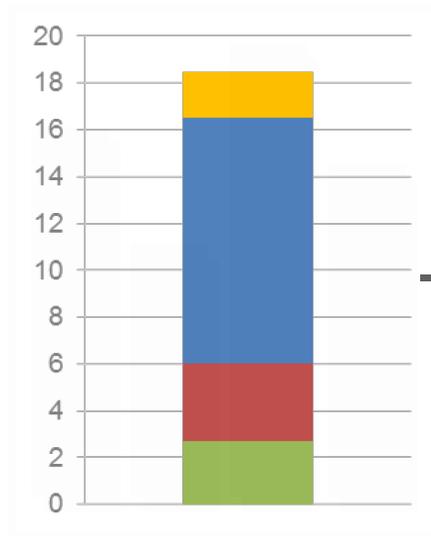
Lab (deep)



Annual Lighting & HVAC Energy Usage (Overhang 10' AFF)

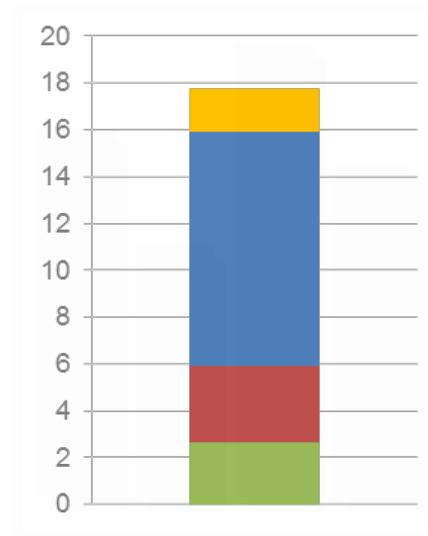


No External Shading



-5%

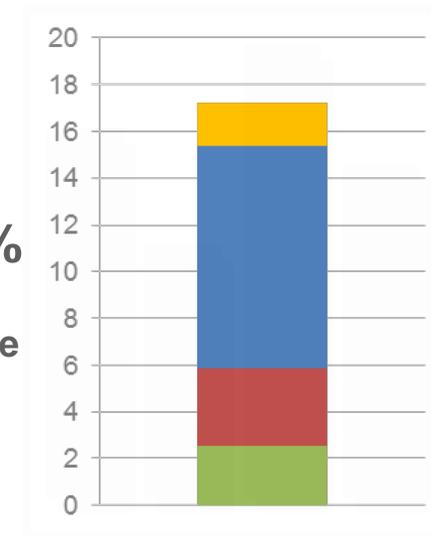
12" Shade



-9%

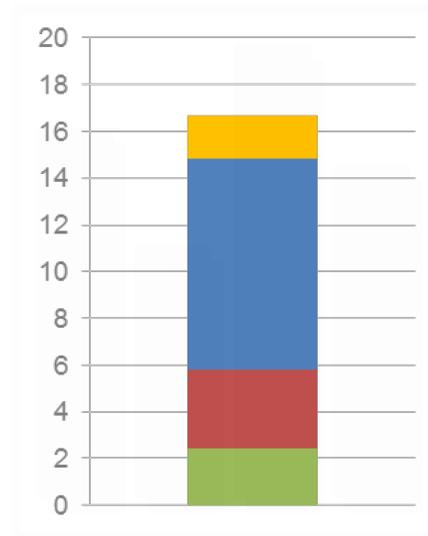
18" Shade

- Lighting
- Cooling
- Heating
- Pumps & Fans



-12%

24" Shade



-14%

30" Shade



Science and
Engineering
Complex

1 Introduction

2 Form-Giving Sunshades

Northeastern University
Interdisciplinary Science and Engineering Complex

3 Minimalist Design

Amherst College, New Science Center

4 Orchestration of Standard Components

Tufts University, Science and Engineering Complex

5 Moderated Discussion | Q&A

Contact Information

- **Andrea Love, AIA**
alove@payette.com
- **Robert Pasersky, AIA**
rpasersky@payette.com
- **Wesley Schwartz, AIA**
wschwartz@payette.com
- **Jeffrey Abramson, AIA**
jabramson@payette.com

Thank you!