

Post-occupancy: Lab Functionality, Flexibility, Energy



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B A L L I N G E R

Agenda



VCU



University of Pittsburgh



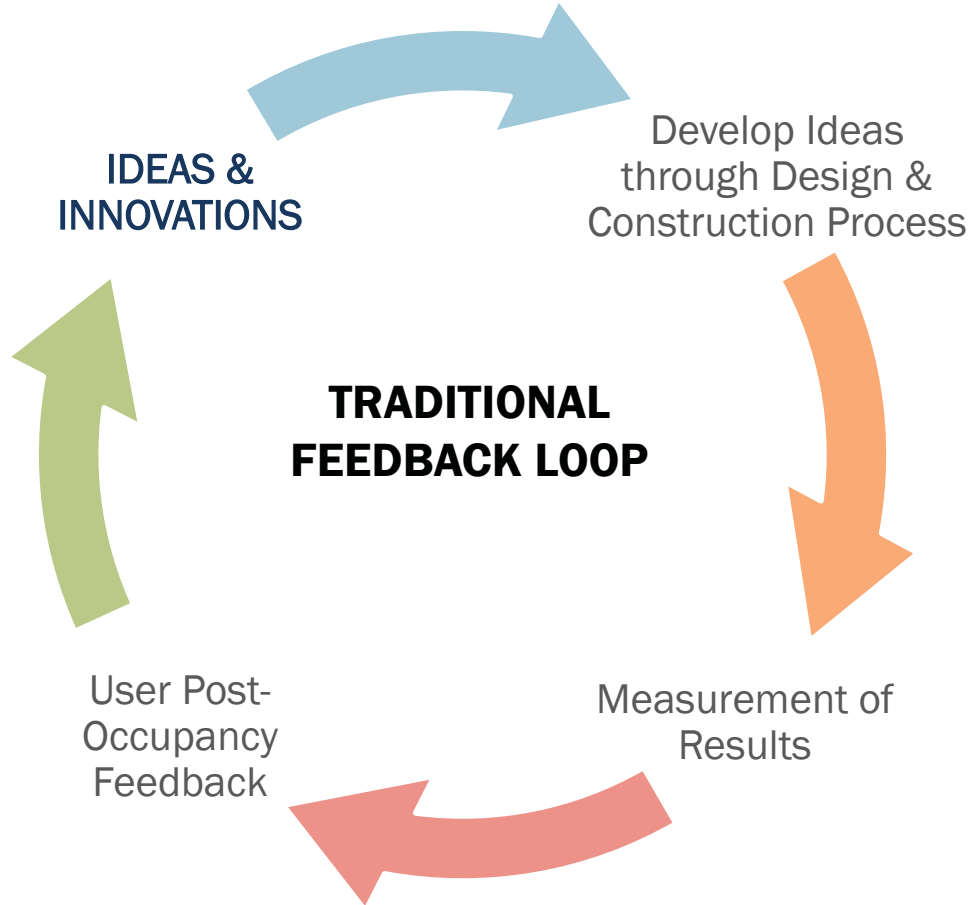
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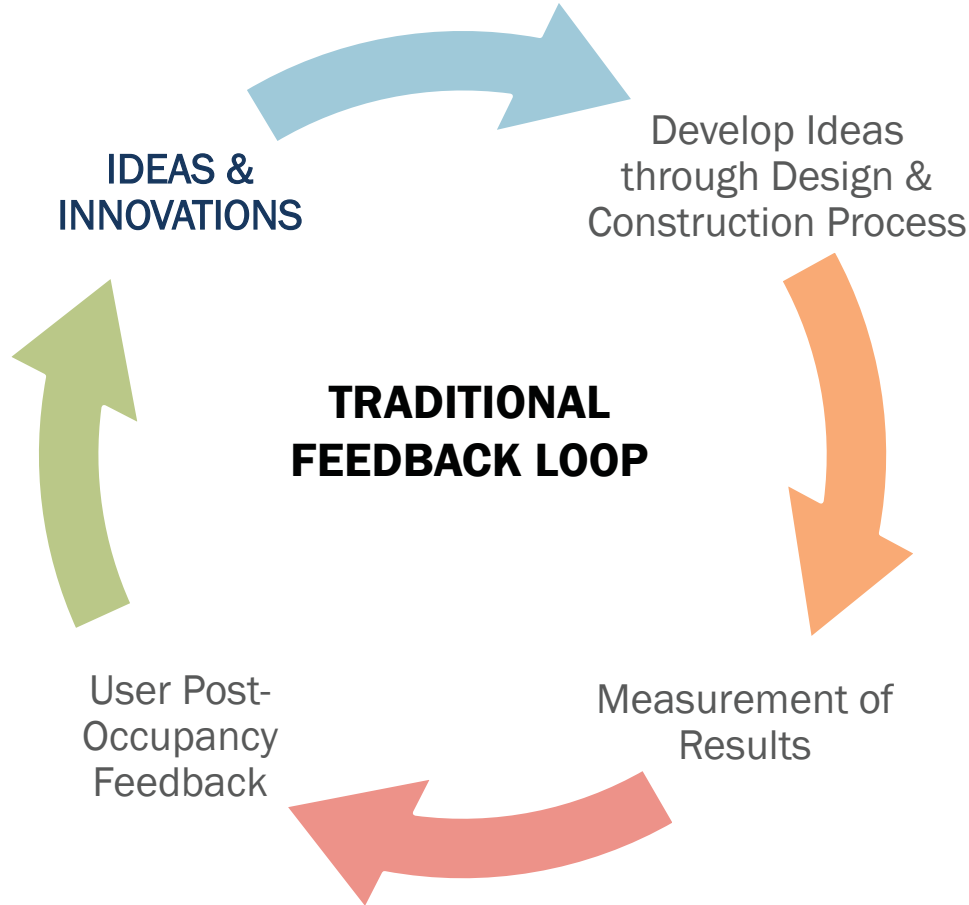
JOHNS HOPKINS
UNIVERSITY

- Innovative Approaches
- Performance / Feedback
- Lessons Learned & Forward Thinking

How to Make Places that Foster Innovation



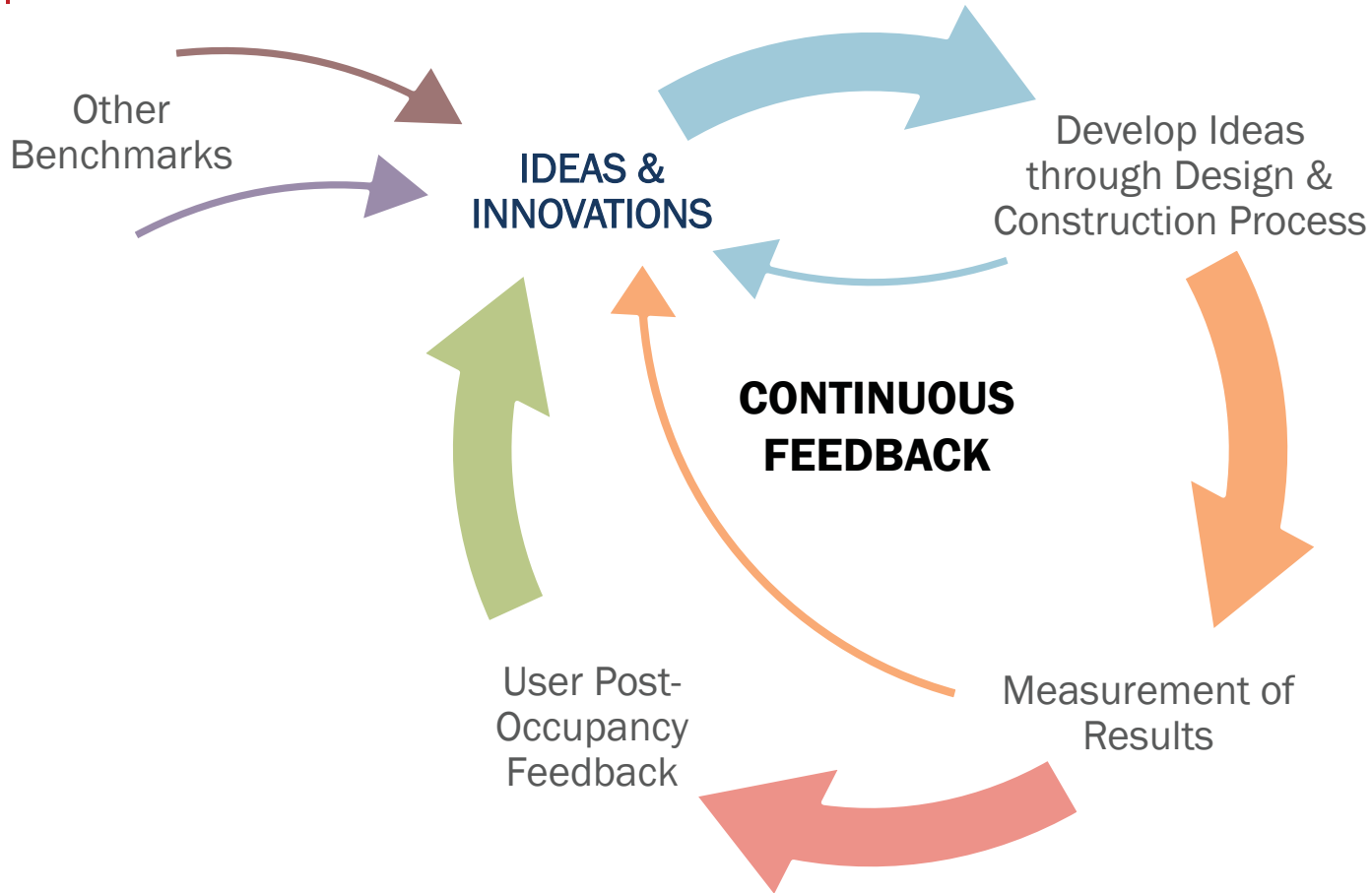
How to Make Places that Foster Innovation



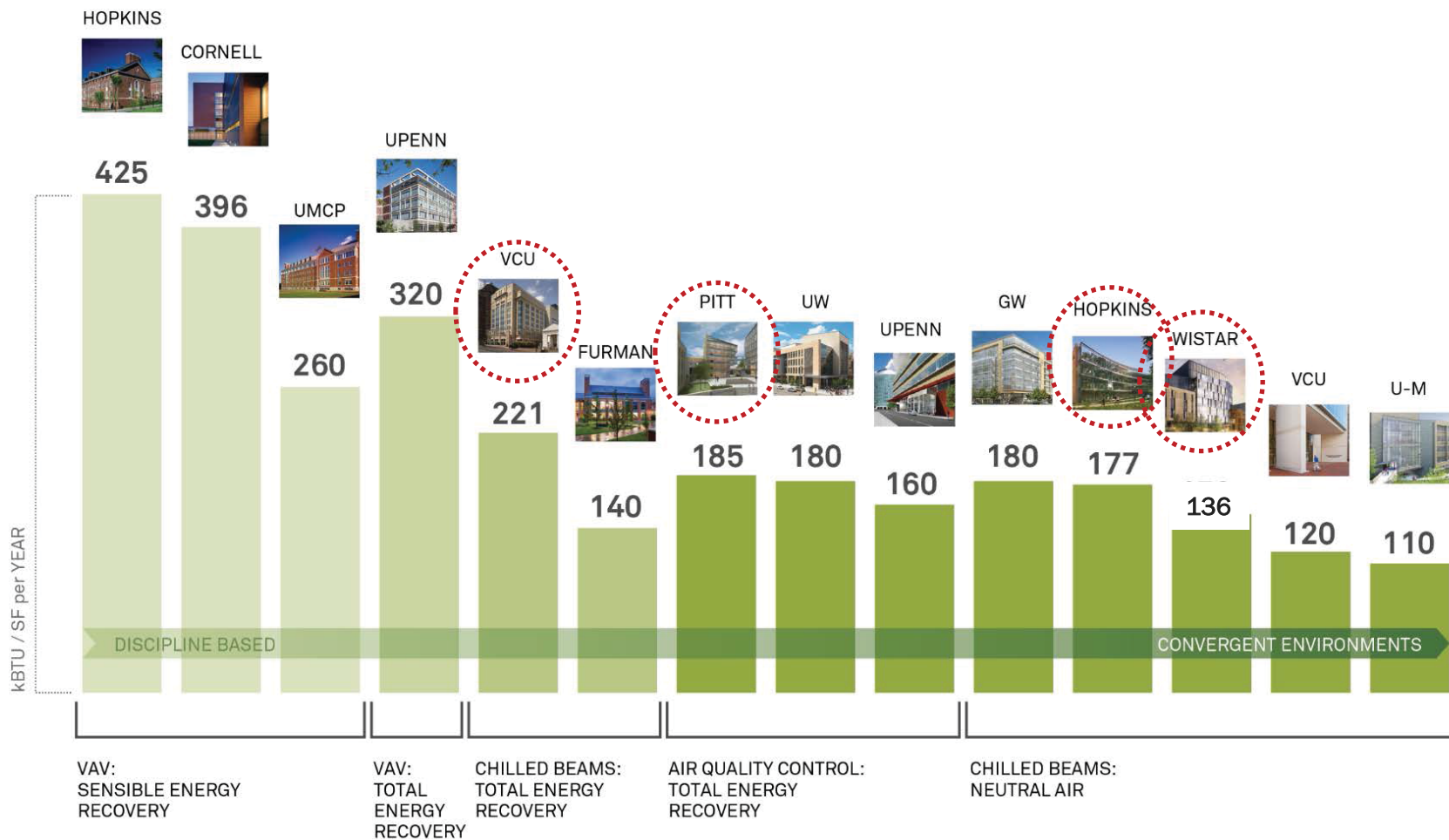
- How to get honest, quality feedback?
- Quicker feedback?

- Role of social media for continuous feedback?
- Will open dialogue bring about spin and static?

How to Make Places that Foster Innovation



Energy Benchmarks – Science Facilities



Recent Work: Energy Performance

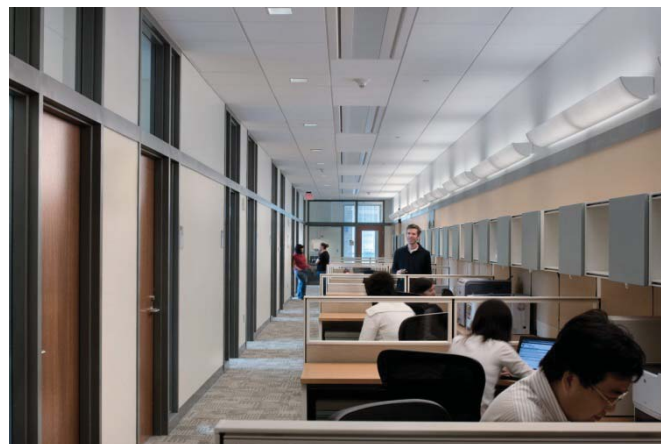
	Program	GSF	% Better Than Baseline	LEED Points (NC 2009)
Penn University City (3737 Market)	Clinical, Office, Research	356,000	51%	20
Johns Hopkins University	Teaching, Research	105,000	51%	20
Swarthmore College	Teaching, Research	165,000	50%+	20*
University of Pennsylvania Pennovation	Incubator	62,000	35/24%	7*
Furman University	Teaching, Research	205,000	34%	12
University of Maryland Bioengineering	Teaching, Research	185,000	30%	10*
Virginia Commonwealth University	Research	125,000	27%	8
Penn Medicine Smilow	Research, Clinical	530,000	25%	7
Virginia Commonwealth University	Teaching	200,000	24%	7
University of Miami LSTP	Office, Research	267,000	20%	5
CHOP Schuylkill Ave	Office	480,000	20%	5*
Penn Medicine South Tower	Research, Teaching, Clinical, Office	520,000	20%	5*
* In design/construction				

VCU MOLECULAR MEDICINE RESEARCH BUILDING

- **Program:** Biology, neuroscience and molecular medicine research laboratory; vivarium and seminar space.
- **Size:** 125,000 gsf
- **Construction Cost:** \$58M; \$464/SF
- **EUI:** 221 kBTU/SF/yr
- **Occupancy:** February 2009



VCU MOLECULAR MEDICINE RESEARCH BUILDING



Traditional Metrics and Factors

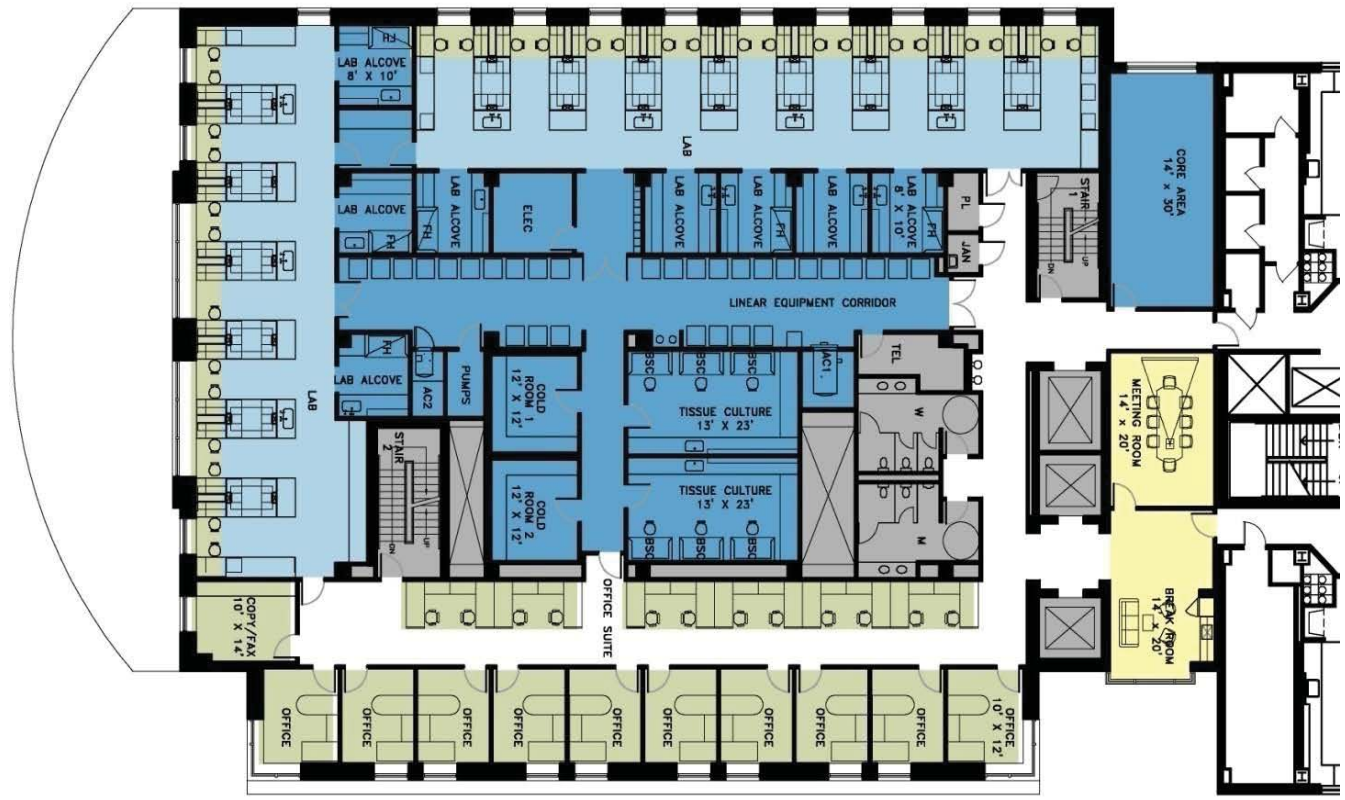
Area:
 GSF: 13,550 sf
 NSF: 9,450 sf
 Efficiency: 70%
 945 NSF/Pt

Density:
 54 FTE/floor
 240 GSF/FTE
 170 NSF/FTE
 16 LF Bench / FTE

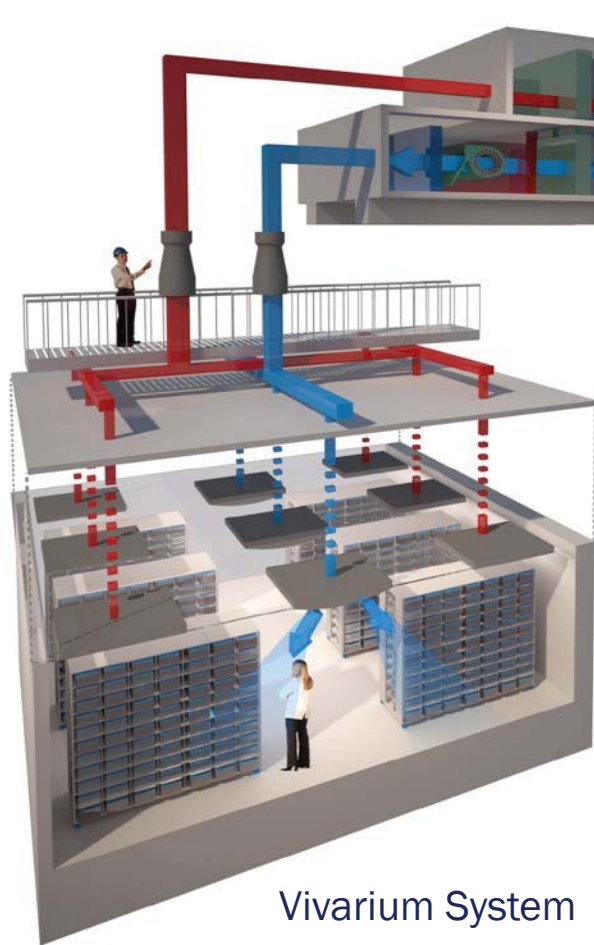
Interaction Metrics

Draws: 2 Total
 Meeting: 1
 Kitchenette: 1

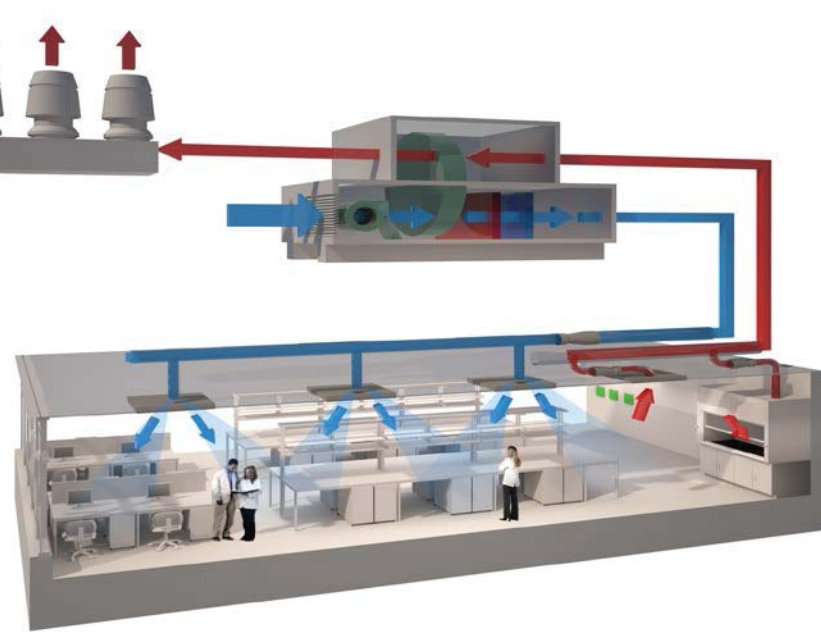
Spatial Neighborhoods:
 2 Total







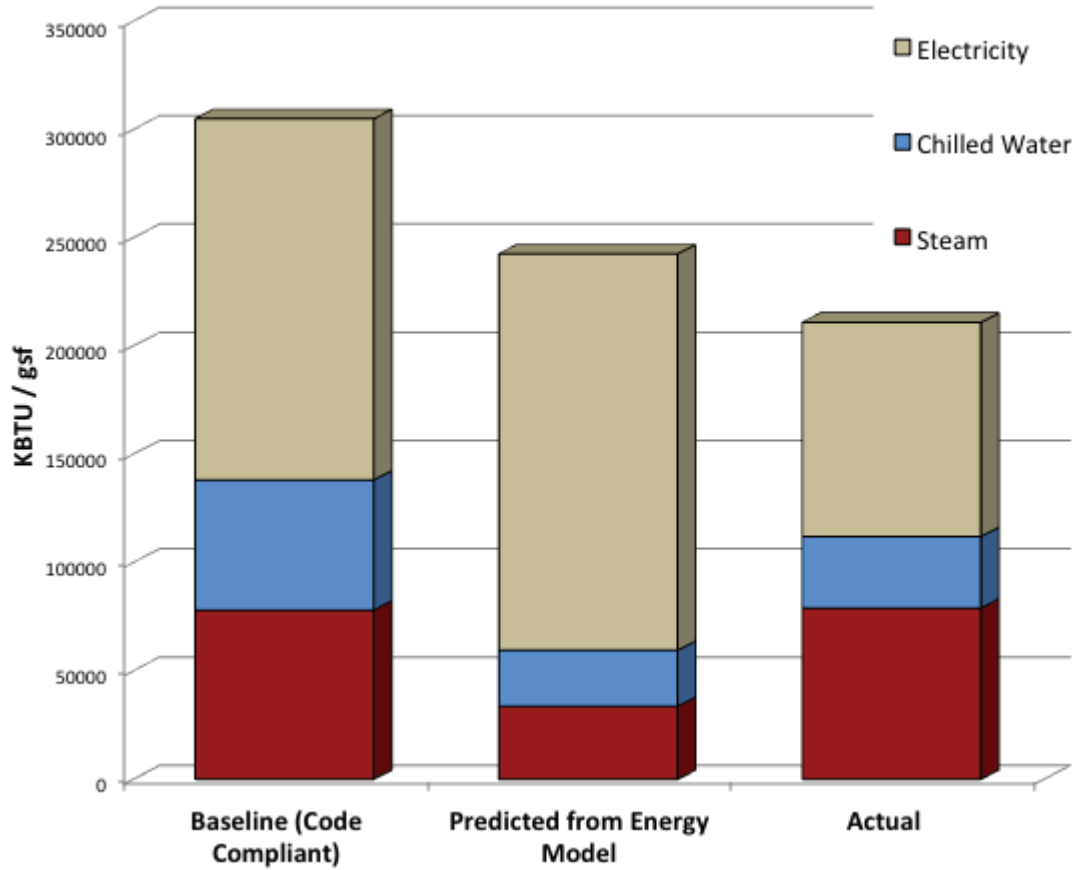
Vivarium System

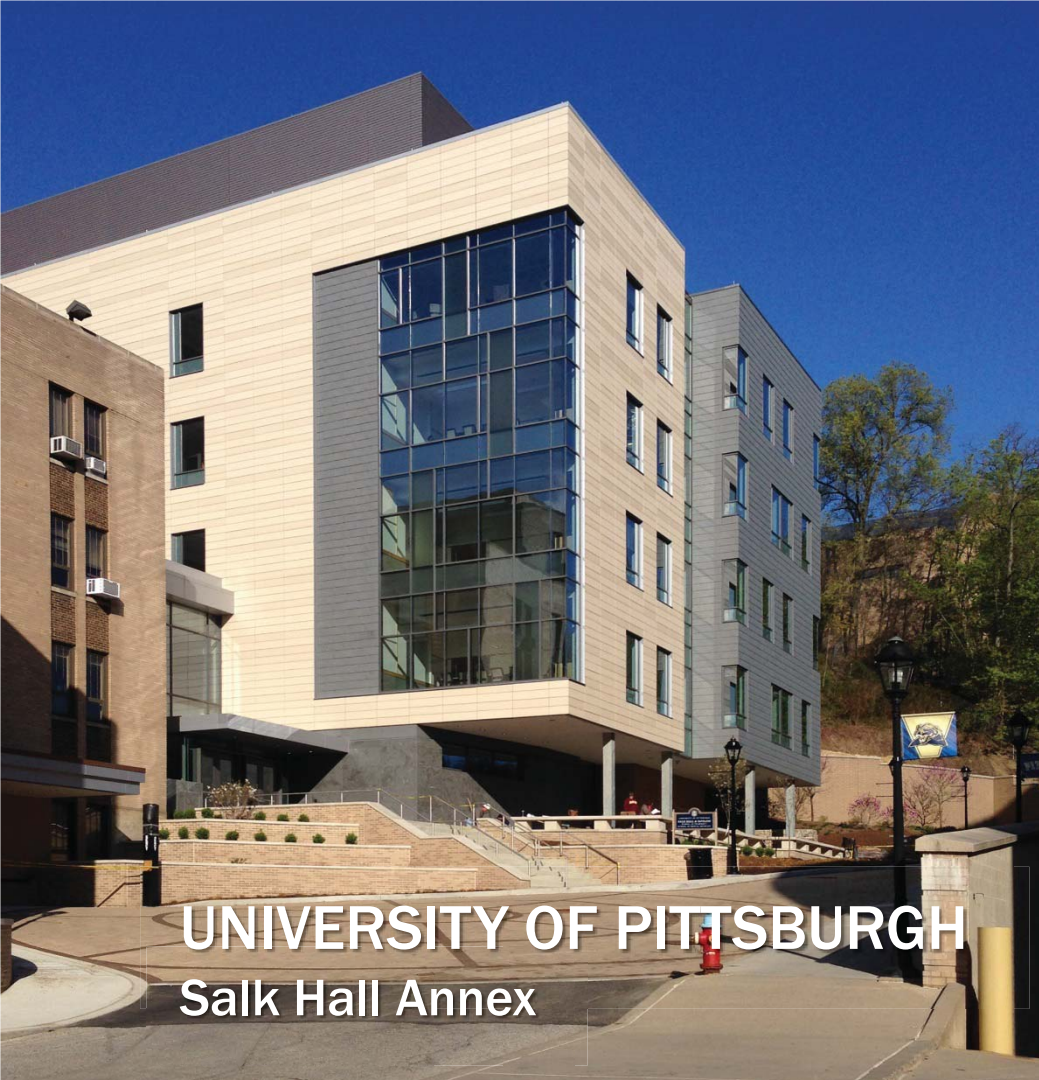


Laboratory System

ANSI/ASHRAE Standard 62.1 Addendum K for Laboratory Hoods

“This addendum modifies the standard such that laboratory exhaust is assigned a default of Air Class 4, but explicitly allows a responsible EH&S professional to determine that a lower air class is appropriate for particular systems. If they assign a lower air class, then the use of heat wheel energy recovery would be allowed. The SSPC believes that determination of the appropriate air class is best made by a qualified professional on a case-by-case basis.”



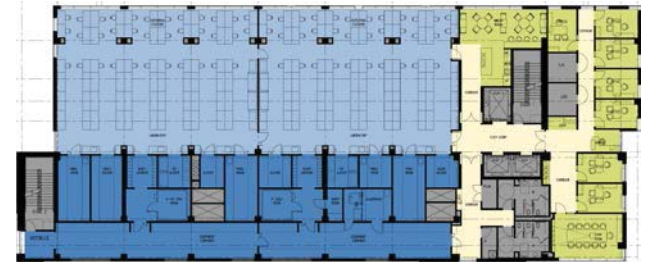


UNIVERSITY OF PITTSBURGH
Salk Hall Annex



University of Pittsburgh

- **Program:** Biomedical research space for School of Pharmacy and School of Dental Medicine.
- **Size:** 81,000 gsf
- **Construction Cost:** \$41M; \$510/SF
- **EUI:** 185 kBTU/SF/yr
- **Occupancy:** 2015





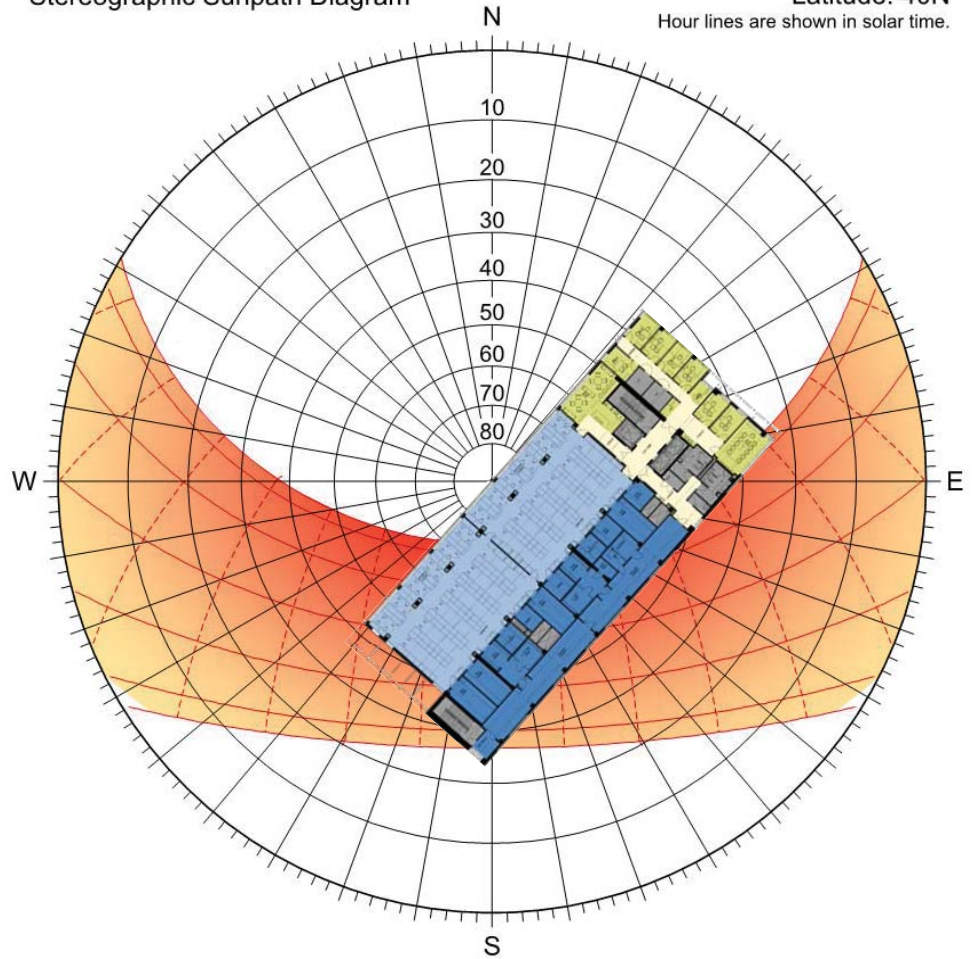


PITTSBURGH, PENNSYLVANIA

Stereographic Sunpath Diagram

Latitude: 40N

Hour lines are shown in solar time.





Traditional Metrics and Factors

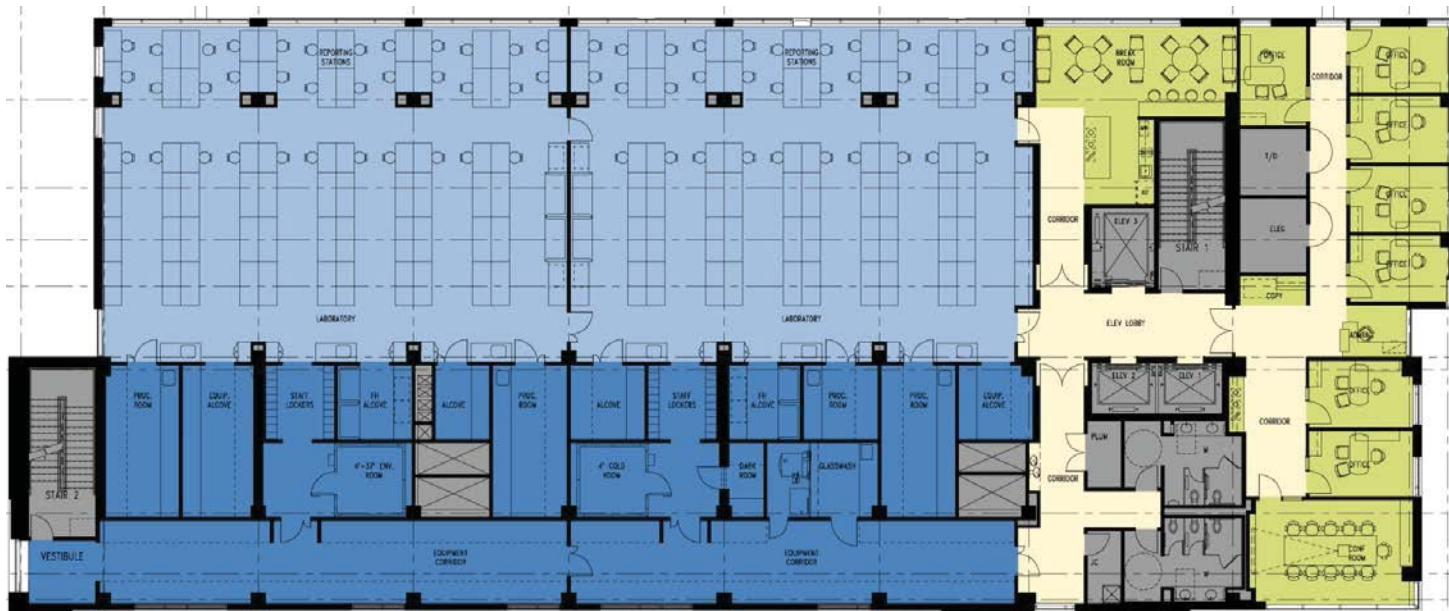
Area:
GSF: 15,004 sf
NSF: 11,554 sf
Efficiency: 78%
1,650 NSF/PI

Density:
77 FTE/floor
194 GSF/FTE
151 NSF/FTE
14 LF Bench / FTE

Interaction Metrics

Draws: 2 Total
Meeting: 1
Kitchenette: 1

Spatial Neighborhoods:
2 Total





Clear Zoning In the Labs: Write Up Workstations at Windows Adjacent to Central Open Lab Area



Standardize Fume Hood Utilities for Long Term Flexibility



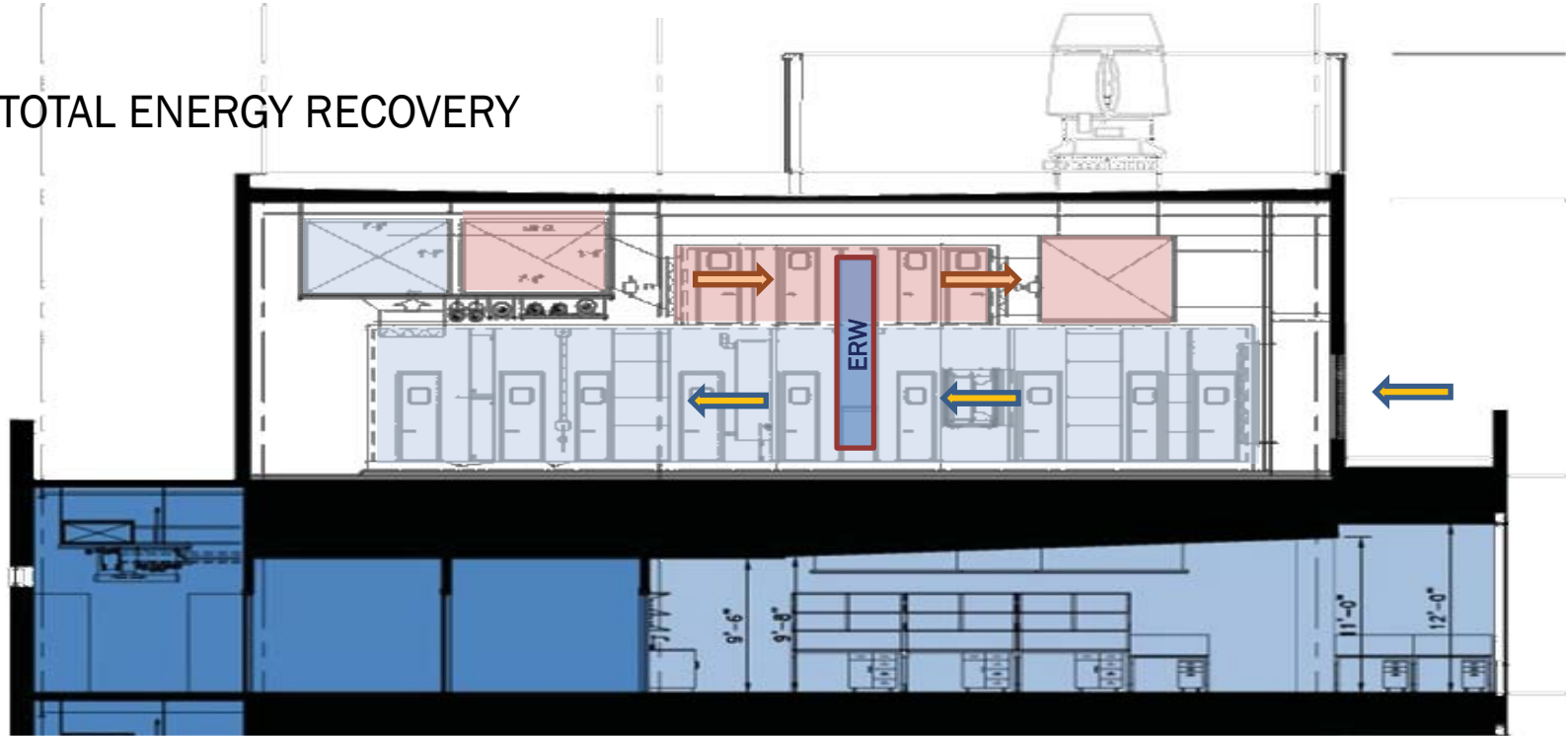
Maximize Daylighting: Panel Radiators at Perimeter with Frit Glass Lower Window Section



Maximize Discussion Space: Whiteboard Hinged Panels with Electrical and Air Monitoring Control Panels Behind



TOTAL ENERGY RECOVERY



Outside Air

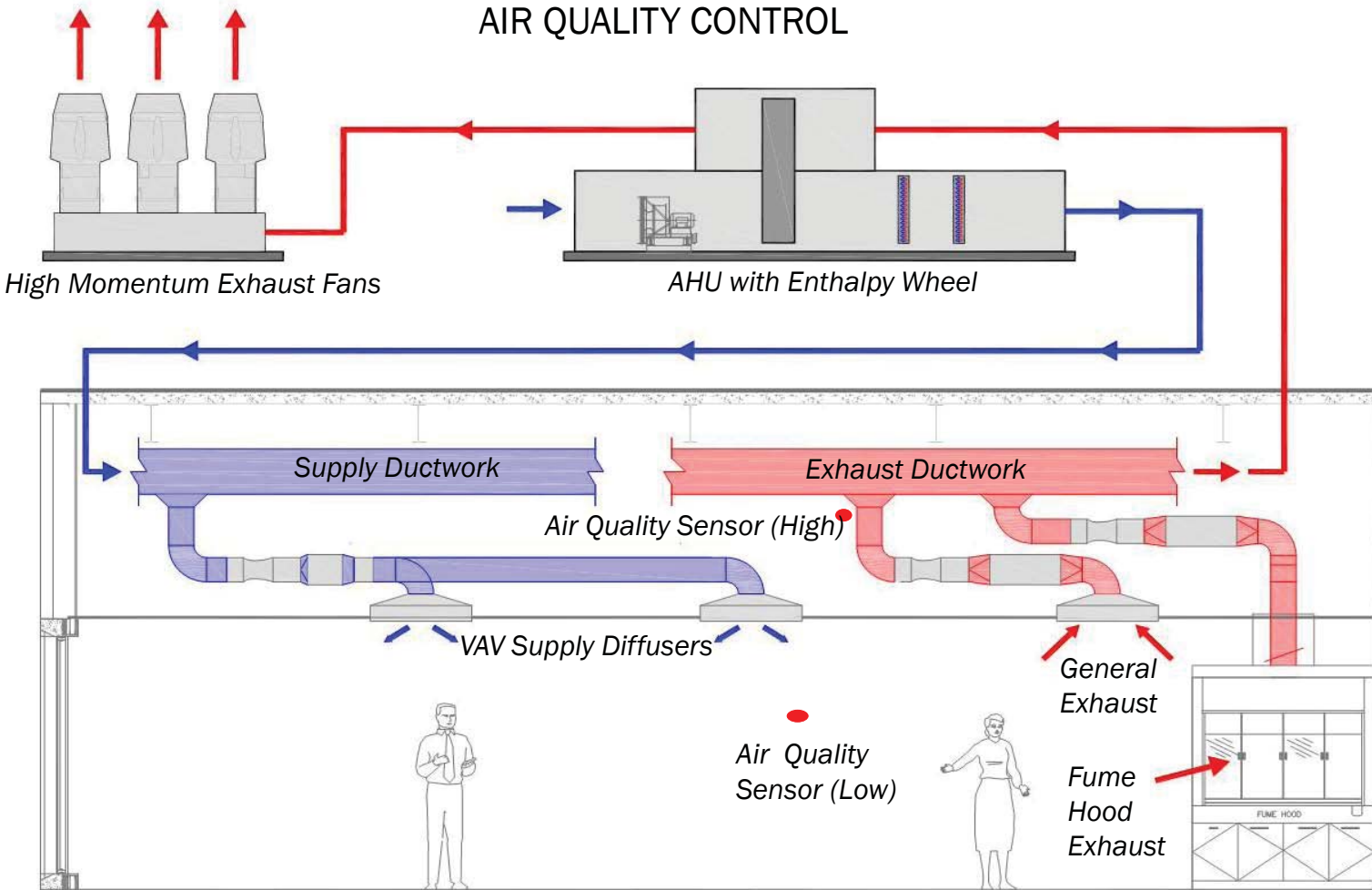
Summer: 93F → 78.7F, 228 tons

Winter: 3F → 53.4F, 5700 lbs./hr. steam

Heat Exchange Effectiveness: 75%



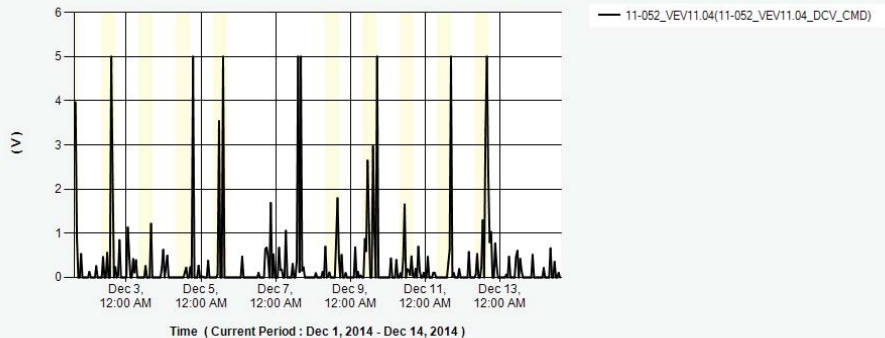
AIR QUALITY CONTROL



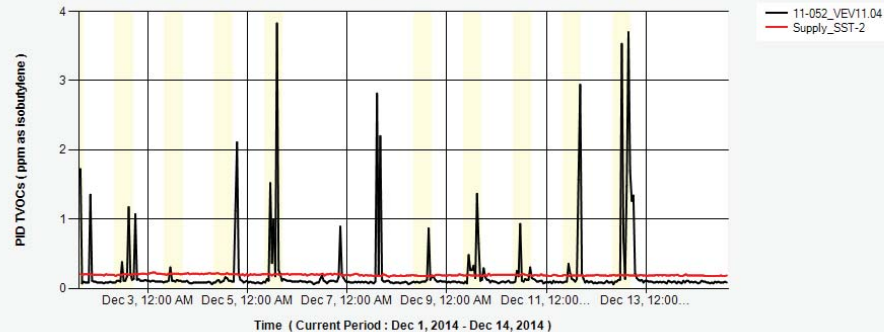
- Direct measurement of air contaminants in lieu of dilution by arbitrary air change rates
- Measures CO₂, CO, VOC's, particulates
- Minimum air change rates: 6 AC/hr to 4 AC/hr, 33% reduction
- Lower to 2 AC/hr after verification



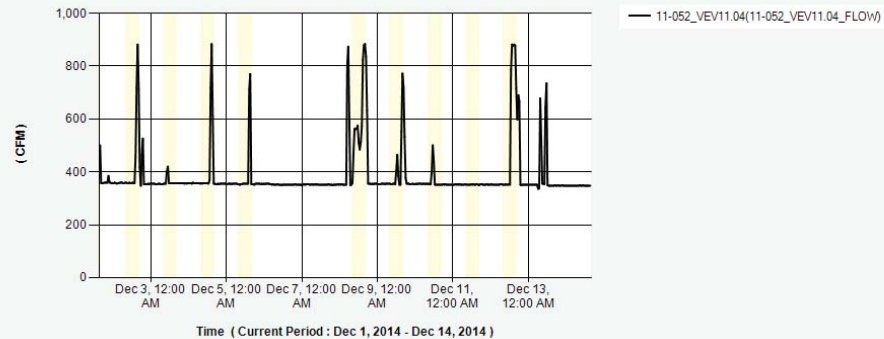
[11-052_VEV11.04_DCV_CMD] user defined point graph for Upenn Tran / Research



PID TVOCs Graph for client "Upenn Tran" and building "Research"



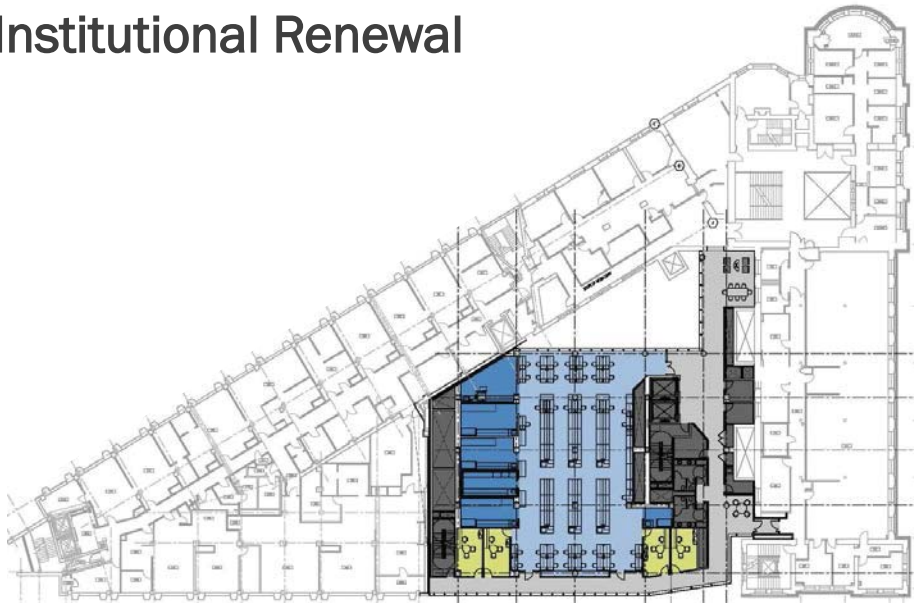
[11-052_VEV11.04_FLOW] user defined point graph for Upenn Tran / Research

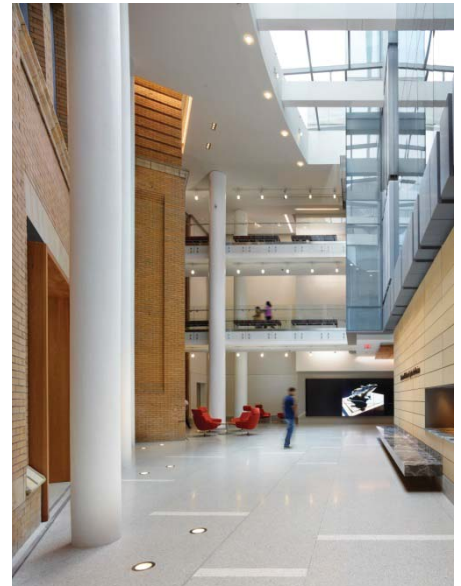


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Institutional Renewal





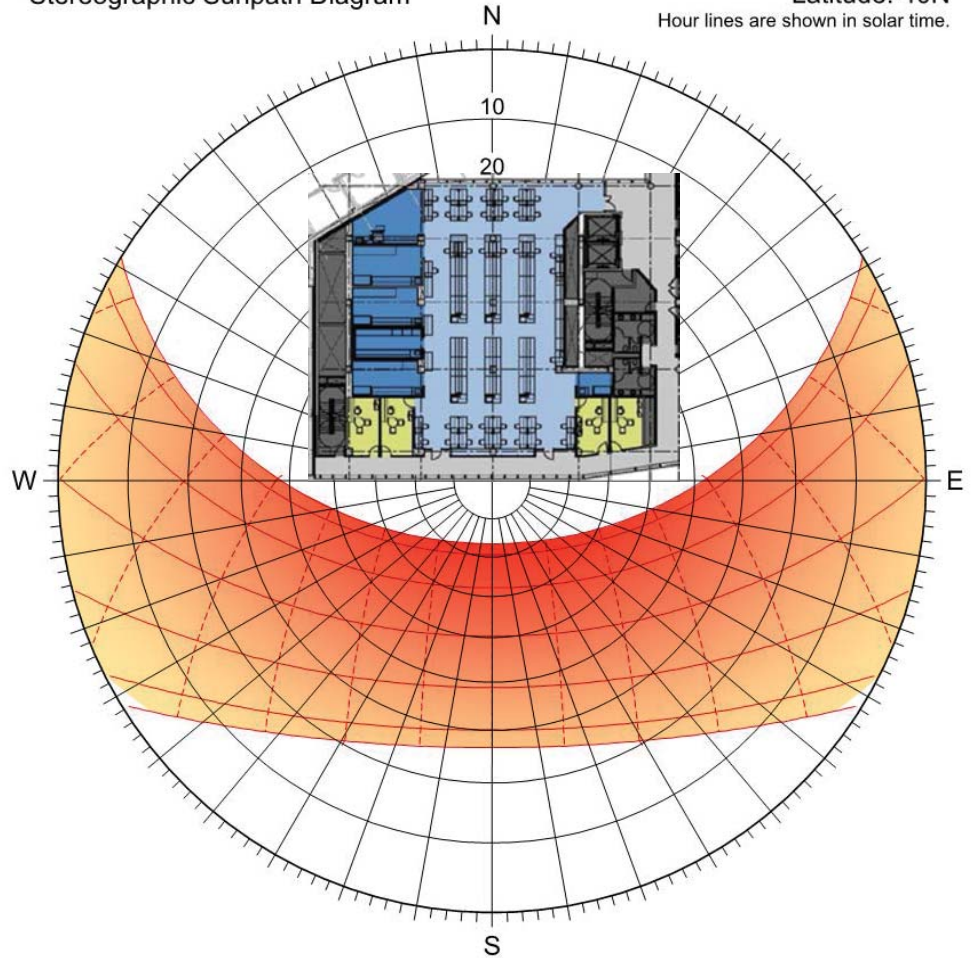


PHILADELPHIA, PENNSYLVANIA

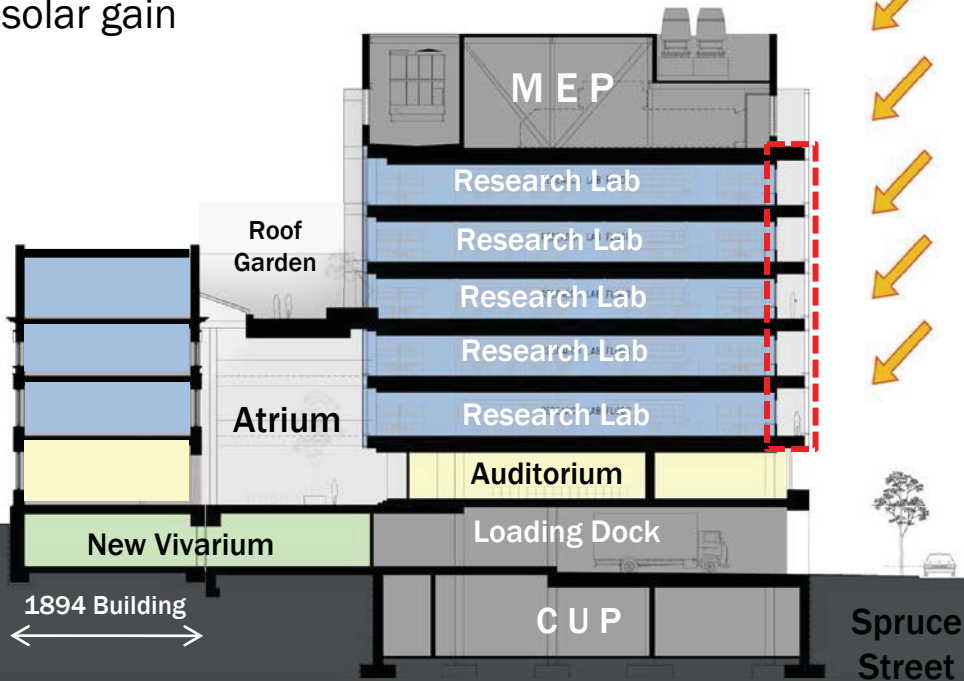
Stereographic Sunpath Diagram

Latitude: 40N

Hour lines are shown in solar time.



Building mass shields atrium skylight from solar gain



South facing perimeter corridor as buffer for noise, light, and heat gain

Traditional Metrics and Factors

Area:

GSF: 10,783 sf

NSF: 6,790 sf

Efficiency: 63%

1,670 NSF/PI

Density:

36 FTE/floor

299 GSF/FTE

188 NSF/FTE

18 LF Bench/ FTE

Interaction Metrics

Draws: 3 Total

Meeting: 1

Kitchenette: 1

Open Seating: 1

Spatial Neighborhoods:

1 Total

RA's

Support

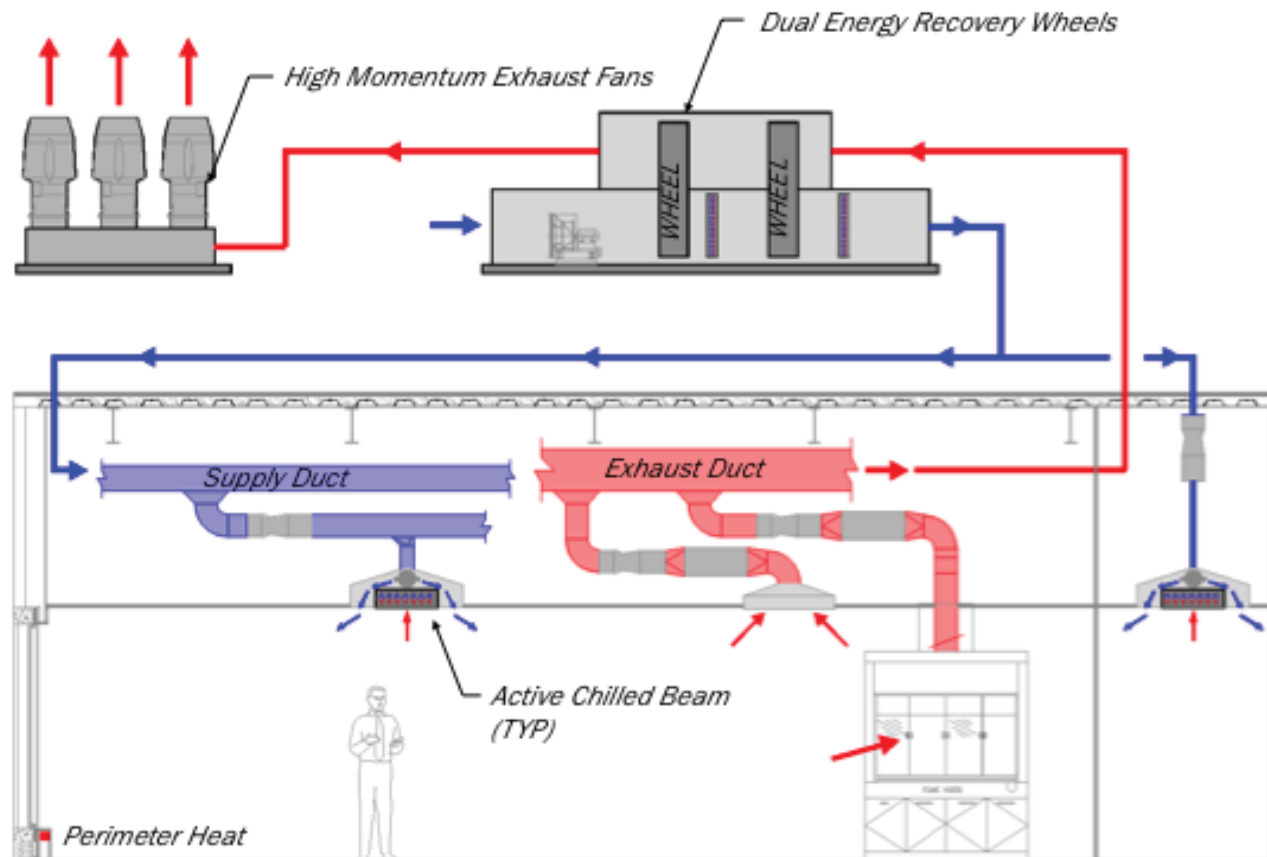
Lab

Offices

RA's

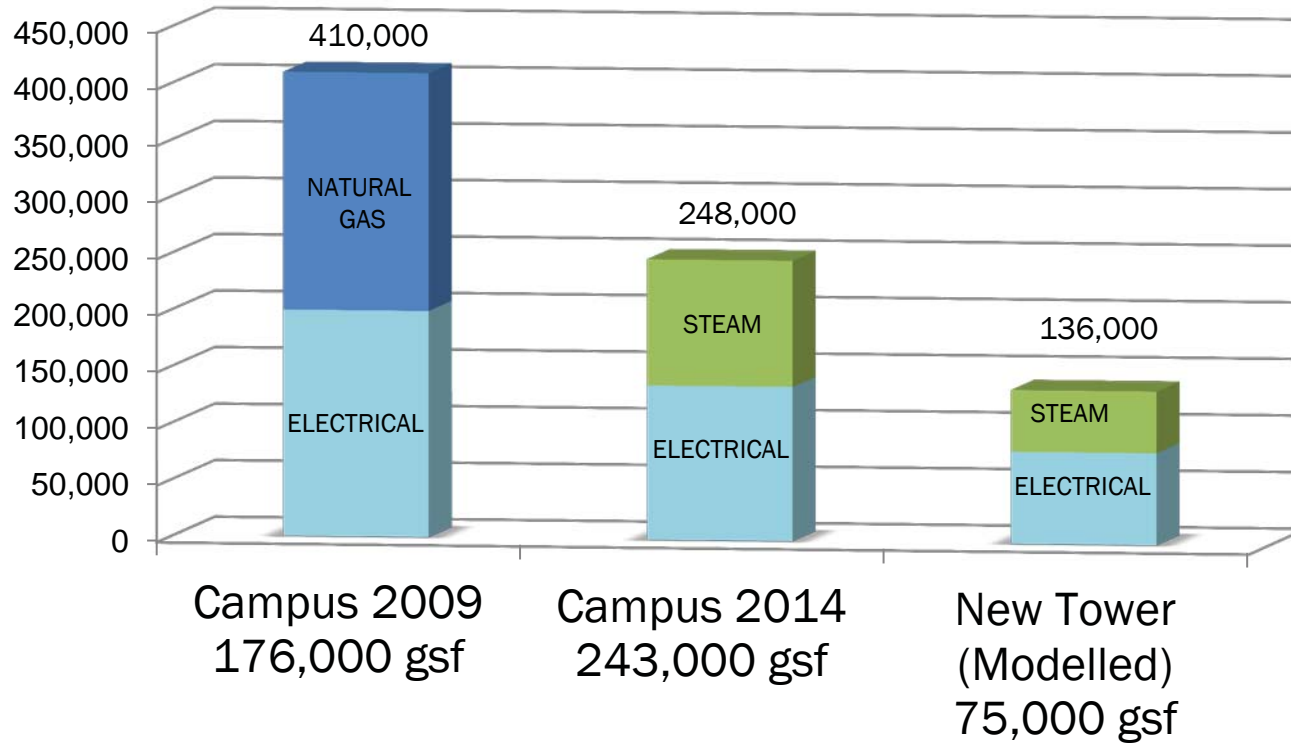
Offices





- *Dual energy recovery: neutral dehumidified air (68°F)*
- *Active chilled beams (58°F)*
- *Reheat energy recovery wheel*
- *High performance fume hoods*

Annual Energy Consumption (btu/yr/sf)



Undergraduate Teaching Laboratories Building

*“It’s inspirational,
graceful....*

*it’s evocative of the
creativity we find in
the labs.”*

*Katherine Newman,
Dean of the Zanvyl
Krieger School of
the Arts &
Sciences, Johns
Hopkins University*



JOHNS HOPKINS
UNIVERSITY



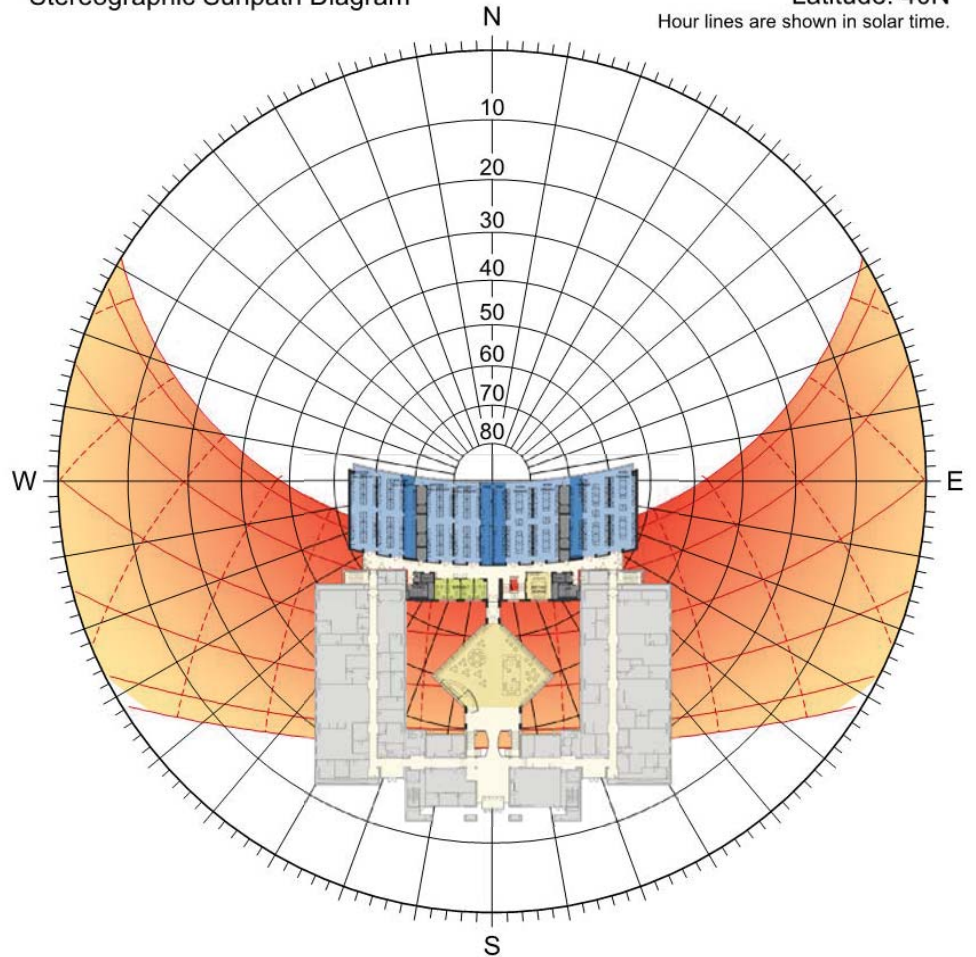


BALTIMORE, MARYLAND

Stereographic Sunpath Diagram

Latitude: 40N

Hour lines are shown in solar time.





Traditional Metrics and Factors

Area:

GSF: 20,157 sf

NSF: 15,506 sf

Efficiency: 77%

2,215 NSF/PI

Density:

85 FTE/floor

237 GSF/FTE

182 NSF/FTE

17 LF Bench / FTE

Interaction Metrics

Draws: 7 Total

Meeting: 4

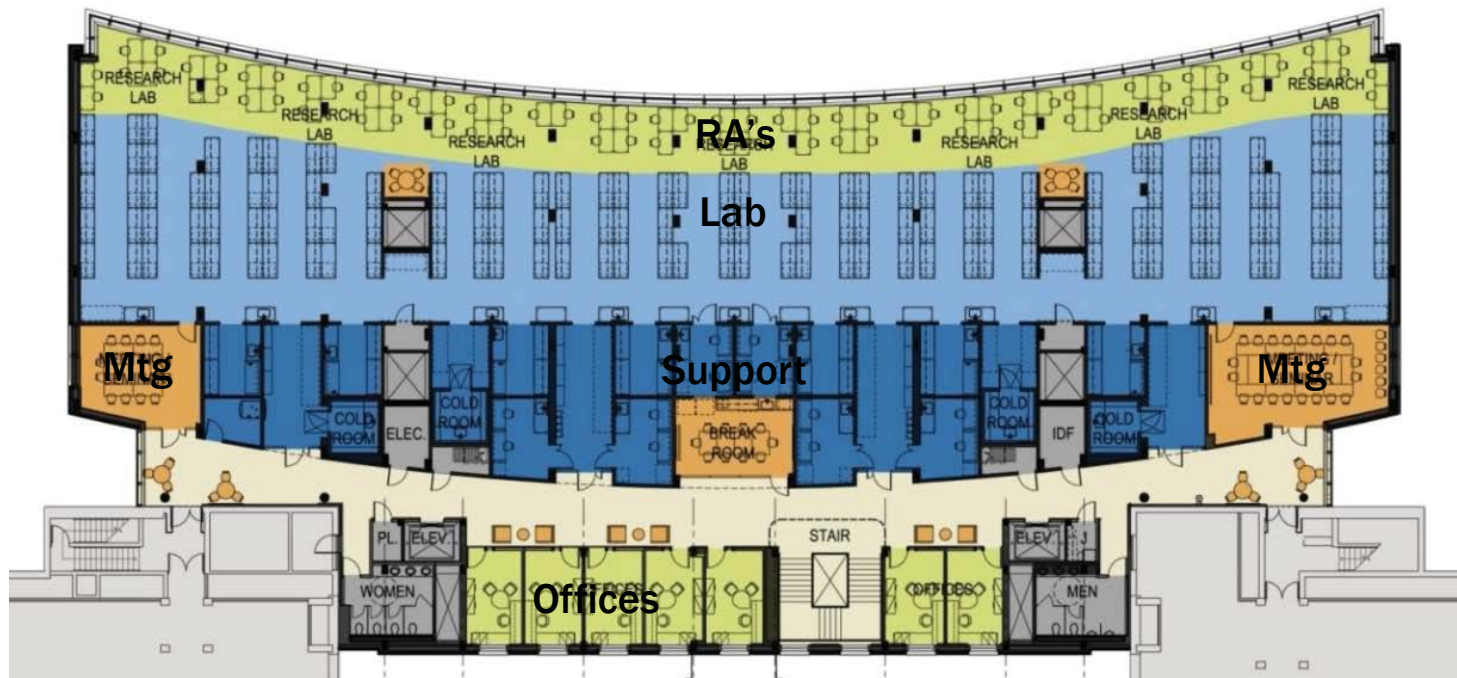
Kitchenette: 1

Open Seating: 1

Open Stair: 1

Spatial Neighborhoods:

3 Total





Neuroscience



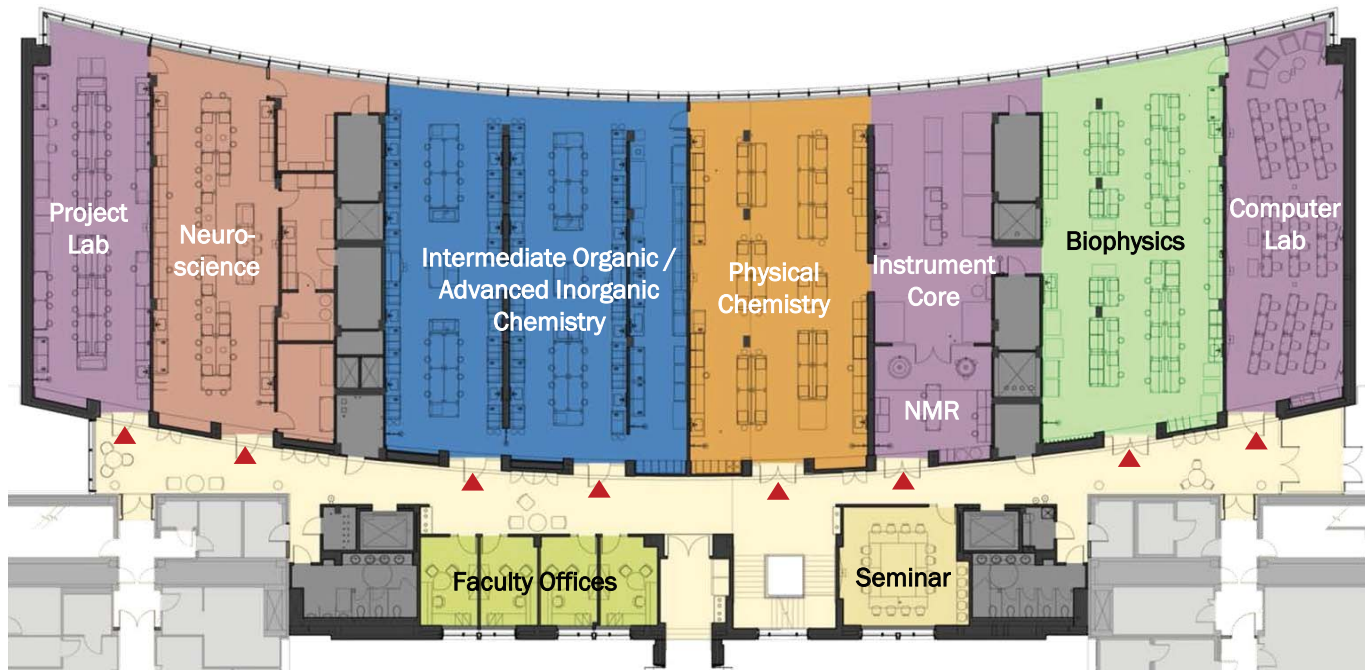
Advanced Organic



Biophysics



Computer Lab



Project Lab

Neuro-science

Intermediate Organic /
Advanced Inorganic
Chemistry

Physical
Chemistry

Instrument
Core

NMR

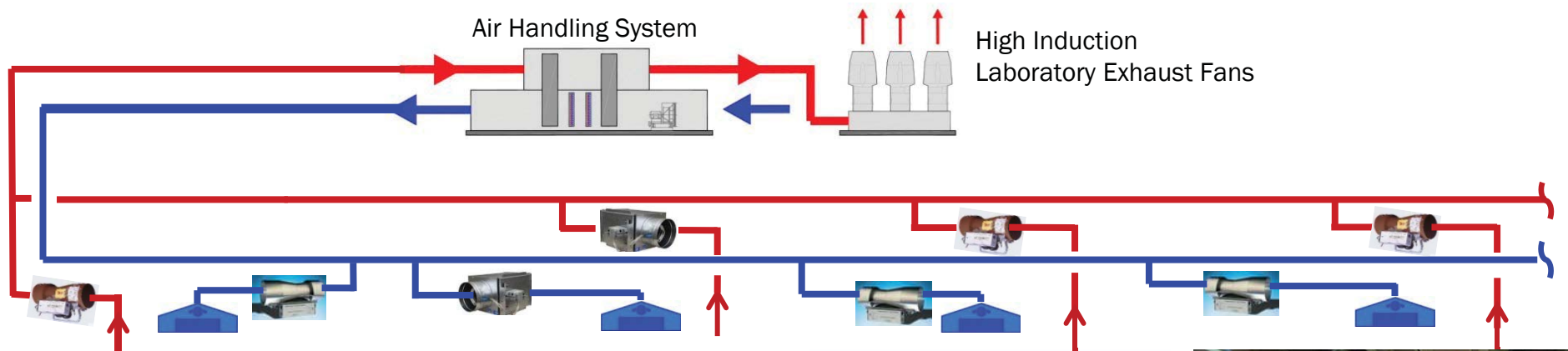
Biophysics

Computer
Lab

Faculty Offices

Seminar

Convertibility



Biology Lab



Social Space

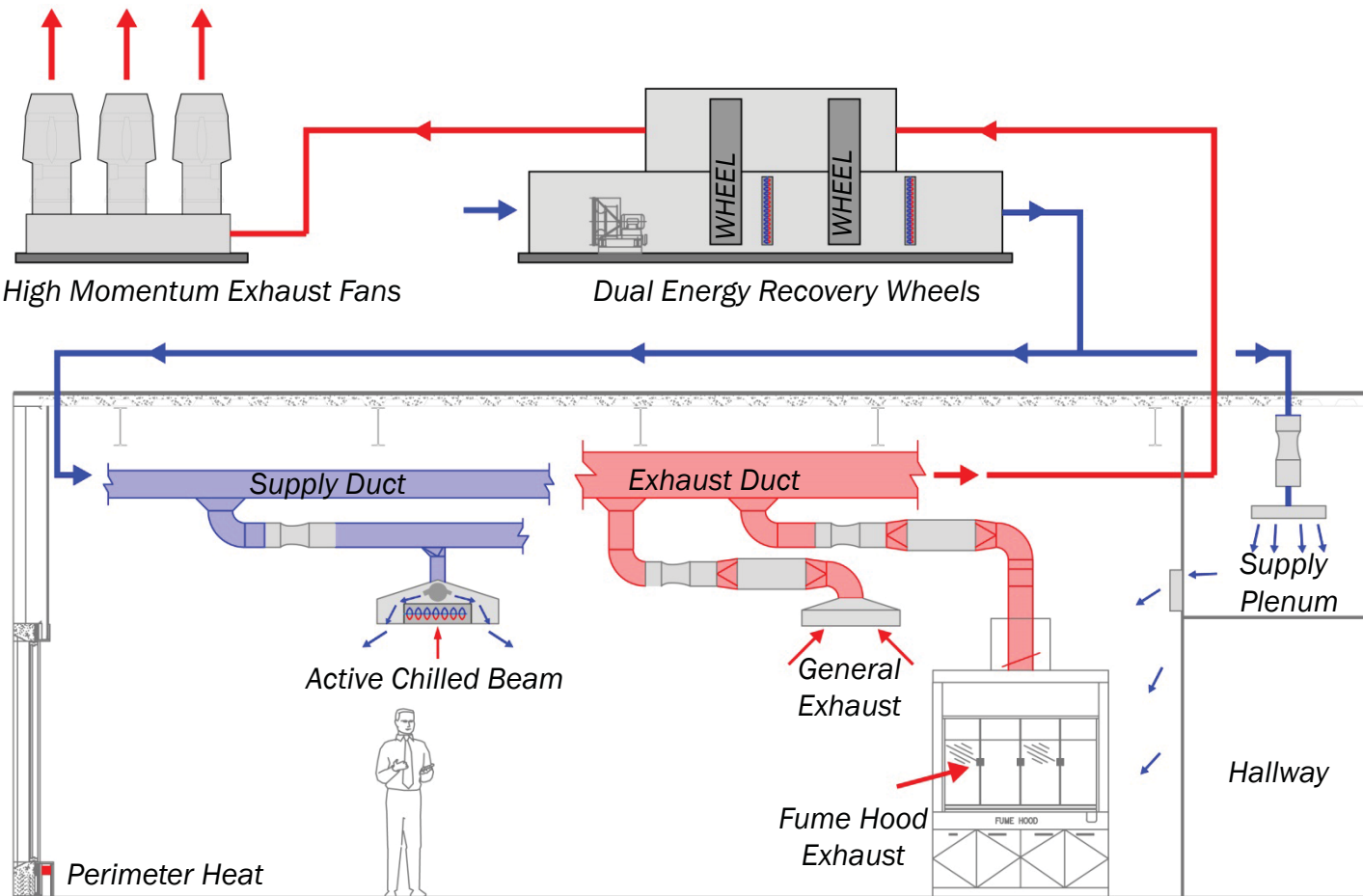


Chemistry Lab
(Fume Hood Intensive)



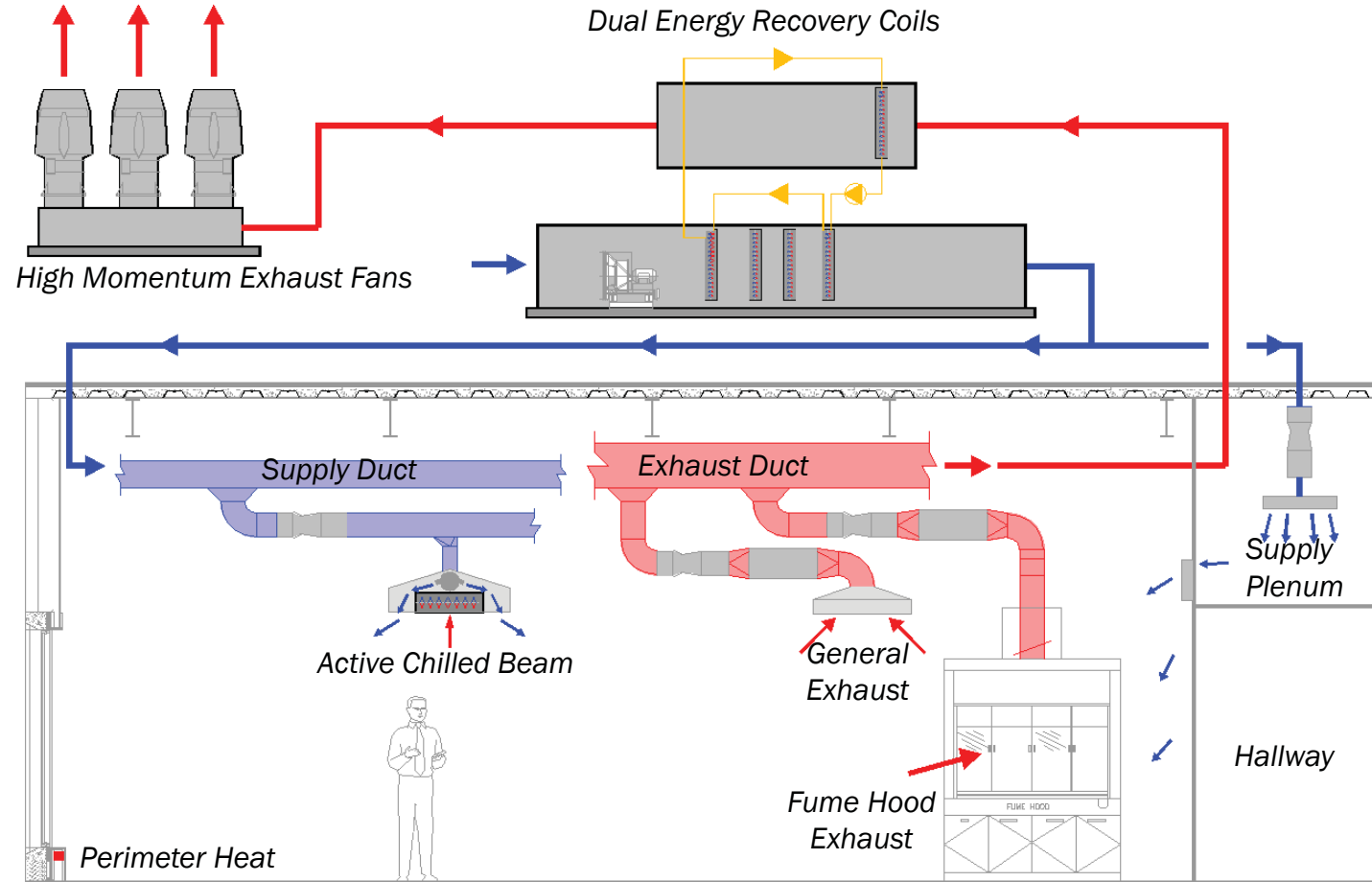
Computer Lab

System Concept: Neutral Air / Active Chilled Beams / Plenum Supply



- Dual energy recovery: neutral dehumidified air (68°F)
- Active chilled beams (58°F)
- Reheat energy recovery wheel
- High performance fume hoods
- Supply plenum to deliver neutral makeup air

System Concept: Neutral Air / Active Chilled Beams / Plenum Supply



- Dual energy recovery: neutral dehumidified air (68°F)
- Active chilled beams (58°F)
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- High performance fume hoods
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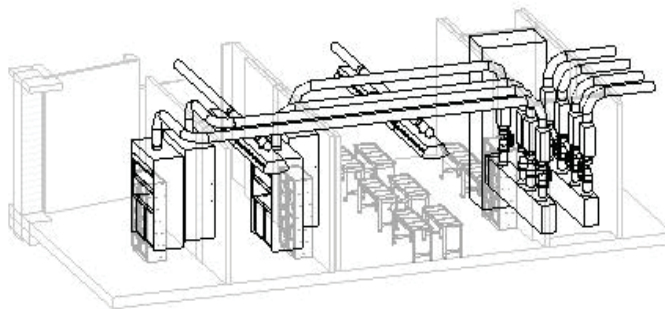
ENERGY RECOVERY PERFORMANCE – NEUTRAL AIR



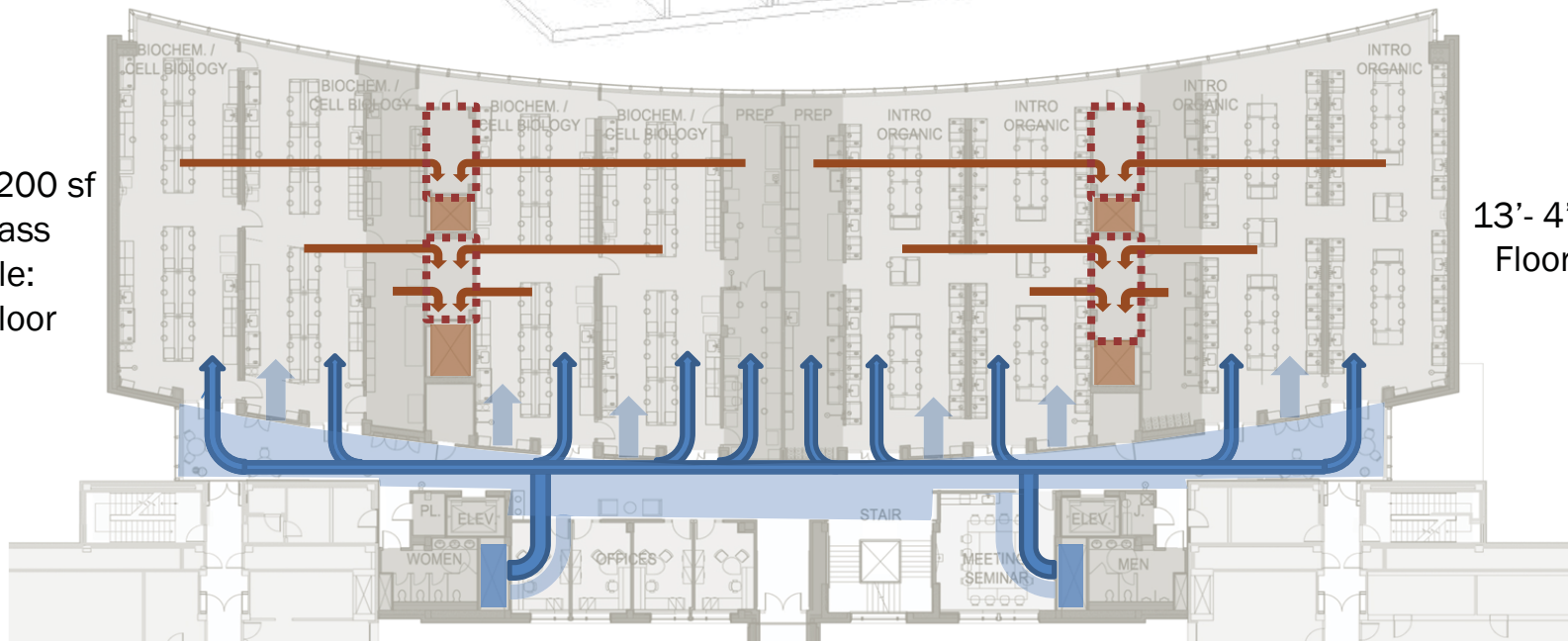
Outdoor Air:

	Wheel #1		-	Wheel #2	
	Entering	Leaving		Entering	Leaving
Winter	8.0F db	27.1F db		27.1 F db	67.0 F db
Summer	96.0F db	66.2F db		51.8F db	68.0F db
		75.9F wb		51.4 wb	57.9 wb
Load Reductions:	8,700 lbs / hr steam				
	503 tons chilled				

Venturi Valve Galleries / Plenum Supply Air

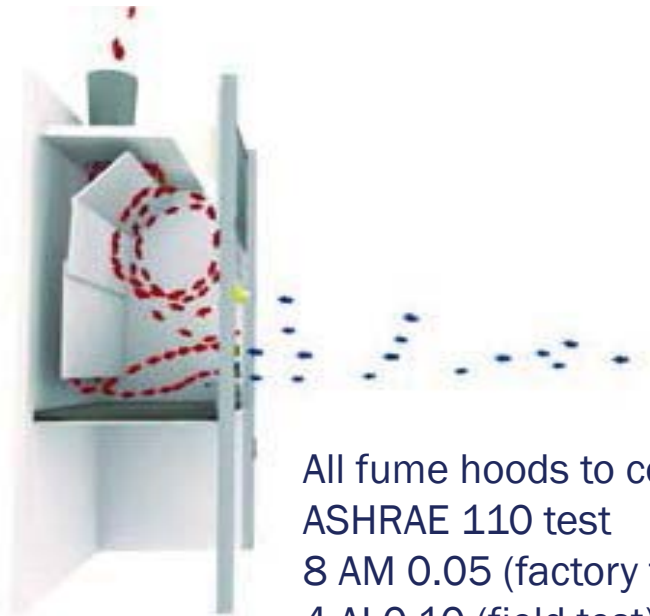


Typical 3,200 sf
Lab/Class
Module:
4 per Floor



13'- 4" Floor to
Floor Height

High Performance Fume Hood



All fume hoods to conform to
ASHRAE 110 test
8 AM 0.05 (factory test),
4 AI 0.10 (field test)



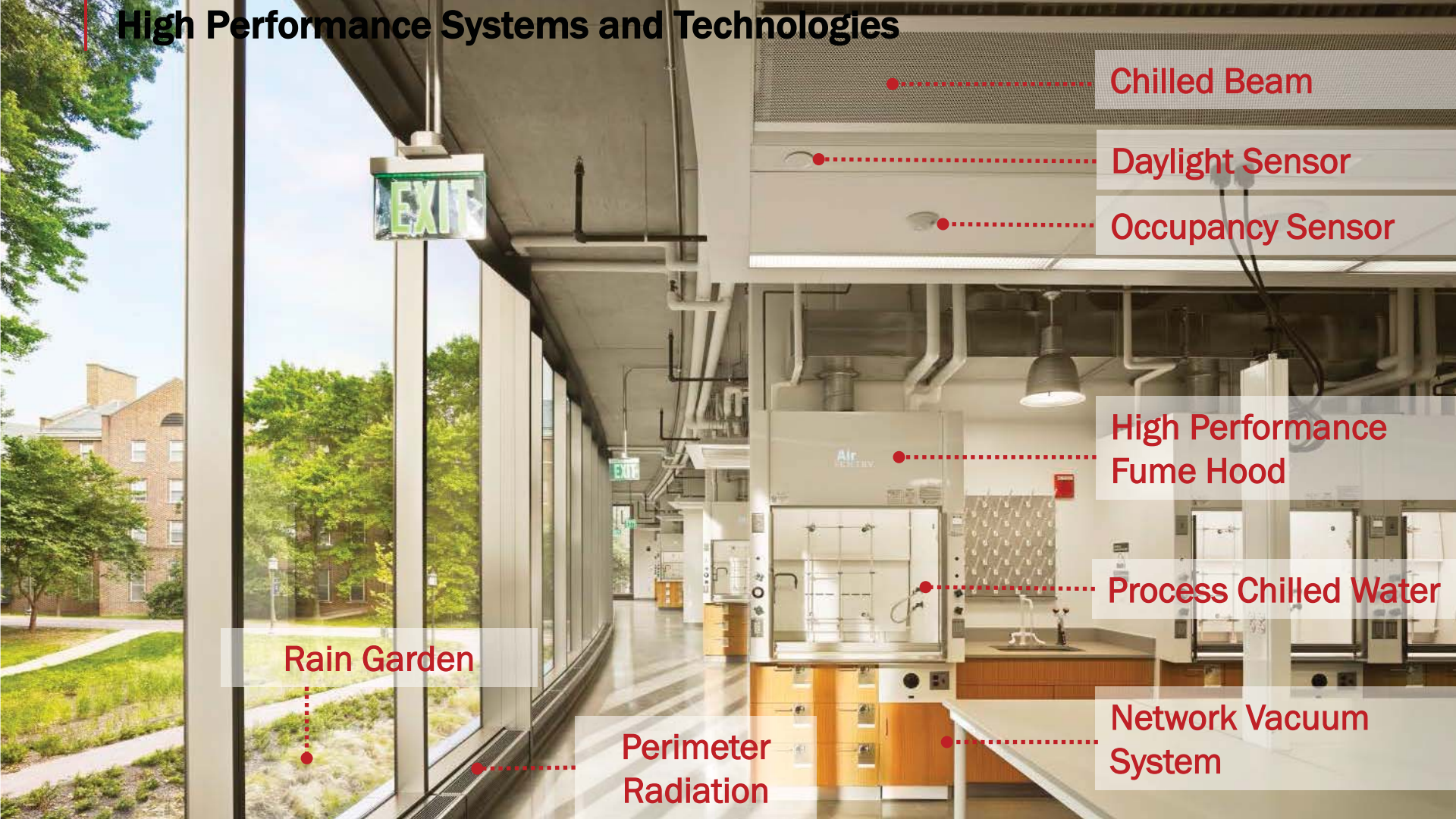
Fume Hood Design CFM

Fume Hood	Minimum Flow Sash Closed (150-200 AC/hr)	Conventional Fume Hood (18" Vert. Sash, 100 fpm)	Conventional Fume Hood (27" Vert. Sash, 65 fpm)	High Performance Fume Hood (18" Vert. Sash, 70 fpm)	High Performance Fume Hood (27" Vert. Sash, 45 fpm)
4" hood	150	520	520 (unsafe)	325	325 (tested)

Lab Decommissioning Switch



High Performance Systems and Technologies



Chilled Beam

Daylight Sensor

Occupancy Sensor

Rain Garden

Perimeter Radiation

High Performance Fume Hood

Process Chilled Water

Network Vacuum System





Network Vacuum



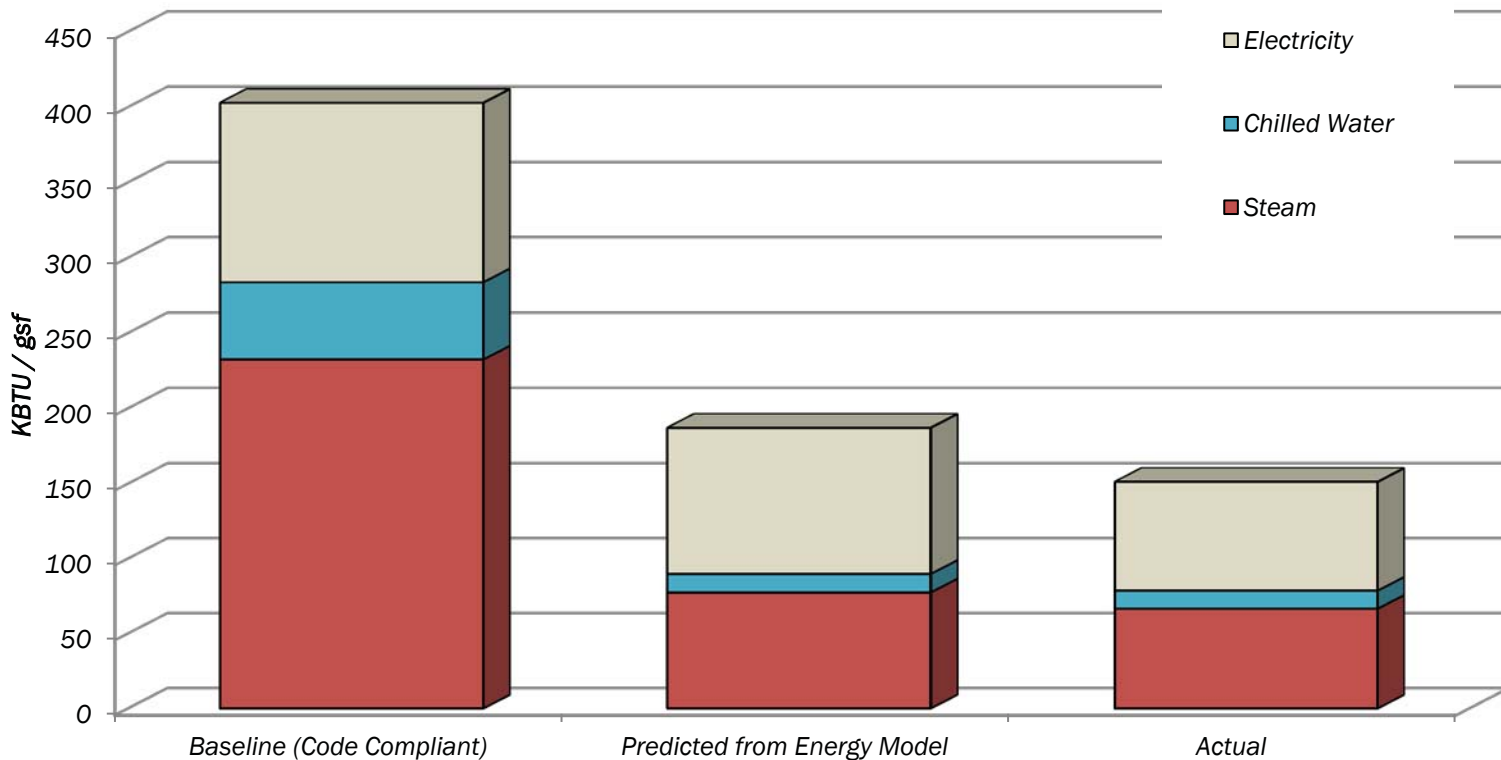
- One pump efficiently creates high vacuum for 4-5 fume hood vacuum outlets
- Pump turns off (indicator switch on fume hood receptacle)

Process Water Cooling



- Used to cool experimentation (condensers)
- Recirculates water in lieu of dumping





2015 Select Recent Projects



VCU



University of Pittsburgh



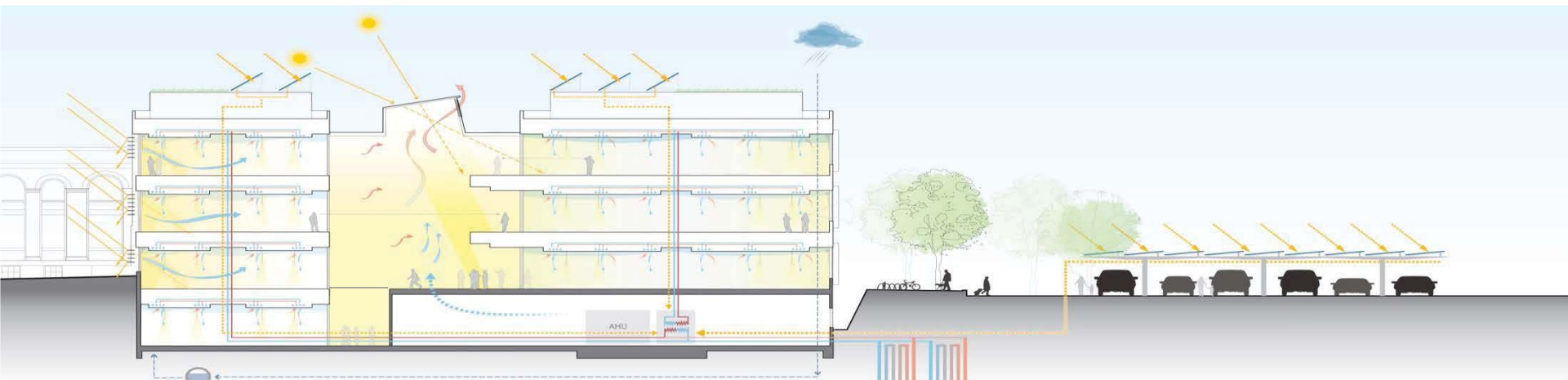
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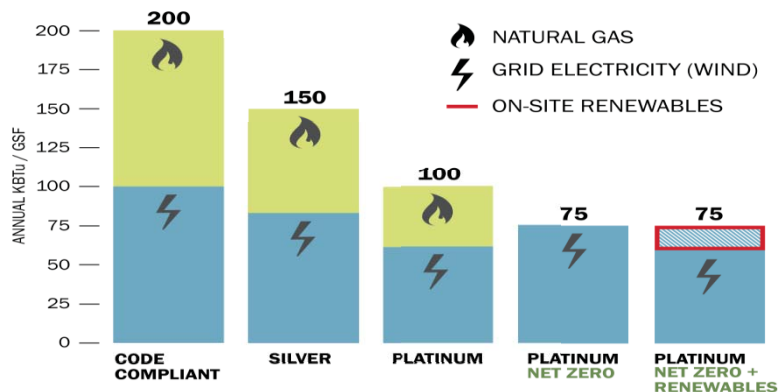
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Range of Functions:	Research / Vivarium	Research	Research / Vivarium	Teaching / Res. / Vivarium
Area/Research Group	945 NSF / PI	1,650 NSF/PI	1,670 NSF/PI	2,115 NSF/PI
EUI from Energy Model:	221 kBtu / sf / yr	185 kBtu / sf / yr	136 kBtu / sf / yr	172 kBtu / sf / yr
Fume Hood Density:	1 FH / 3,400 GSF	1 FH / 2,800 GSF	1 FH / 4,500 GSF	1 FH / 750 GSF
HVAC Systems Approach:	Chilled Beams / Total Energy Recovery	Air Quality Control / Total Energy Recovery	Chilled Beams / Neutral Air	Chilled Beams / Neutral Air / Plenum Supply
Construction Cost:	\$465 / SF (2009)	\$510 / SF(2013)	\$550 / SF(2014)	\$470 / SF(2013)

Next: Swarthmore College Biology-Engineering-Psychology / Carbon Net Zero



Energy Use Intensity (EUI)



Initiatives beyond PLATINUM/NET ZERO MAX ENERGY PERFORMANCE

- Solar hot water
- Photovoltaics on roof and parking lot
- 55% to 70% energy savings better than code

Tradeline Three

Continuous Feedback Loop:

Constructive feedback drives innovation.
Solicit feedback and filter wisely.

Optimize the Human-Machine Interface:

Technology advances faster than culture.
Ensure user friendly control systems.

Innovation Pays:

High performance systems work: chilled beams, neutral air, air quality control.

- Save construction \$\$
- Save energy \$\$
- Superior teaching/research environment



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B A L L I N G E R