The UVM STEM Complex

High Performance, Affordability, and Efficiency, in High Ventilation Buildings

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UVM STEM: Presentation Team

Lynn Wood, Zone Manager

The University of Vermont

Alex Halpern, Principal in Charge

Freeman French Freeman Architects

Bryan Rydingsward, Senior Associate

BR+A Engineers

Evan Champagne, Project Architect

Freeman French Freeman Architects

UVM STEM: Learning Objectives

- Importance of collaborative A&E **energy modeling**
- Why improved **insulation** sometimes doesn't matter
- Better understand **controls** systems
- Understanding the options and operation for **energy recovery** devices

UVM STEM: Presentation Overview

- Design Challenge – *Efficiency with 100% out door air; No Cross Contamination – collaborative process*
- STEM Project Overview
- Design process: A+E+Owner
- Energy Modeling
- Selected Systems and Operation
- Current Energy Performance
- Thoughts for the future
- Questions and Discussion

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UVM STEM: Site Pre-construction

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UVM STEM: Site During Construction

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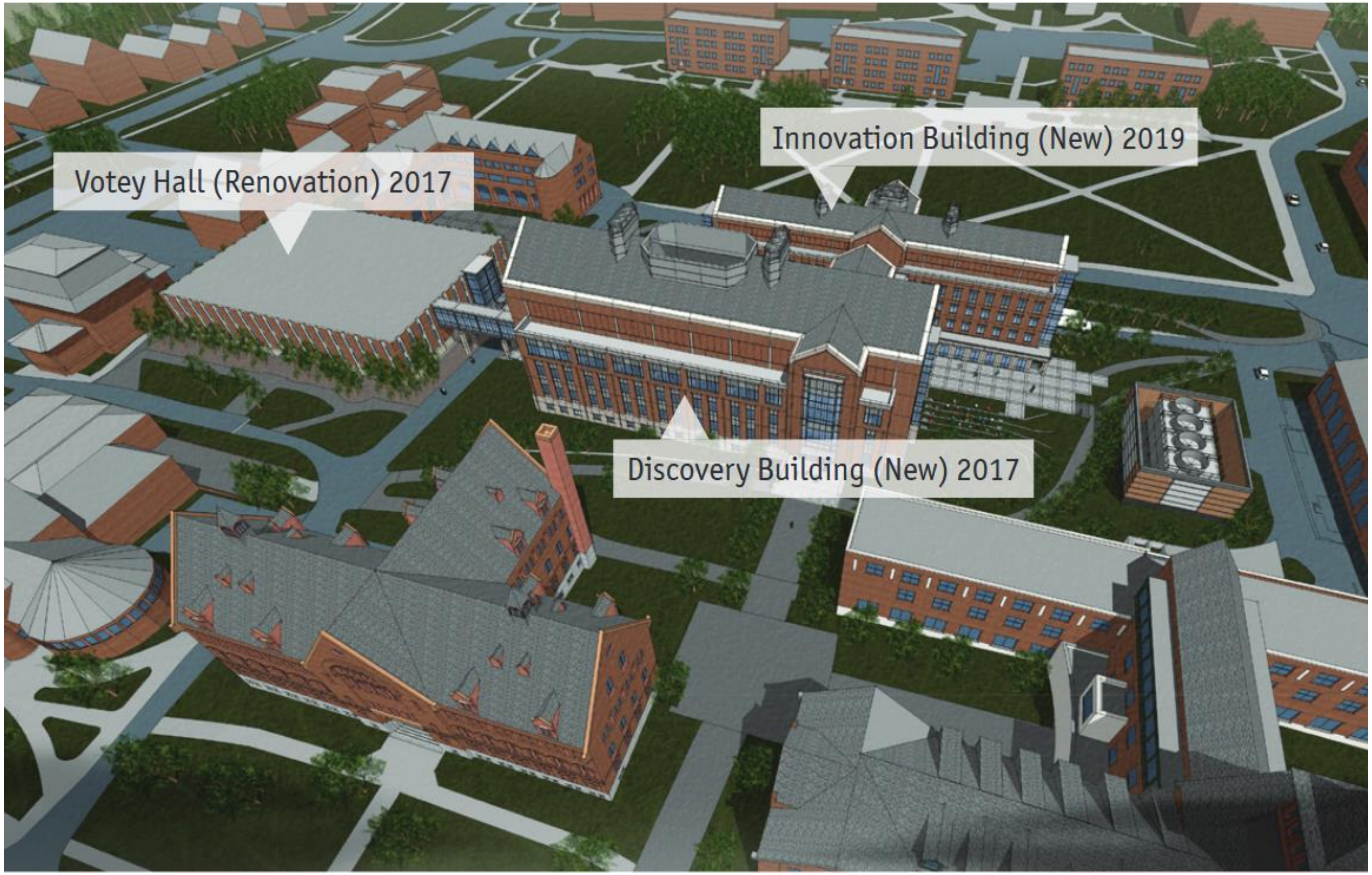
Central Campus/ Historic Core



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From Cook to STEM

- Renovate or Rebuild
- The need for updated chemistry facilities
- Decision making process
- Criteria
- Cost Comparison

Cook Building

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From Cook to STEM

- Outdated facilities
- Lack of natural light
- Low Floor to Floor
- Rigid layout
- Heavy CIP Construction
- Difficult to renovate

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UVM STEM: Innovation & Discovery

- 180,000 SF
- 100% Outdoor Air
- Teaching/ Research Lab.
- Chemistry, Physics
- Engineering, Mathmatics
- 5 Stories + Penthouse
- 149 Fume Hoods
- Lecture Halls
- Classrooms
- Faculty/ Admin Offices
- Conference + Work Spaces
- Pedestrian connectors
- Loading Dock
- Campus Central Plant
  - Steam/ Chilled Water
- 2013 Design Start
- 2015 Construction Start
- 2019 Construction Complete

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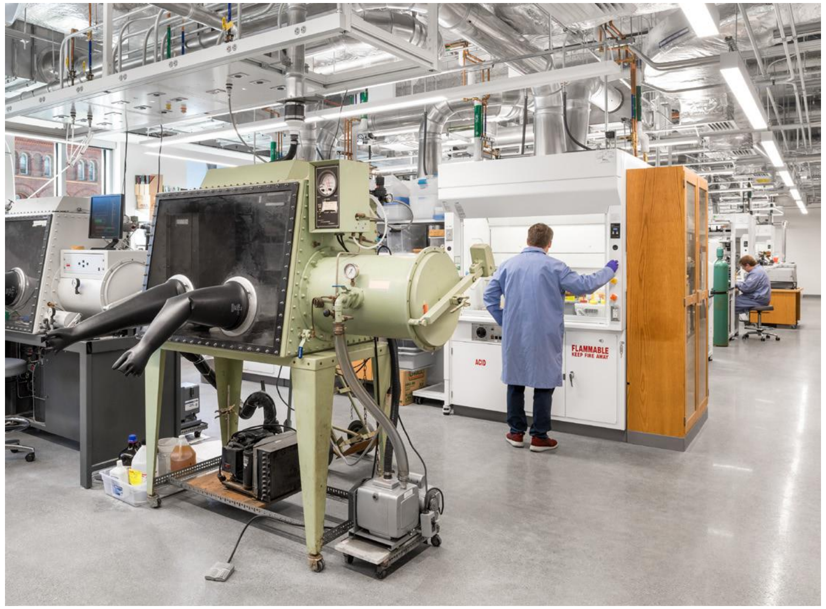

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FLAMMABLE

Historical Context

The Design

- LEED Silver Target
- Steel frame with brick cavity wall construction
- Curtain wall for all glazed openings
- Vermont Slate roof with ventilated roofing system
- Large gutters to capture snow and provide roof drainage
- Aesthetic and scale compliment the historic buildings to the west that front the campus green

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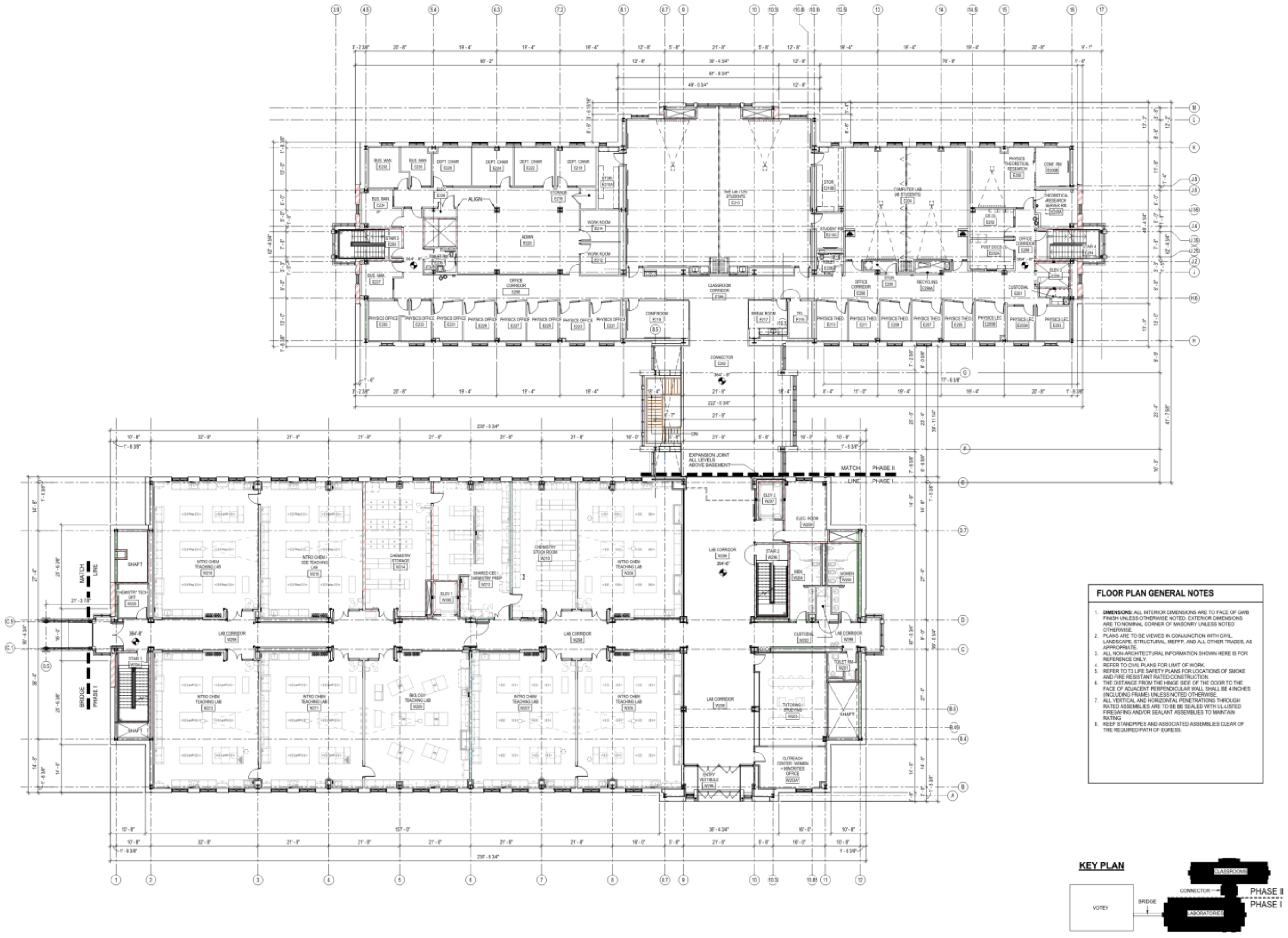
The Design

- Phased Construction
- Separation of lab and classroom wings for redundancy of systems
- Lab wing is organized with a central corridor with lab spaces on each side
- Admin/Classroom wing has an offset corridor with offices on the west with larger function areas on the east



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The Design

- Vertically, the electrical room, plumbing and wet mechanical, water service and specialized Clean Room are housed in basement
- Levels 1-4 alternate between Research Labs and Teaching Labs on each floor
- Mechanical in the Penthouse

The Design

- The Connector between the Lab and Classroom Wings has lobby space, club space, and conference rooms
- Offset floor plates on levels 3 & 4 due to higher floor-to-floor required in Lab Wing
- HVAC in Penthouse
- Elec, Plumb, Water Service in Basement

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The Design

- The design and layout developed with functionality and efficiency of HVAC systems in mind.
- Exhaust Enclosures express and accommodate high ventilation
- The cladding system of the penthouse provide flexibility of louver layout and size
- Each space has access to natural light to minimize need for electric lighting.

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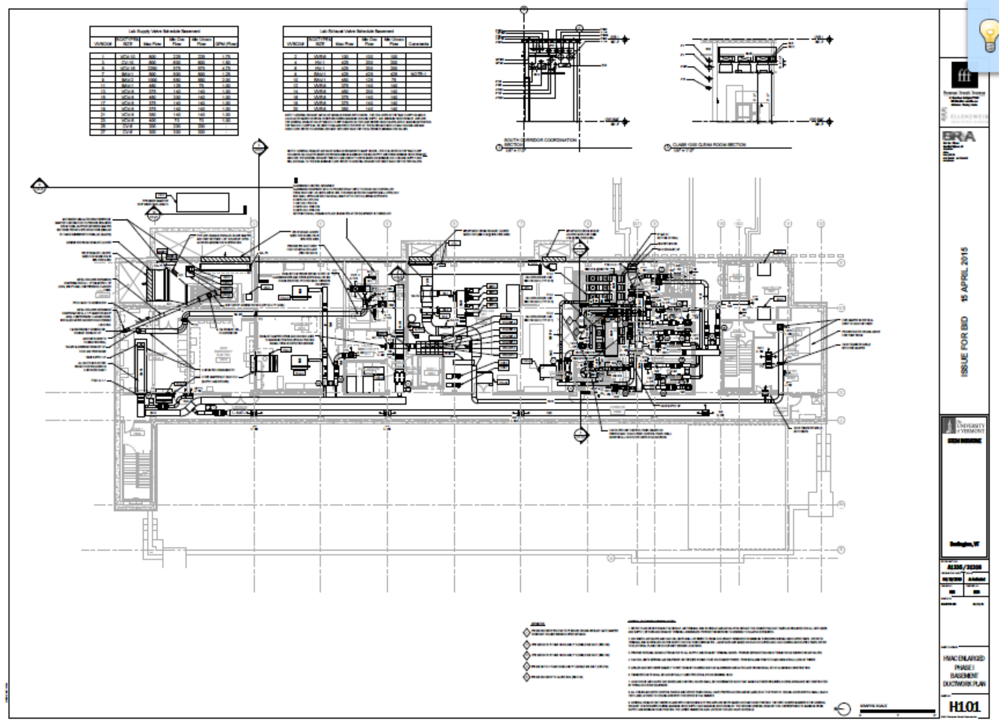
Design and Review Process



- Owner Project Requirements (OPR)
- Basis of Design (BOD)
- Extensive Design Reviews over multiple phases
  - Schematic Design
  - Design Development
  - Construction Documents at 50%, 85%, 100%
- Selection and maintainability
- Submittal Review-controls approach
- Life cycle costs analysis – include maintenance, parts, labor – full picture.
- Overall Energy Consumption!
- Triple bottom line: Social. Environmental. Economical.

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The Design Phase-Major Systems and Considerations

- High Performance Heat Recovery System
- Exhaust System
- Supply System
- Ductless fume hoods
- Chilled Beams
- Lab Systems and Controls
- Lighting Controls
- Building Envelope
- Redundancy of Critical Systems

The Supply System

- Redundancy
  - North and South Units 75,000 CFM each
  - Cross Connect Dampers
  - Oversized Steam Snow Melt Coil
  - 6 Supply Fan Array
- High Efficiency Heat Recovery
  - 100% Outside Air
  - Combined Heat Recovery and Preheat
  - Energy Savings from reduced coil pressure to overcome
- Controls
  - Fans modulate to maintain static pressure
  - Demand static pressure reset based on call in space
  - Reduced Air Change Rates for unoccupied
- Accessibility and Ease of Maintenance for Critical Equipment

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The Exhaust System

- 149 Exhaust Hoods
- Re-entrainment Analysis
- Maintaining the plume velocity
- Exhaust Fans
  - Two systems
  - 3 fans each - Modulate
  and rotate based on sequence
- Controls - Necessity
  - Fans modulate to maintain minimum plume
  - Demand static pressure determines number of fans and speed to maintain setpoint
  - Rotate based on manual selection

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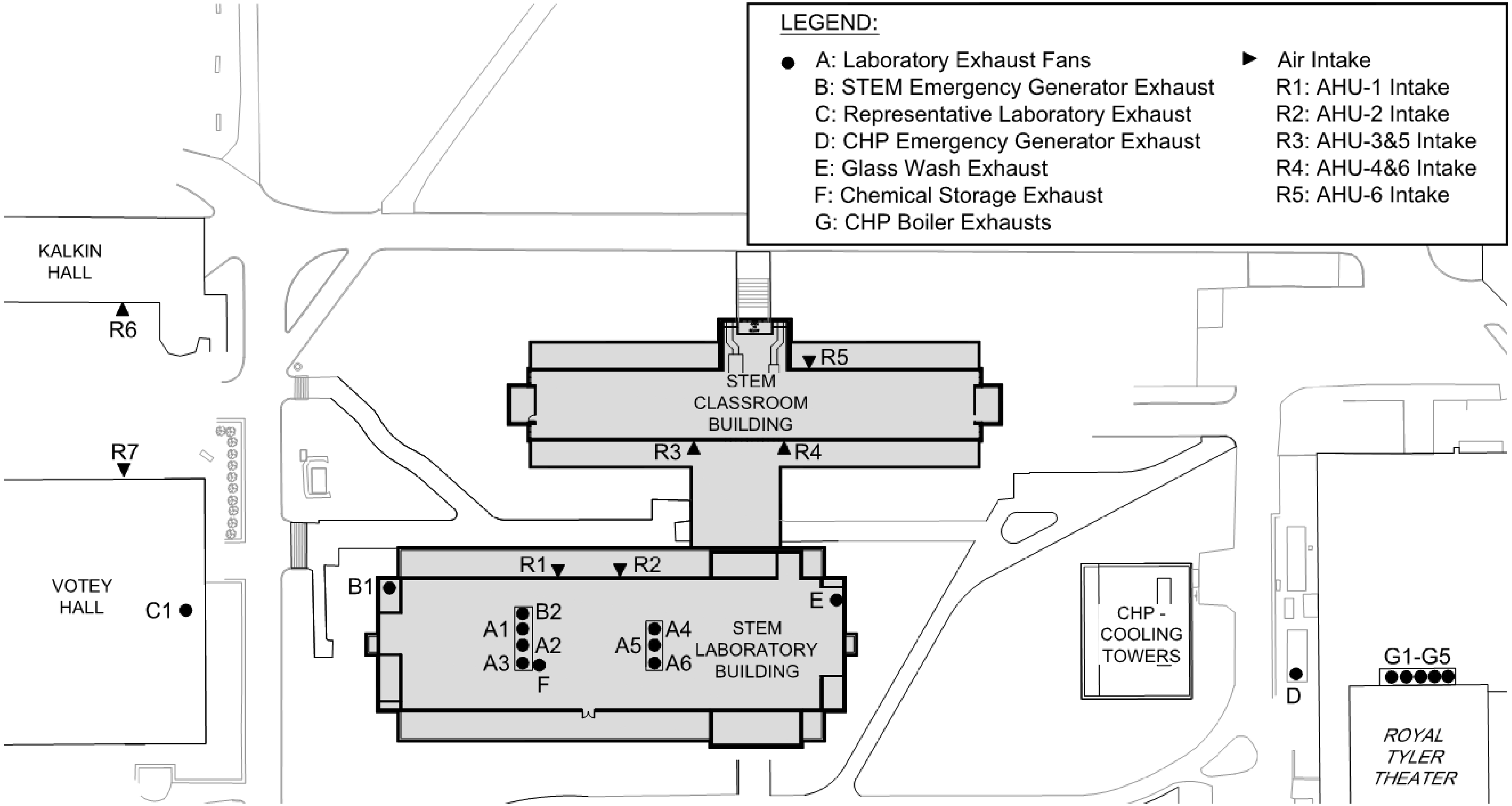
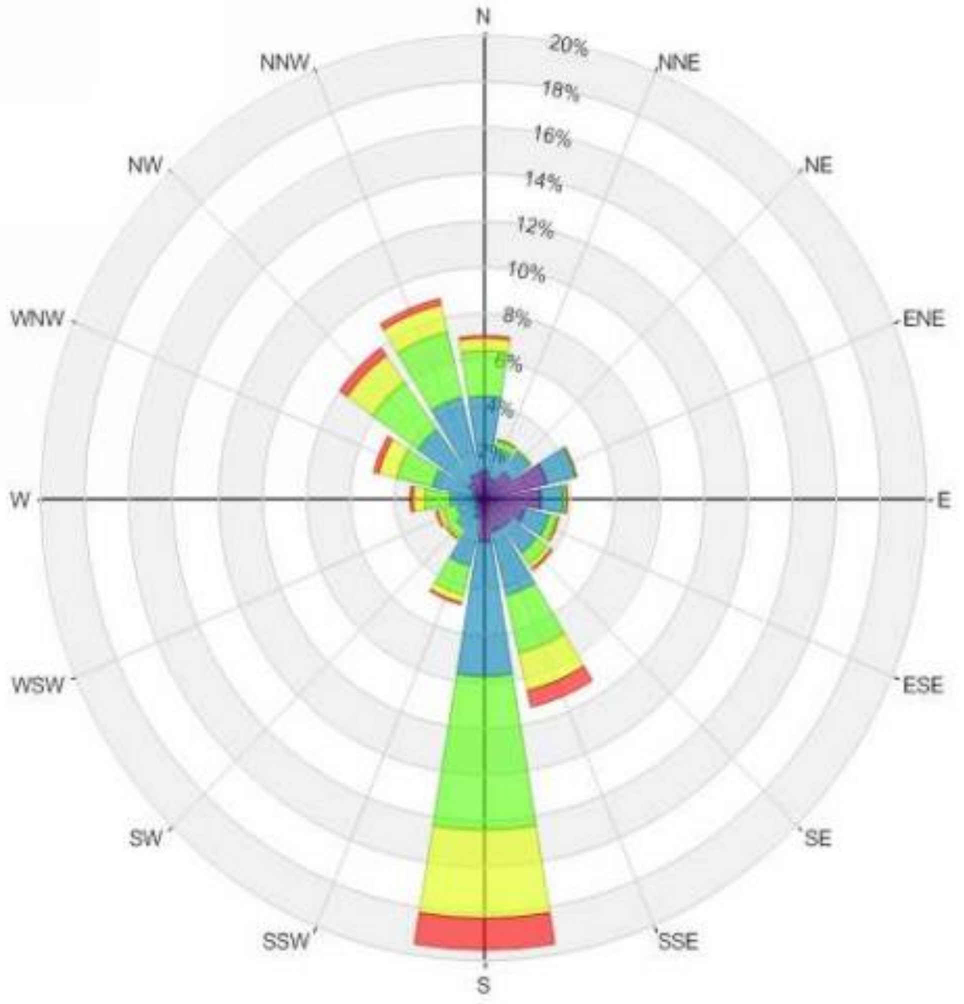
Energy Opportunities: Exhaust Dispersion Analysis



Energy Opportunities: Prevailing Wind Study



Wind Speed (mph)	Probability (%)
Calm	9.3
1-5	20.4
6-10	32.5
11-15	23.2
16-20	11.2
>20	3.4

Directional Distribution (%) of Winds (Blowing From)
Station: Burlington International Airport, Burlington, VT (1973 – 2012)

RWDI CONSULTING ENGINEERS & SCIENTISTS

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Redundancy of Critical Systems

- Sizing
- Multi Coil / Spare Coil
- Fan Array
- Cross Connect AHUs

- Dual Pumps
- Emergency Power

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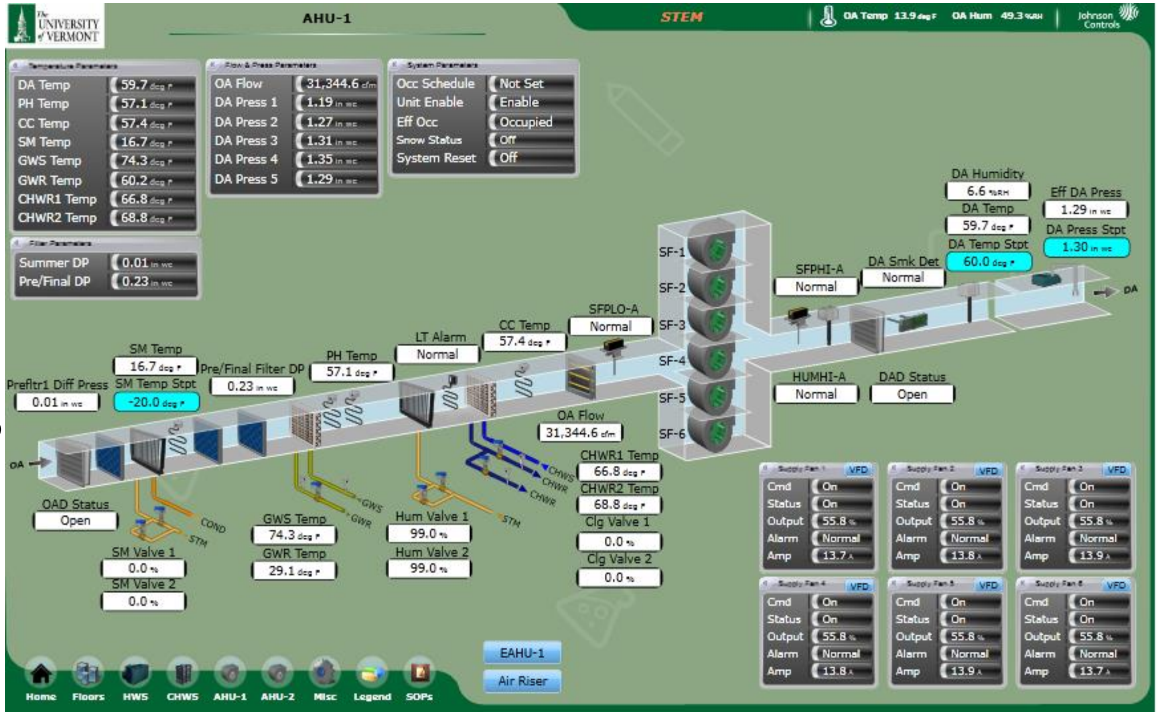
Lab Systems & Controls

- ACH 6 occupied/4 unoccupied
- Multiple supply/exhaust/hood air valves
- Supply tracking exhaust based on offset
- 80-85 fpm hood face velocity
- High performance hoods for capture
- Integration with Lighting Control and motion sensors for occupancy
- Controls & 3rd Party Integration



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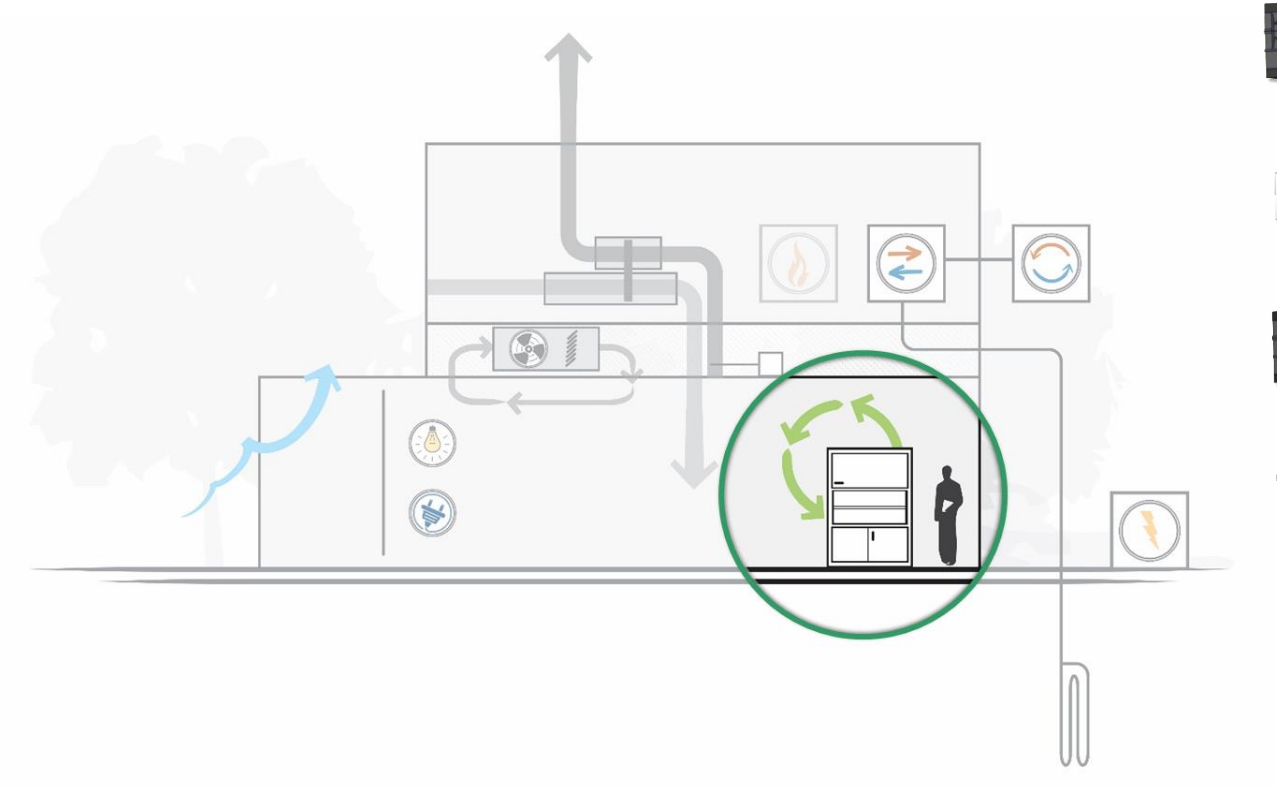
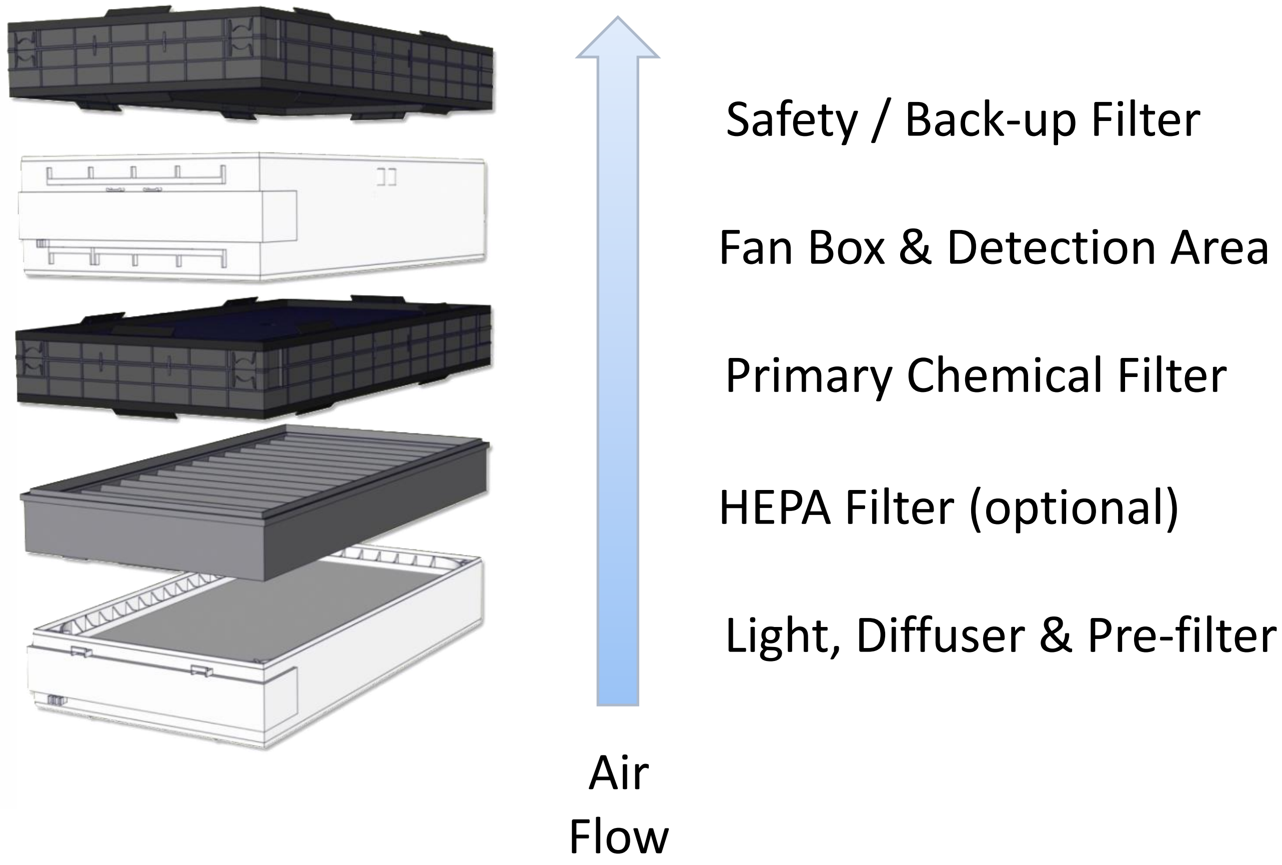
Energy Opportunities

- Envelope
- Lighting
- HVAC Zoning
- Hydronic Cooling
- Reduce Air Changes
- Energy Recovery options
- Separate hot water loops for reheat, preheat, and perimeter heat
- Low Pressure ductwork
- Wind Analysis
- Controls

Energy Opportunities: Filtered Fume Hoods





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Filtered Fume Hood Considerations

FILTERED FUME HOOD

- Filters fume hood exhaust and returns air to laboratory space
- Tested to U.S. + European safety standards
- Significant exhaust and make-up air ductwork installation cost savings
- Easy filter replacement (third-party filter replacement program also available)
- Sash position detection system and air quality monitoring system with alarm
- Back-up filter provides redundancy for safety

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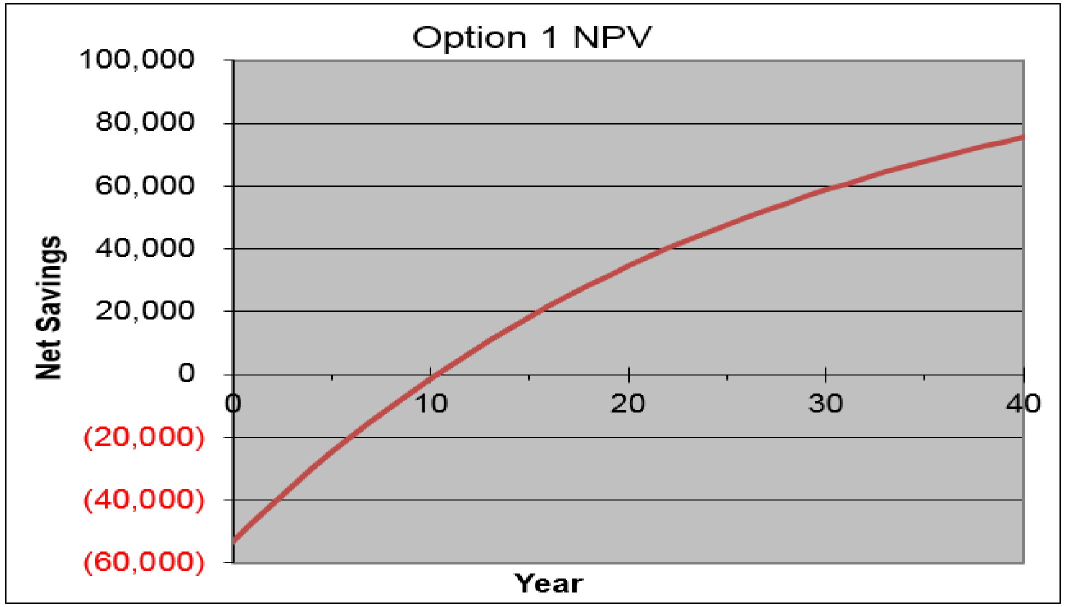
Filtered Hood LCCA

Option 1 Compared to baseline analysis

Simple Payback Analysis	
Additional Investment	$53,356
Annual Operating Savings (FY18 rates)	$6,586
Simple Payback Period	8.10
Return on Investment	12.3%
Life Cycle Cost Metrics	
Baseline Net Present Cost	$87,803
Option 1 Net Present Cost	$53,356
20 Year Net Present Savings	$34,447
20 Savings to Investment Ratio	0.65
Discounted Payback Period (years)	10.56
Internal Rate of Return	15.02%



- 3 Teaching Labs with 10 hoods in each Lab
- Compared traditional fume hood with a 10 year Life Cycle Cost
  - Compared utility usage
  - Maintenance time and materials
- Energy Savings
- 10 year payback
- Flexibility

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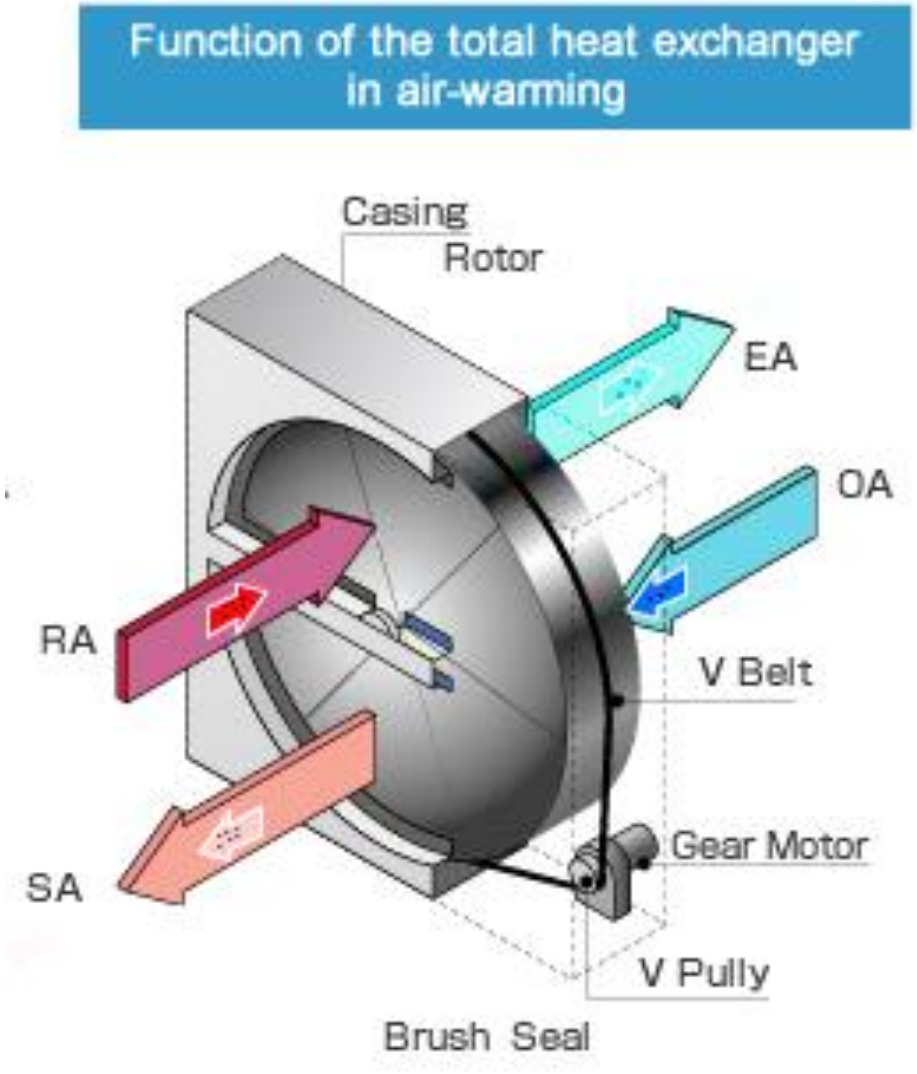
Energy Recovery Options



- Traditional Glycol Run-Around
- Konvekta
- Enthalpy Wheel
  - Carry Over Analysis-RWDI
- Heat pipe
- Plate HEX

High Performance Heat Recovery System

- Konvekta System optimizes heating and cooling recovery
- Coil Design
- Heat Recovery and Heating Coils combined
  - Decreased pressure drop
  - Energy Savings

- Konvekta Skid
- Customization
  - Cold weather start-up
  - Interface with Controls

- Remote Support/Energy Guarantee
- Compare to traditional Glycol systems.

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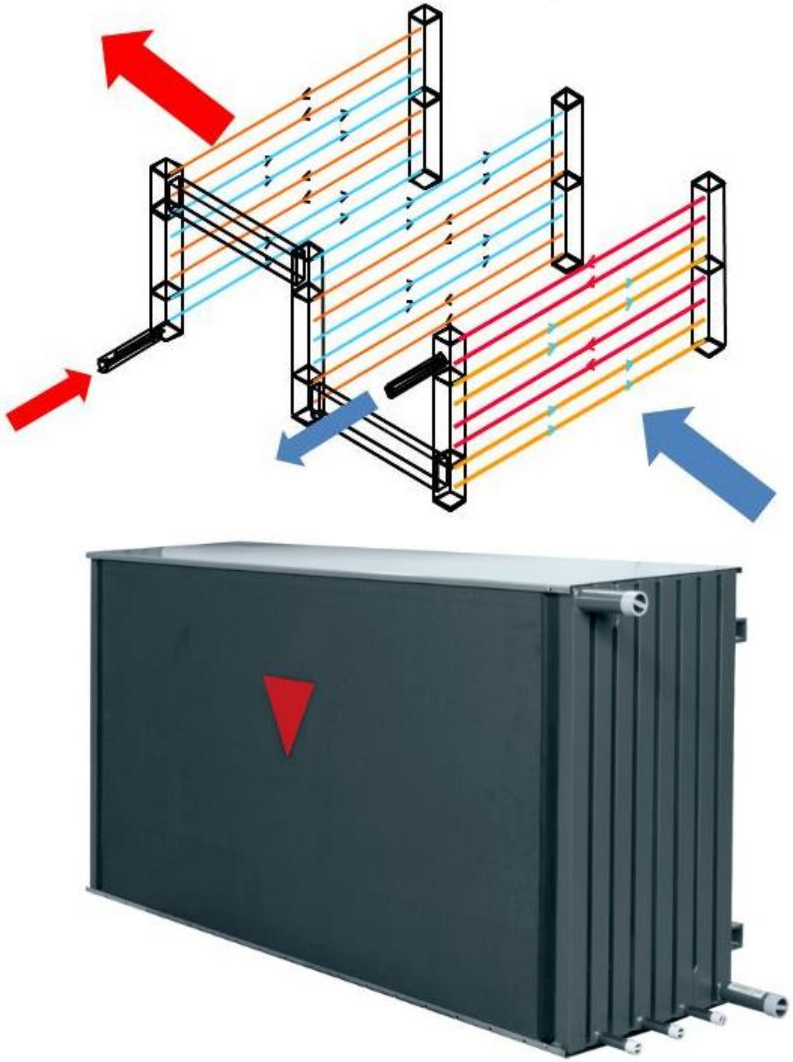
Energy Strategies: Konvekta

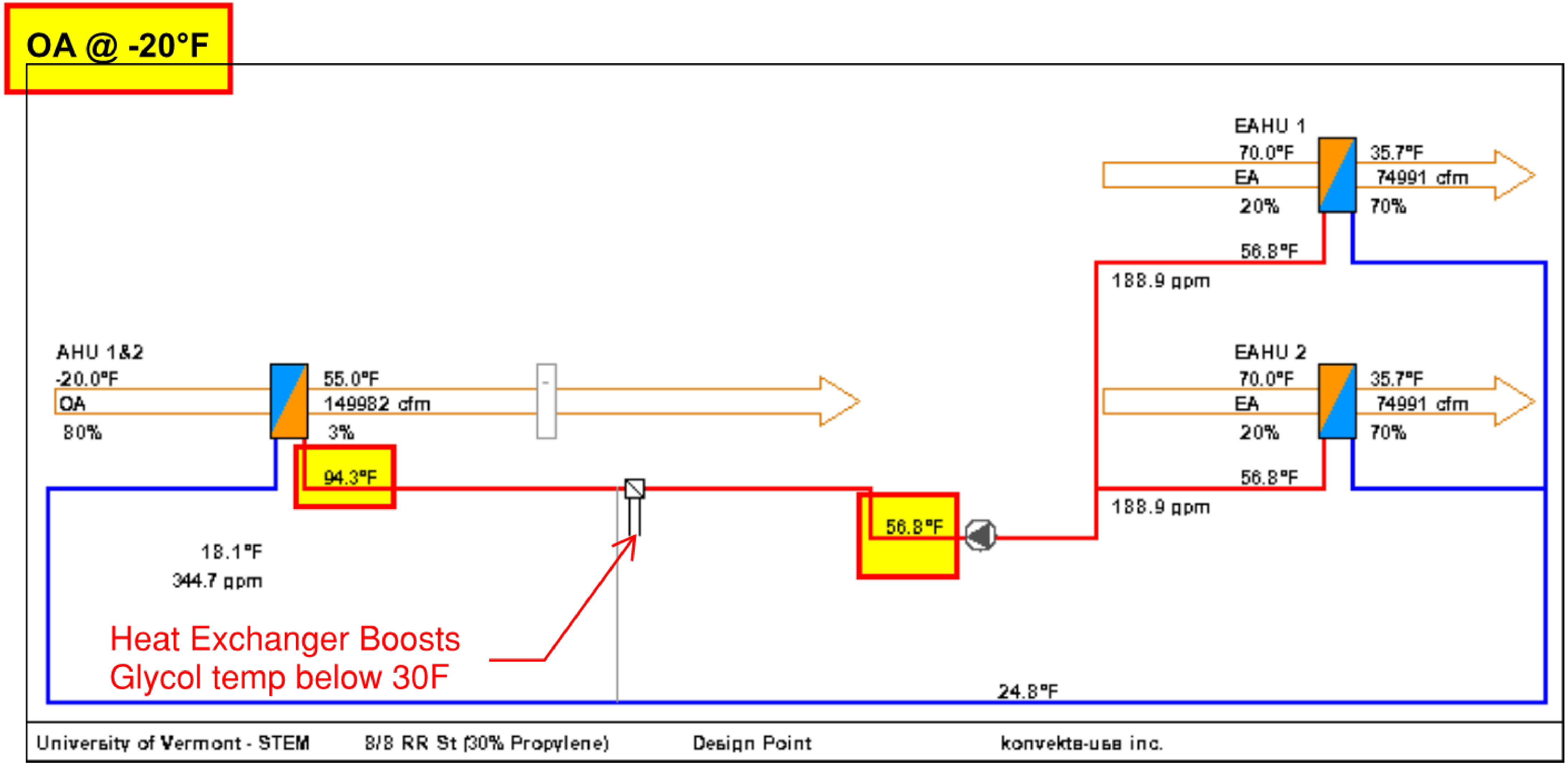


- Similar to glycol energy recovery, except higher effectiveness
  - 70% sensible effectiveness or higher is possible
- Can be enhanced to further increase performance and reduce building energy consumption
  - Central reheat heat recovery
  - Snow melt coil
  - Evaporative cooling heat rejection
- Enhanced – with Evaporative Cooling

Concerns…

- User Adjustability – low - go to user adjustability.
- Access to performance Trend data.
- Interface with BAS
- Freeze Protection Safeties
- Corrosives
- Commissioning Process
- Snow Melt Integration
- Frost Control
- Company location (Switzerland)
- Snowmelt coils sized for redundancy
- Snow management system – plenum entrainment

Heat Recovery Flow Diagram @ -20F



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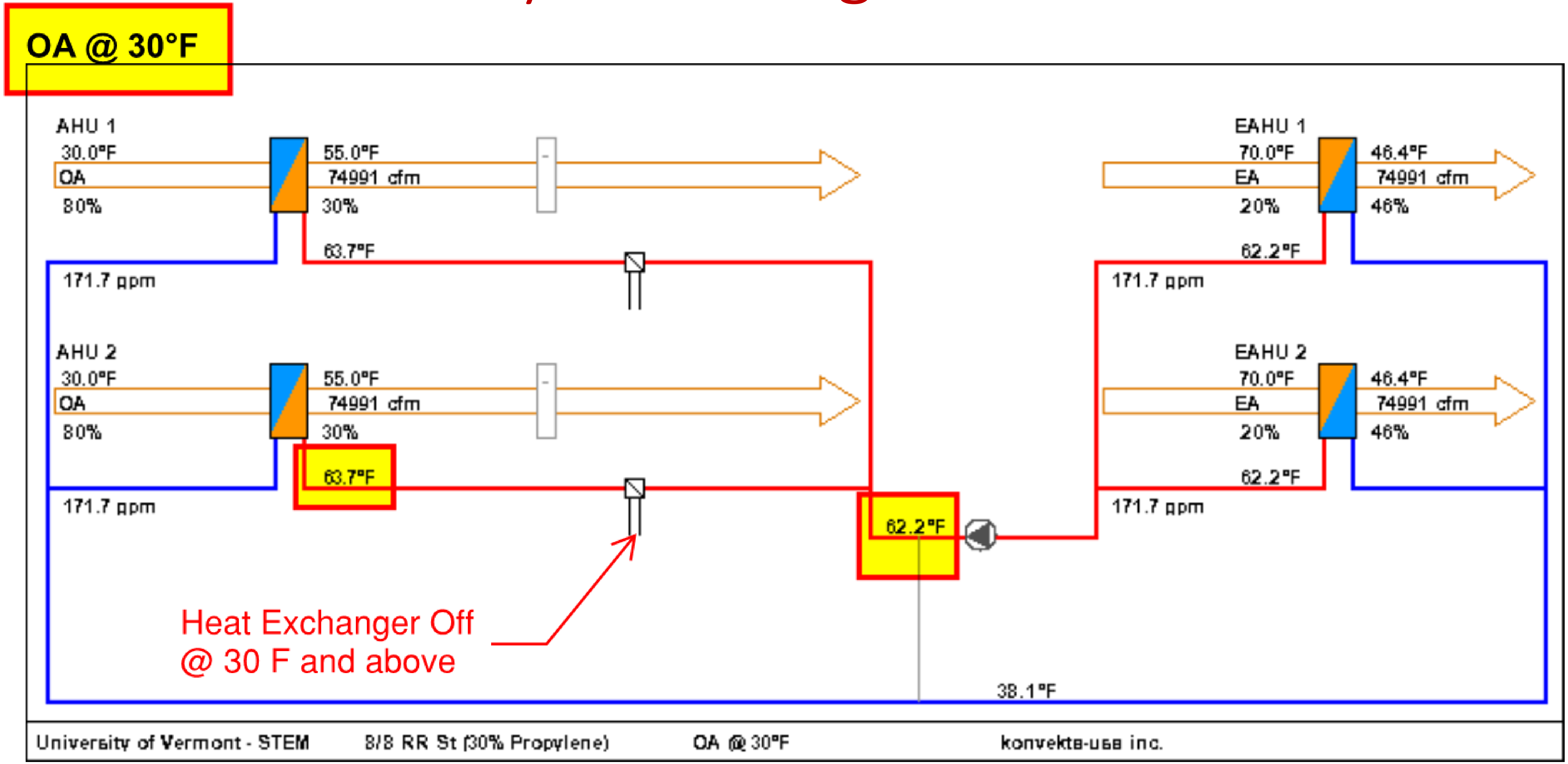
Heat Recovery Flow Diagram @ 30F



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Konvekta LCCA

	KONVEKTA SYSTEM
Net Construction Cost	$525,000
Net Annual Energy Cost Savings (FY18 rates)	$56,300
Simple Payback Period	9.3 years
Return on Investment	10.7%
20-Year Net Present Value	**$225,300**
Discounted Payback Period	12.2 years
Internal Rate of Return	**11.5%**

Traditional Heat Recovery – can't get there from here

Detailed Energy Model Results

		BASELINE	PROPOSED W/ TRAD GLYCOL		PROPOSED W/ KONVEKTA	
ENERGY COST	SOURCE	COST ($)	COST ($)	**PERCENT SAVINGS OVER BASELINE**	COST ($)	**PERCENT SAVINGS OVER BASELINE**
Space Cooling	Chilled Water	104,400	107,200	-3%	103,400	1%
Space Heating	Electricity	0	3,700	n/a	3,700	n/a
Space Heating	Steam	194,000	159,500	18%	120,200	38%
Pumps	Electricity	9,300	12,200	-31%	15,900	-72%
Fans	Electricity	224,000	188,600	16%	179,500	20%
Equipment Loads	Electricity	163,200	165,300	-1%	165,300	-1%
Domestic Hot Water	Steam	9,500	7,600	20%	7,600	20%
Interior Lighting	Electricity	87,600	62,300	29%	62,300	29%
Exterior Lighting	Electricity	830	850	-1%	850	-1%
Total Building Energy Cost		**792,500**	**707,200**	**11%**	**658,900**	**17%**

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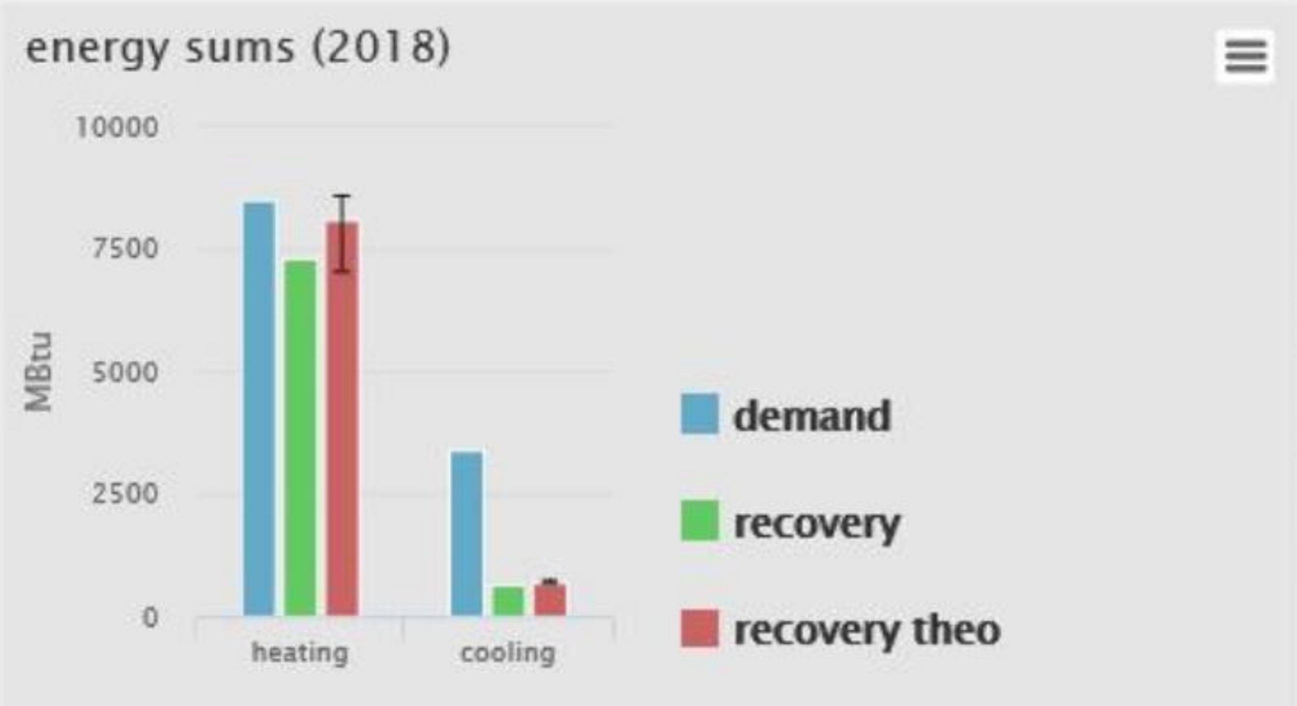
Konvekta Energy – Measured Performance at STEM



energy sums (2018) // (MBtu)	heating	cooling
demand	8509.57	3407.44
recovery	7278.34	636.42
recovery theo	8077.03	691.98
recovery theo range(max)	8561.43	726.39
recovery theo range(min)	7042.48	654.15
rate of use (%)	85.5	

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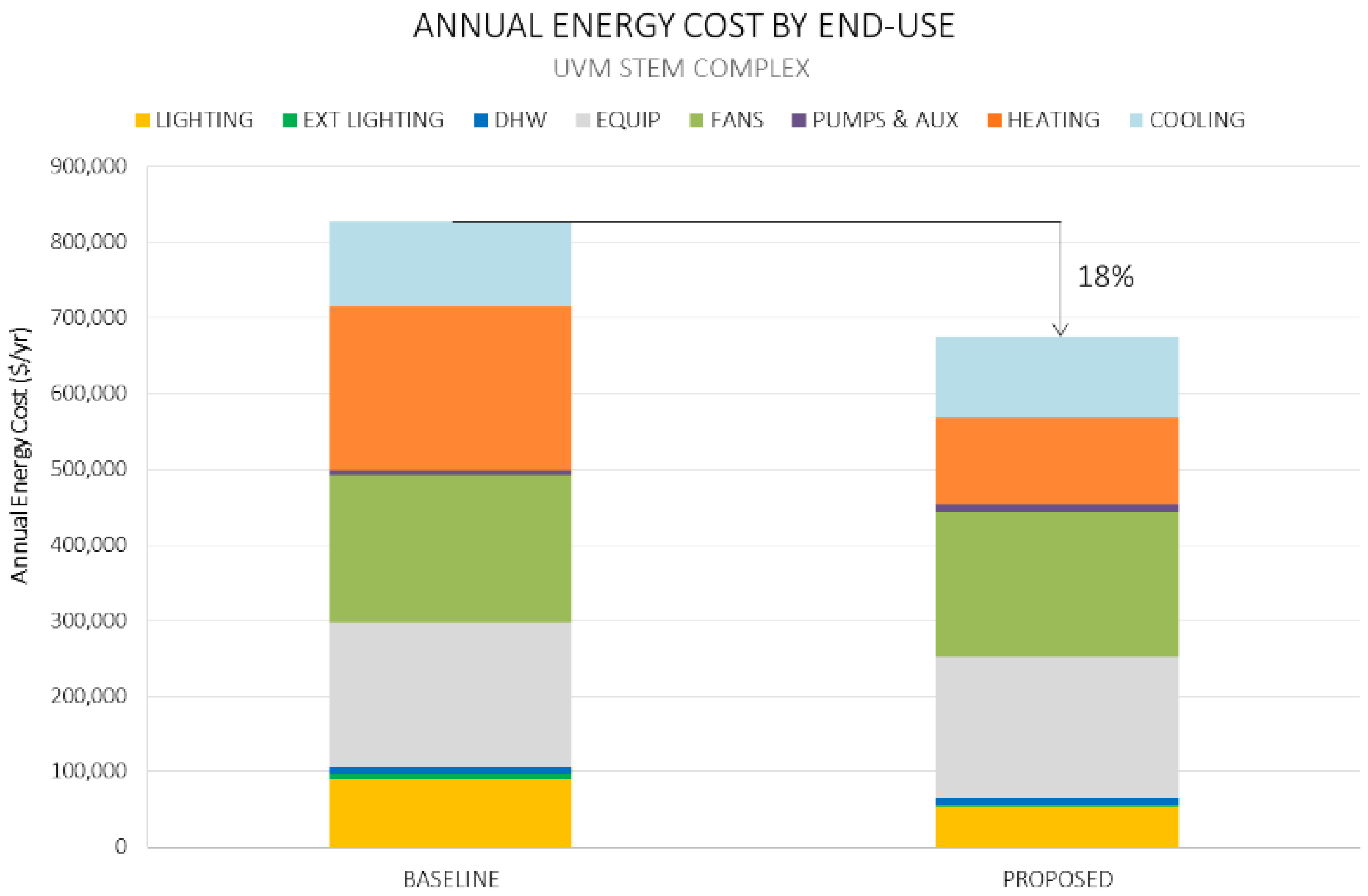
Energy Modeling Projected Energy Cost Savings



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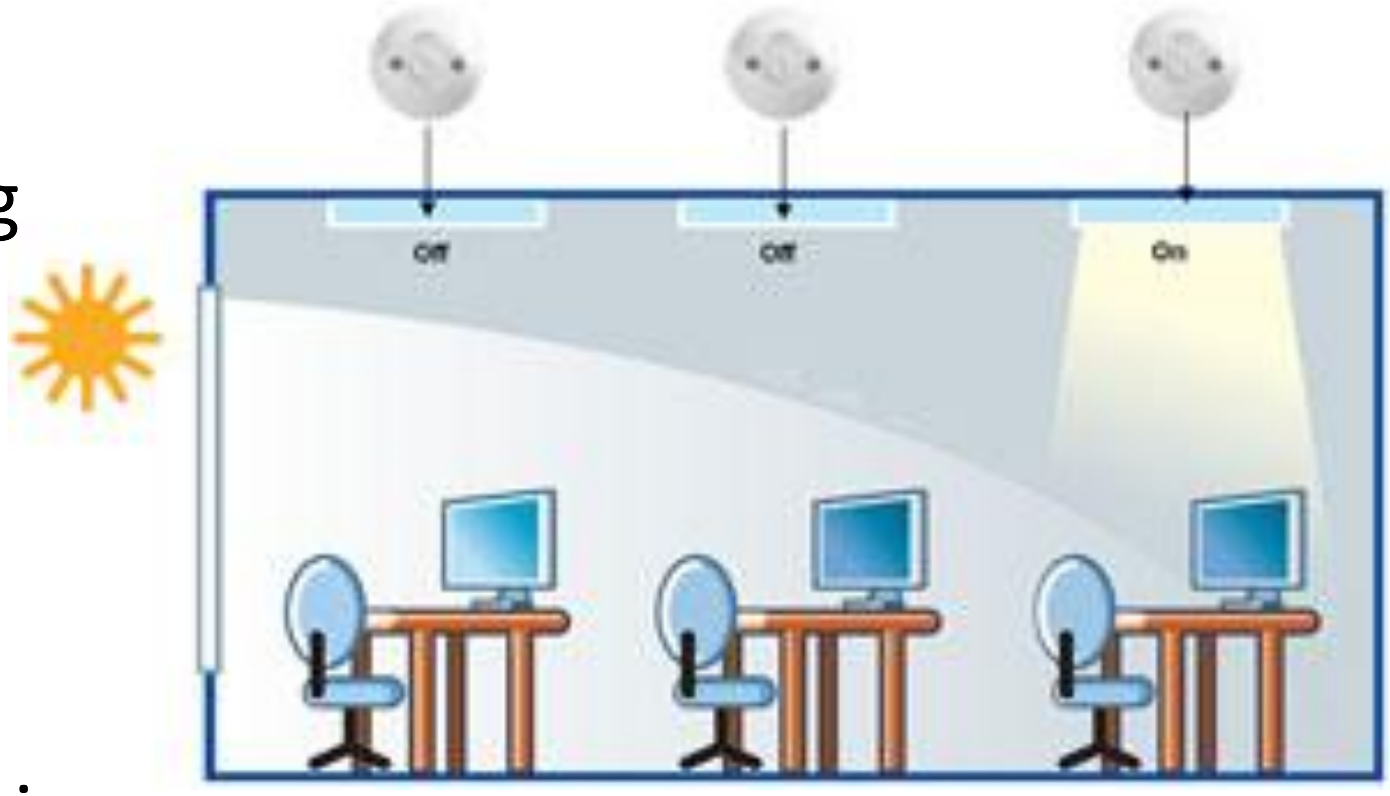
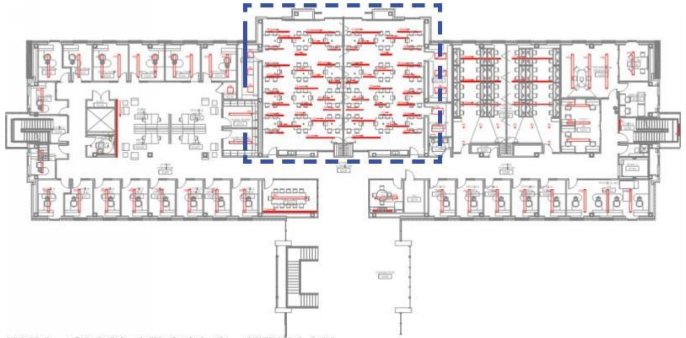
Lighting Controls

- High efficiency LED lighting fixtures and lamps (33.3 % better than ASHRAE 90.1)
- Occupancy sensor based lighting & VAV control in most areas
- Daylight dimming controls in perimeter areas

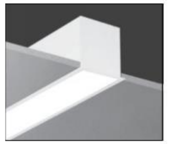


Lighting Performance



UMV - CLASS / FLOOR 2 - KEY PLAN

M100 LED Recessed Linear LED Flanged Extrusion **selux**



Project: ______

Type: ______ Qty: ______

___ – 1L35 – ___ – LW – ___ – ___ – ___ – ___

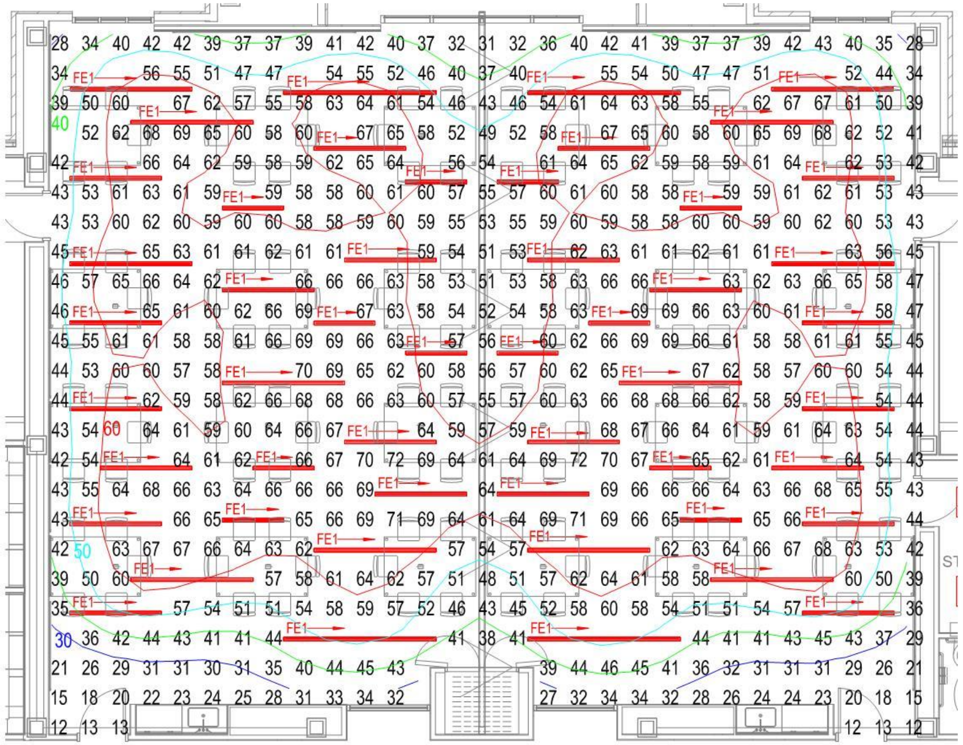
Series – Light Engine – CCT – Shielding – Mounting – Nominal Length – Finish – Voltage

______

Options

Series	Light Engine	CCT	Shielding	Mounting	Nominal Length	Finish	Voltage	Options
L1R1U M100 Recessed Linear LED Flanged Extrusion **L1R2U** M100 Recessed Linear LED Flush End (Flanged Extrusion /Flangeless Endcaps) (L1R2U not to be used with T-Bar ceiling)	**1L35** Single Linear LED	**27** 2700K **30** 3000K **35** 3500K **40** 4000K	**LW** LED optimized white lens	**SH** Suspension Clips **TS** 1" Studs (factory installed) **RC**[2,3] Rotating Crossbars **PM** Perimeter Mount	**01** 1 ft. **02** 2 ft. **03** 3 ft. **04** 4 ft. **05** 5 ft. **06** 6 ft. **07** 7 ft. **08** 8 ft. **RUN** Create Run Runs can be pre-configured using various combinations in 1/4" steps, starting at 8ft.	**WH** White **BK** Black **SV** Silver **SP** Specify Premium Color	**120** **277**	**DM**[1] Dimming (0-10V) Linear **DML**[1] Dimming (0-10V) Logarithmic **DCE**[1] Lutron Eco-System Dimming CCR **DC3**[1] Lutron 3-Wire Dimming CCR **DMD**[1] Digital Addressable (DALI) Dimming **CCEA**[4] Chicago Plenum **EMN**[1] Battery Pack **TB** T-Bar Length (used for RUN only) **DL** Damp Location

[1] Consult factory for less than 2 ft. fixture length. [2] 3 ft. min. when using with DM, DML, DMD, or EMN. [3] Not available in 1' length. [4] Not available in combination with EMN.



IES RECOMMENDED ILLUMINANCE = 50Fc
DESIGN ILLUMINANCE (LED) = 54.9Fc

TYPE FE1= 10.1W/LF

TOTAL POWER LED = 3192W

SoE LAB AREA = 2778.8SF

AHSRAE 90.1 2007 = 1.4W/SF
DESIGN LPD LED = 1.2W/SF

SoE LAB
UVM-STEM LIGHTING ILLUMINANCE STUDIES

ARCHITECTURAL LIGHTING DESIGN

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Building Envelope

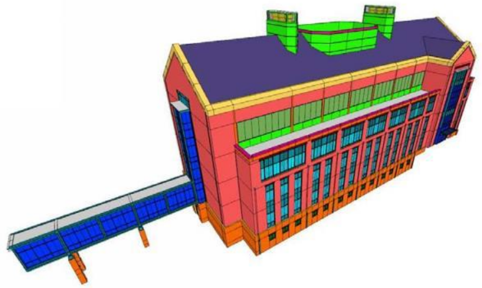
- Walls – R14.7 Continuous
- Roof – R35 Continuous
- Curtain wall – U 0.35
- Window-to-Wall Ration= 16%

STEM Complex – exterior materials areas

Lab building

UVM STEM Exterior building areas

	Lab bldg+bridge	Classrm bldg	Votey	Total
Brick veneer	34510	21424		55934
Cast stone veneer	9857	4888	228	14973
Cast stone coping	3712	2882		6594
Granite base	47	224	17	288
ACM panels	7312	3419	661	11392
ACM lintels	1273	1528		2801
Insulated metal panel	18147	2297		20444
Aluminum coping	2221	2557		4778
Curtain wall	5119	9150	1153	15422
Storefront	5486	3246		8732
Window units	239	1883		2122
Louvers	3692	1917		5609
Perf metal	407	462		869
Glass canopy	98	98	75	271
Slate roofing	15506	9072		24578
Membrane roofing	9140	8809	257	18206
Total surface area:	116766	73856	2391	193013



5 May 2014

More Insulation = Better....Usually

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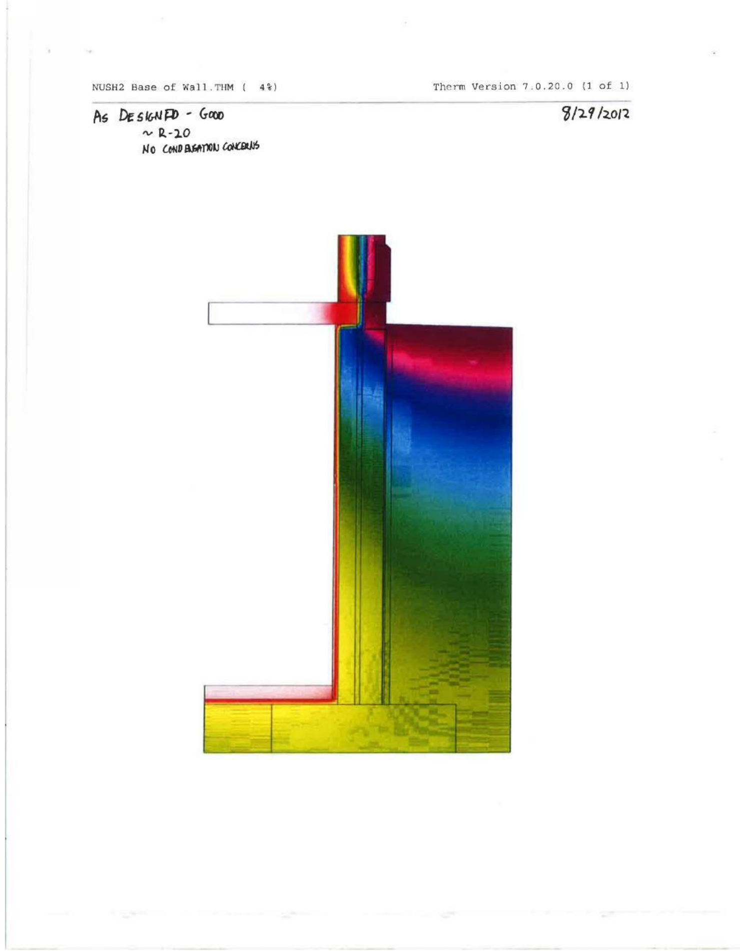
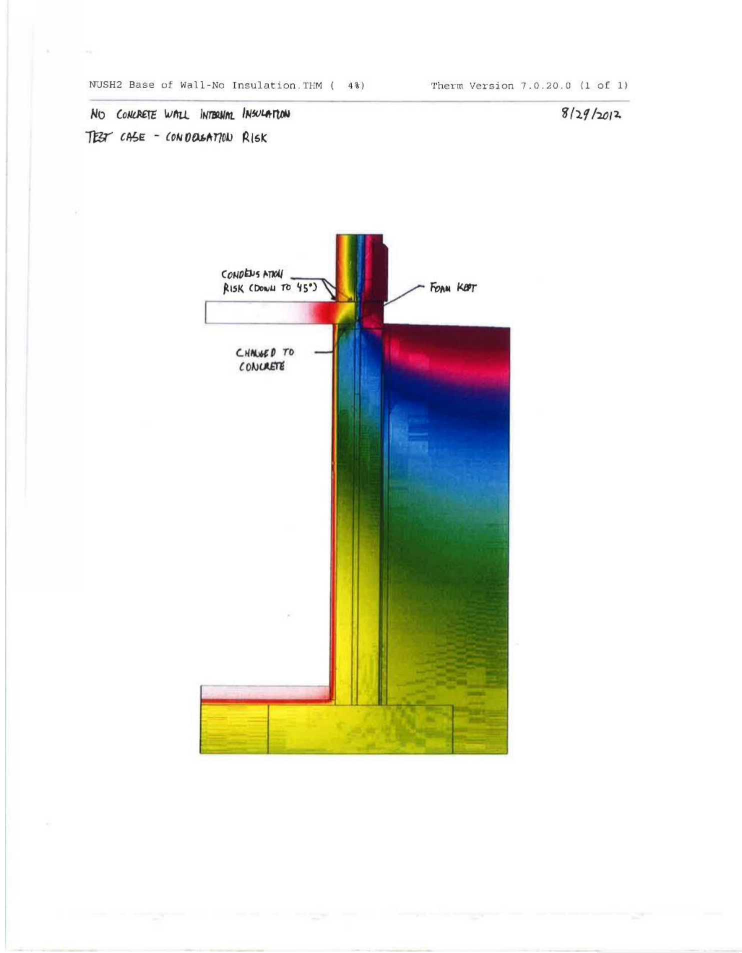
Details - Thermal Analysis





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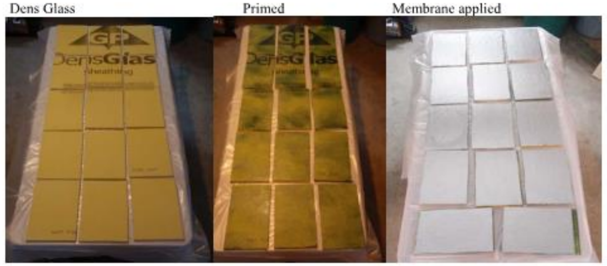
High Performance Air Barrier - Testing

Dens Glass Primed Membrane applied



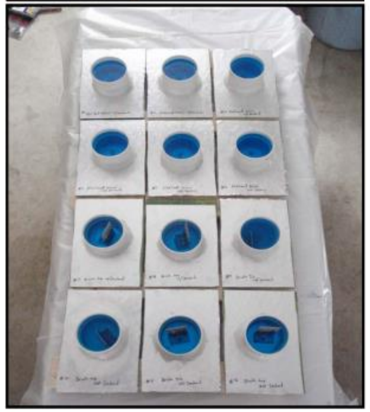
Left: masonry anchor and screws
Right: Glazing Screws

1-3 Flat head screw with sealant

4-6 Flat Head screw w/o sealant

7-9 Brick tie with sealant

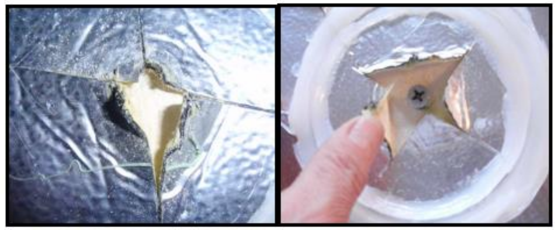
10-12 Brick tie without sealant



Dye water solution added and conditioned for 3 days, prior to review and inspection

Note: the size and the diameter of the fastener lifted the membrane as it displaced the gypsum in the board. In addition because the test was modified by using exterior gypsum the fasteners were never tightened down as installation in the field will be.

No leakage observed on screw bottoms



No leakage was observed passing the membrane when cut open

Results:

Assembly	Sample 1	Sample 2	Sample 3
Flat Head Screws w/Sealant	Pass	Pass	Pass
Flat Head Screws w/o Sealant	Pass	Pass	Pass
Brick Tie w/ Sealant	Pass	Pass	Pass
Brick Tie w/o Sealant	Pass	Pass	Pass

Observations and Conclusions:

Based on the above results Henry Metal Clad complies with the project requirements.

The testing has been modified to provide some representation of values that can be achieved on the actual project. However, these results were achieved by following the ASTM standard, and all work was performed in a controlled environment. Actual field installation results could vary. A conservative approach to sealing fasteners is always recommended vs. total reliance on the membrane's ability to self-gasket. Henry has a number of tech-notes on "sealing of fasteners" Additional information can be found at www.henry.com

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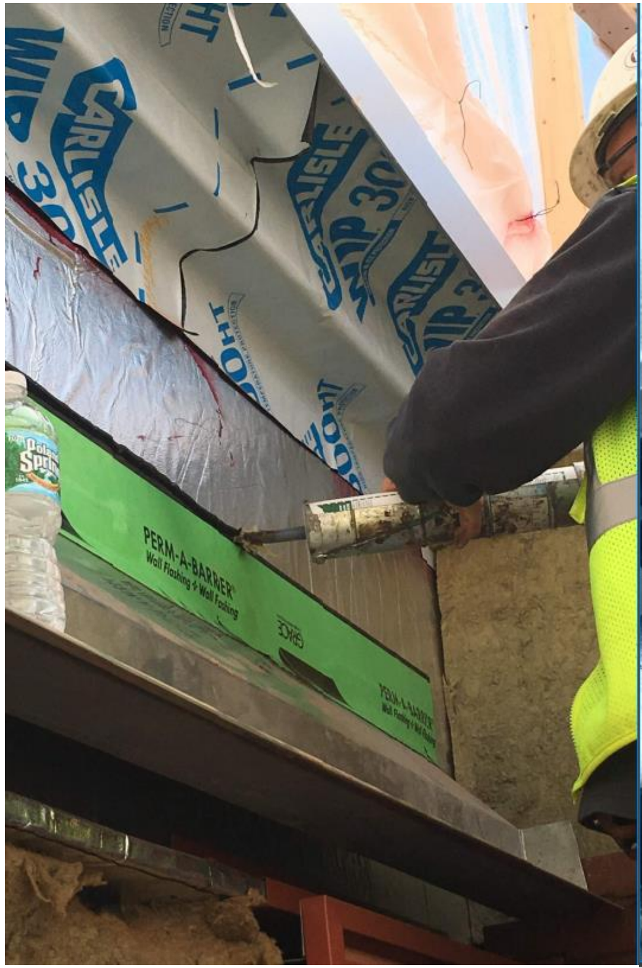
High Performance Air Barrier - Mockup



Building Envelope – Installation & Testing

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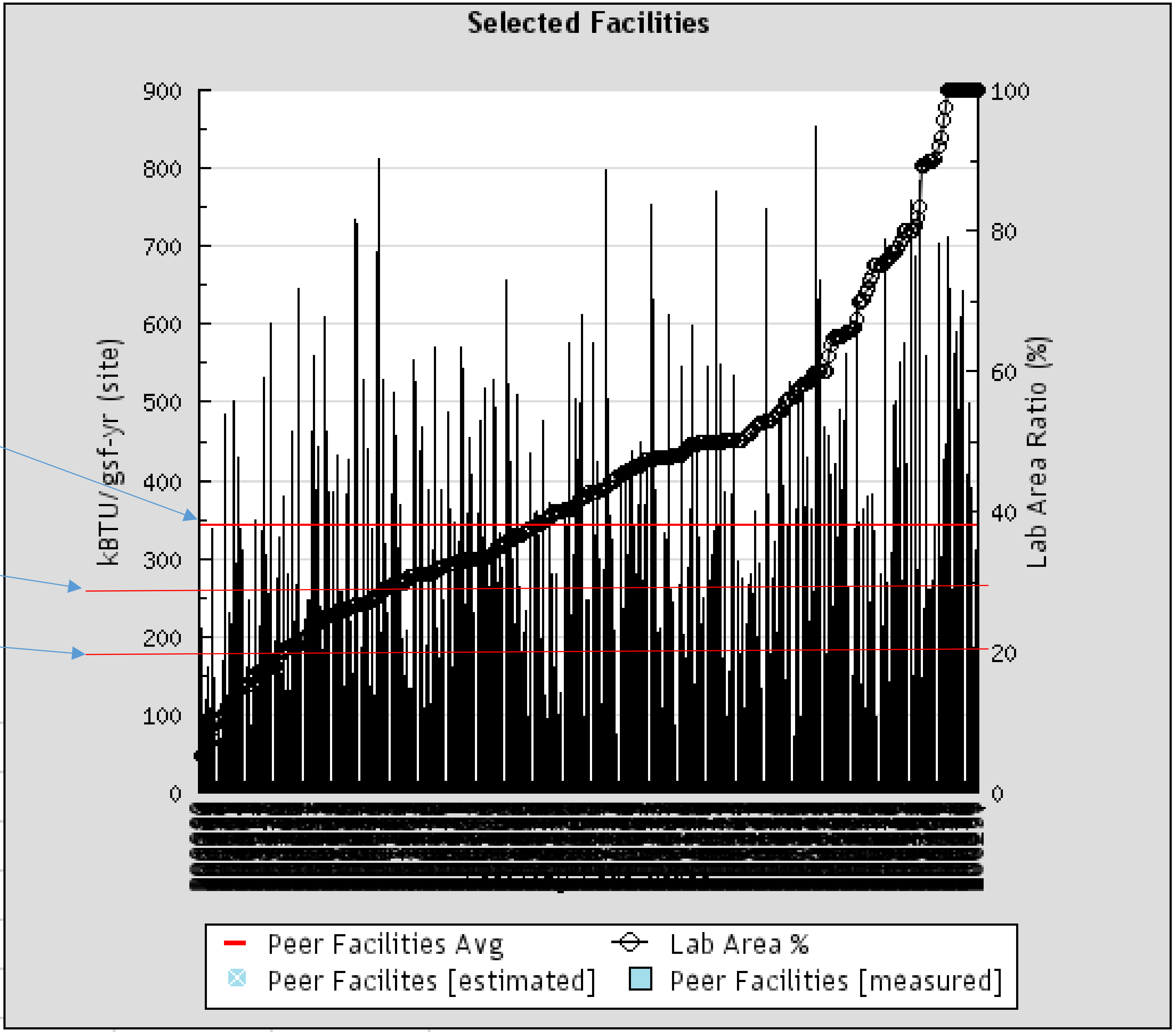
How STEM Stacks Up Labs21 Benchmarking

Labs21 AVG = 344 EUI

STEM Energy Model Baseline = 253 EUI

STEM = 188 EUI PREDICTED



Benchmark Statistics for Peer Facilities			
Total Building kBTU/gsf-yr (site)			
Min	Avg	Max	Count
70.45	344.44	853.48	333
Lab area ratio	0.00-1.00		
Occupancy hours	Both		
Lab type	Chemical, Biological, ChemicalBiological		
Lab uses	Research/Development, Manufacturing, Combination/Others, Teaching		
Climate zones	4A, 4B, 4C, 5A, 5B, 6A, 6B		

Electrical Energy Comparisons

STEM Discovery Bldg.

114,000 SQ FT

$ 2.72/SQ FT

Jeffords Research Bldg.

97,000 SQ FT

$ 3.88/SQ FT

Health Science Research Bldg.

125,000 SQ FT

$ 4.14/SQ FT

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Steam Performance Comparison

Health Science Research Bldg.

125,000 SQ FT

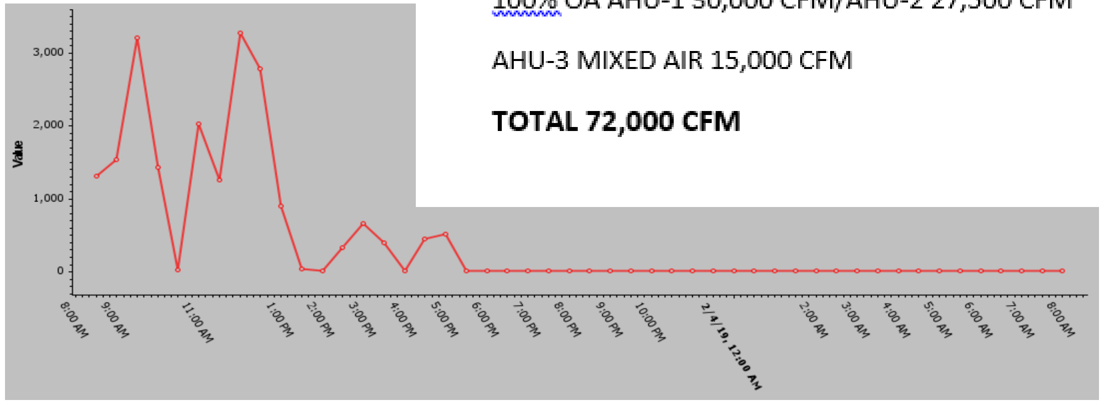
Peak Steam 1,000-3,000 LB/HR

HSRF 24 hour log 2/3-2/4

100% OA AHU-1 30,000 CFM/AHU-2 27,500 CFM

AHU-3 MIXED AIR 15,000 CFM

TOTAL 72,000 CFM



STEM Discovery Bldg.

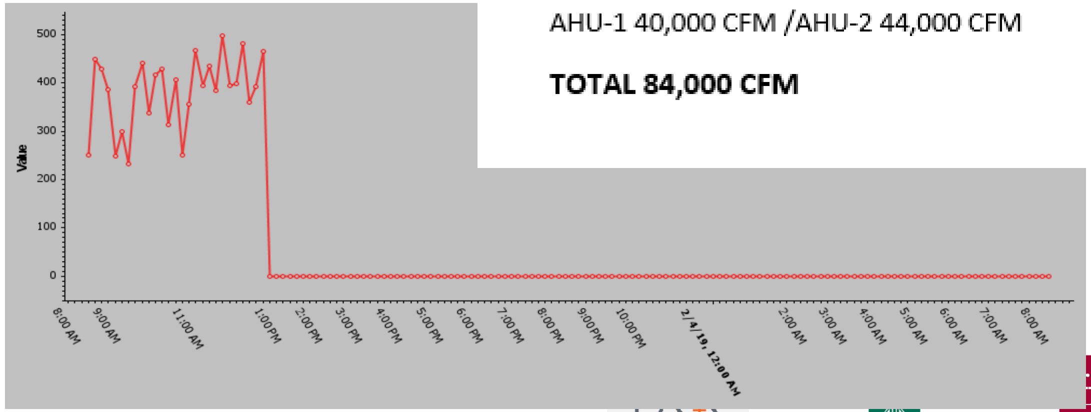
114,000 SQ FT

Peak Steam 300 - 500 LB/HR

STEM 24 hour log 2/3-2/4

AHU-1 40,000 CFM /AHU-2 44,000 CFM

TOTAL 84,000 CFM



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Moving Forward

Evolving Energy Codes - New Technologies - Flexibility/ Adaptability - Automation & Monitoring - Collaboration

Highly ventilated building types include: Manufacturing Foodservice Restroom Production Automotive + more

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Questions and Discussion

- Lynn Wood, Davis Zone Manager, University of Vermont 802-656-8864
- Bryan Rydingsward, PE Engineer, BR+A 617-925-8225
- Evan Champagne, Project Architect, Freeman French Freeman 802-864-6844
- Alex Halpern, Principal In Charge, Freeman French Freeman 802-864-6844

<u>Overall Design Team</u>

The University of Vermont – Owner

Freeman French Freeman - Architect of Record

Ellenzweig – Design Architect & Lab Planner

BR+A - MEP Engineers

RWDI – Air Quality/ Wind Analysis

LeMessurier – Structural Engineer

Krebs & Lansing – Civil Engineer

SE Group – Landscape Architect

Acentech – Acoustical & Vibration Engineer

Cavanaugh Tocci Associates - Audio Visual Consultant

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