Keeping a Smart Lab Smart Requires Metering, Monitoring, and Metrics

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Learning Objectives:

- Identify building operation metrics, and how they are affected by lab practices.
- Understand how UCI uses sub metering and dash boarding to compile data at the building, floor, and zone level.
- How to use data analysis to reduce operating cost and ensure continuous commissioning.

Agenda

1. Smart Lab vs. Previous Best Practice
2. Metering and Monitoring Installed
3. Lab Energy Use, 2001 vs. 2010
4. Smart Continuous Commissioning

Previous Best Practice vs. Smart Lab

	2001 Best Practice	Gross Hall 2010 Smart Lab
Air-handler/filtration airspeeds	400 ft/min. max	350 ft/min. max
Total system (supply + exhaust) pressure-drop	6 in. w.g.	<5 in. w.g. (incl. dirty filter allow.)
Duct noise attenuators	Few	None
Occupied lab air-changes/hr. (ACH)	6 ACH	4 ACH w/contaminant sensing
Night air-change setback (unoccupied)	No setback	2 ACH w/occupancy + contaminant sensing
Fume hood face-velocities	100 FPM	100 FPM
Fume hood face-velocities (unoccupied)	100 FPM	60 FPM (Zone Presence Sensors)
Exhaust stack discharge velocity	~3,500 FPM	~2,100 FPM Wind Tunnel Modeled
Lab illumination power-density	0.9 watt/SF	0.6 watt/SF w/LED task lighting
Fixtures near windows on daylight sensors	No	Yes
Energy Star freezers & refrigerators	No	Yes
Out-perform CA Title 24	20-25%	50%

Lab Efficiency Cycle

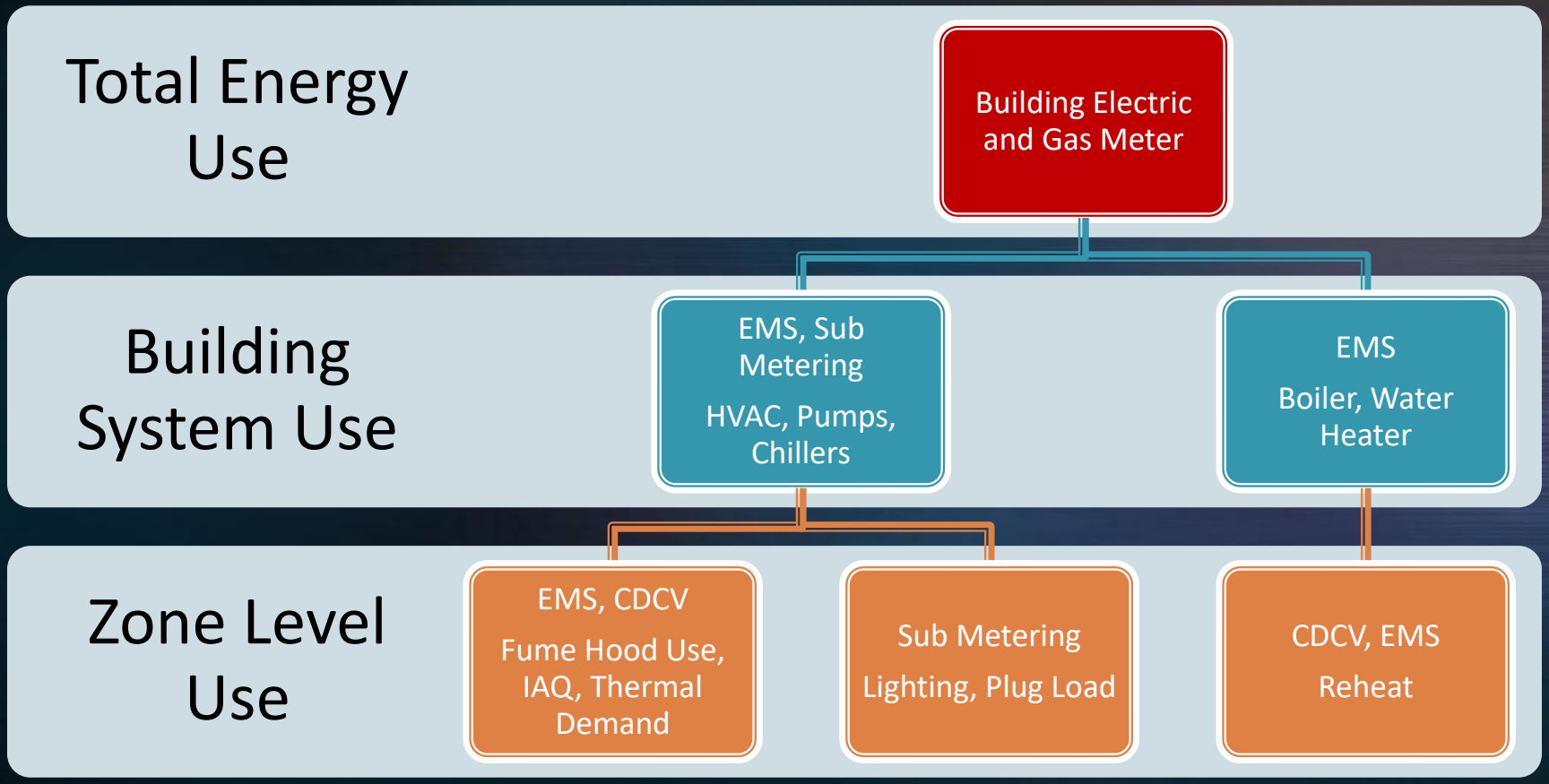
UCI's Goal is to reduce lab energy consumption by 50%

Verify savings and use added tools to constantly commission labs

Review data, Labs21 Toolkit, Scope out energy project

Implement Smart Labs
CDCV, ESDVR, Day Lighting and Lighting Controls, Low Pressure Drop Filters, Remove Duct Noise Attenuators, Static Pressure Reset

If you can't see where the energy is going, finding savings will be difficult.



At the zone level, measurement and verification resolution are so high you are essentially constantly commissioning the building

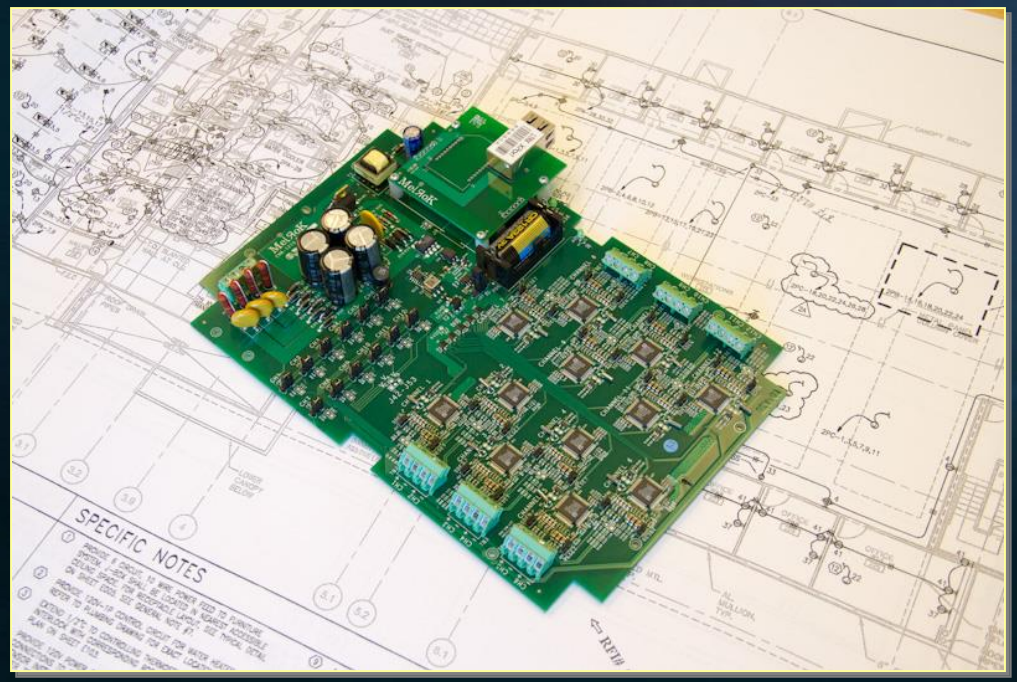
Cost Effective Sub Metering

Meter Specs

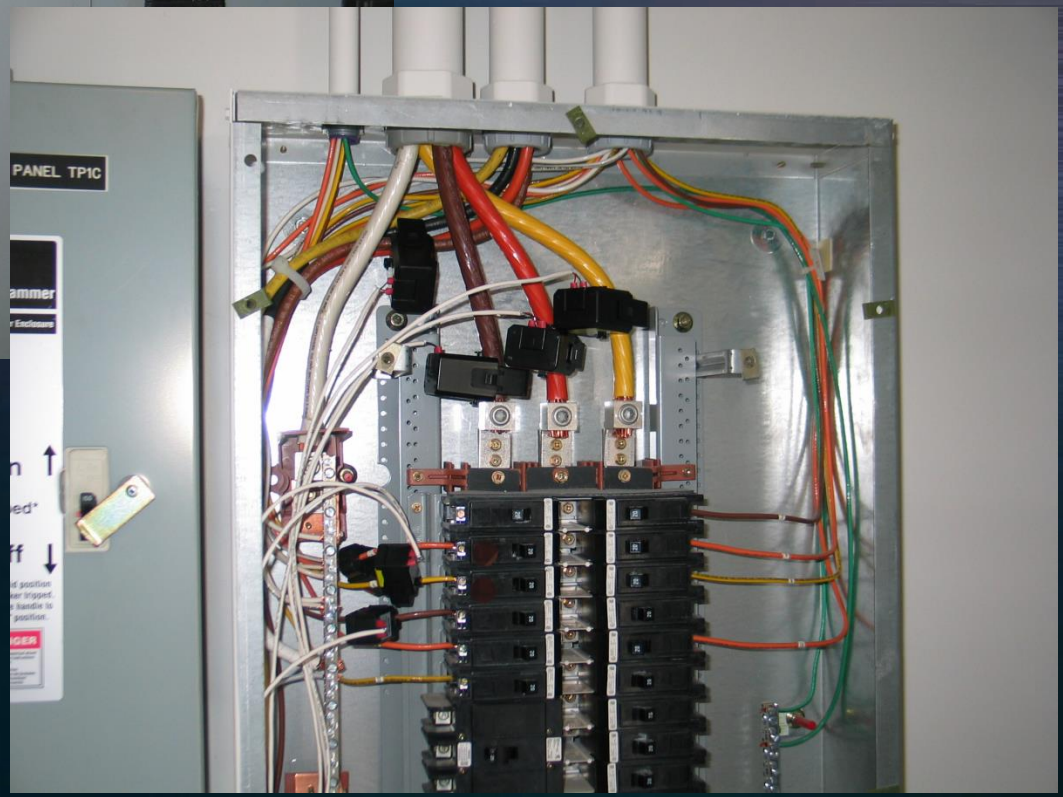
- 12 Channels Per Board
- Meter accuracy: +/- 0.5% (0.25% Typ.)
- V, I, Active Energy, Reactive Energy, Power Factor

Current Transformer Specs

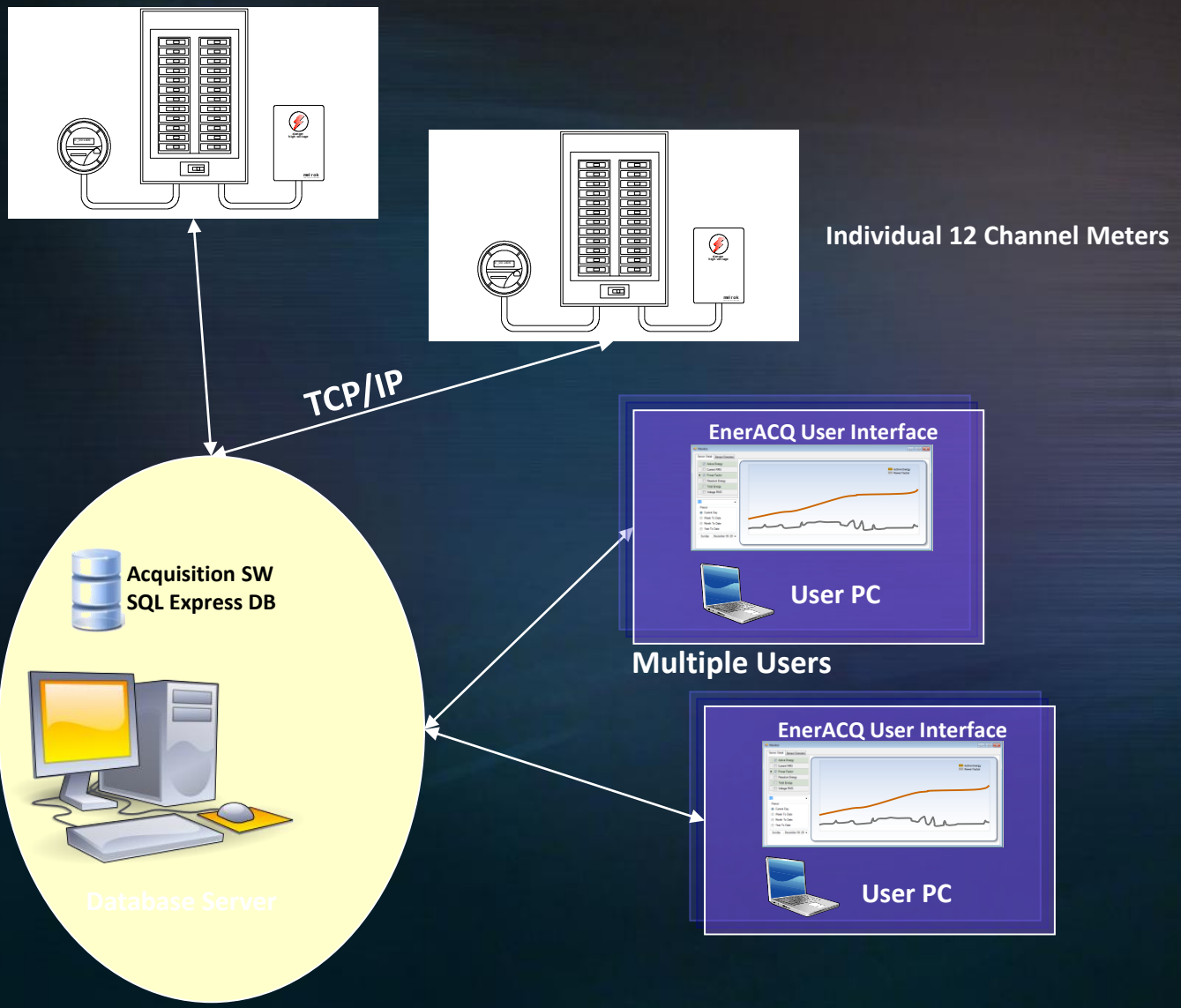
- Sensor Accuracy: +/- 1%
- CT's 60-400 Amps
- Clamp on installation



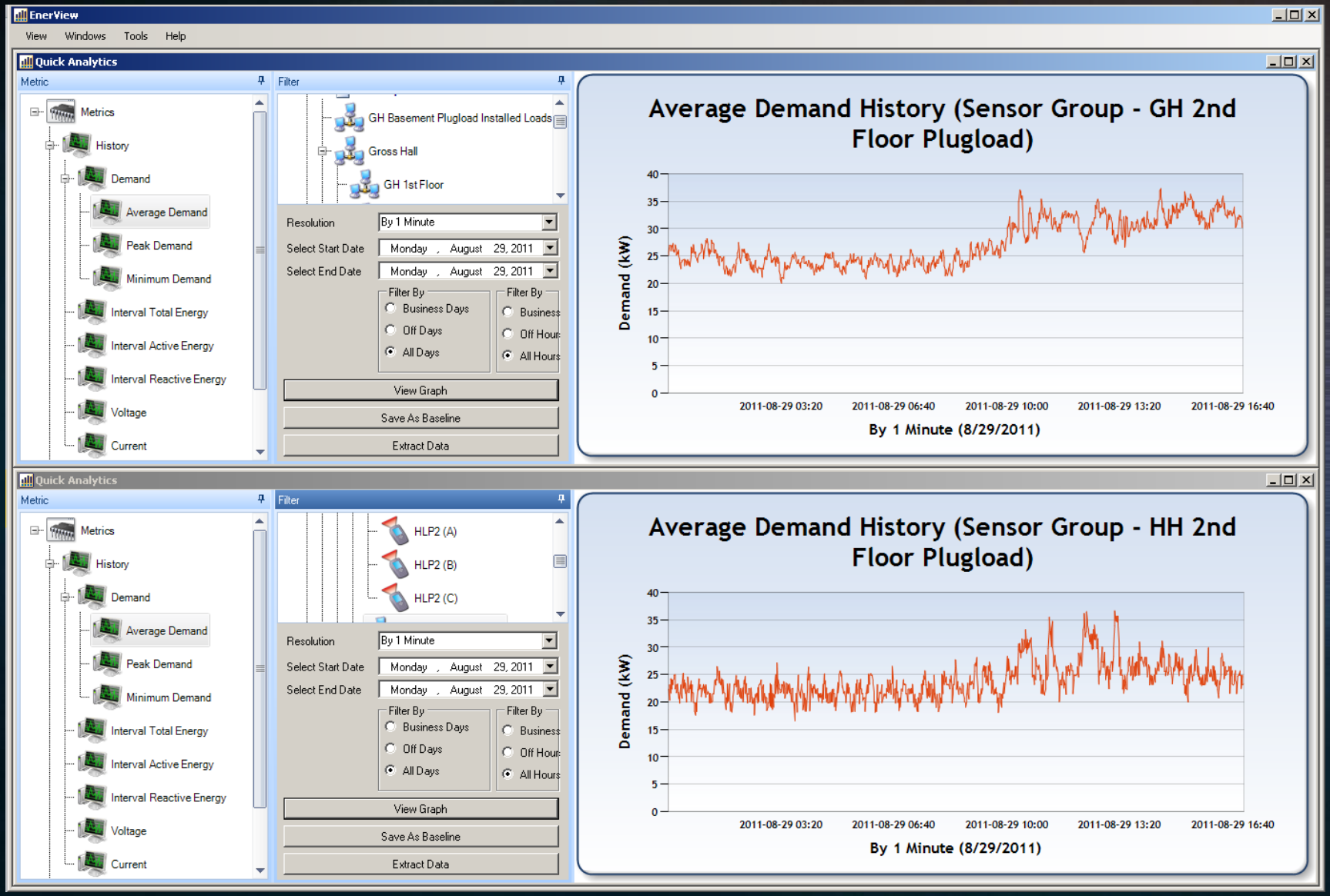

WARNING / HIGH VOLTAGE INSIDE
DISCONNECT SUPPLY BEFORE OPENING
HIGH WATER ALARM
PNL 1HA 277/480V
CKT 19 21 23


PANEL TP1C

System Description



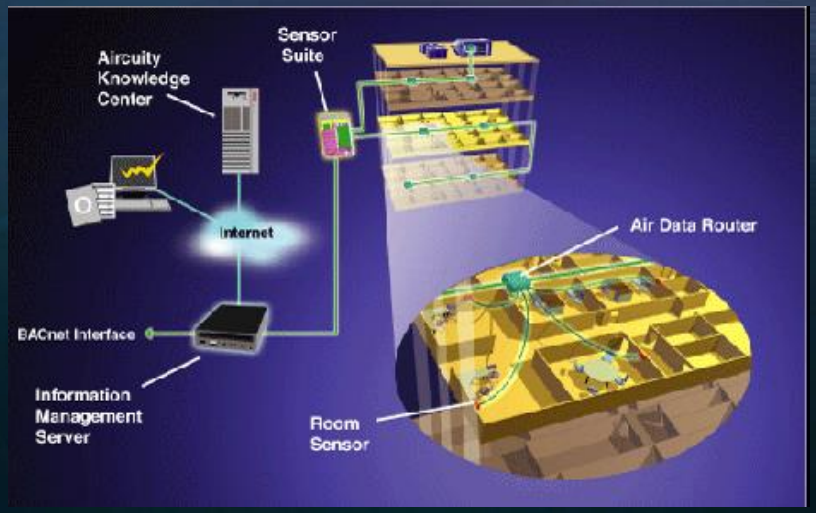
Visualization of lab energy use



CDCV System

Dashboard and Data Trends for each zone:

- Air Change Rates
- IAQ
- Sash position of each fume hood
- Occupancy
- Relative Humidity
- Temperature
- Total Supply
- Total Exhaust

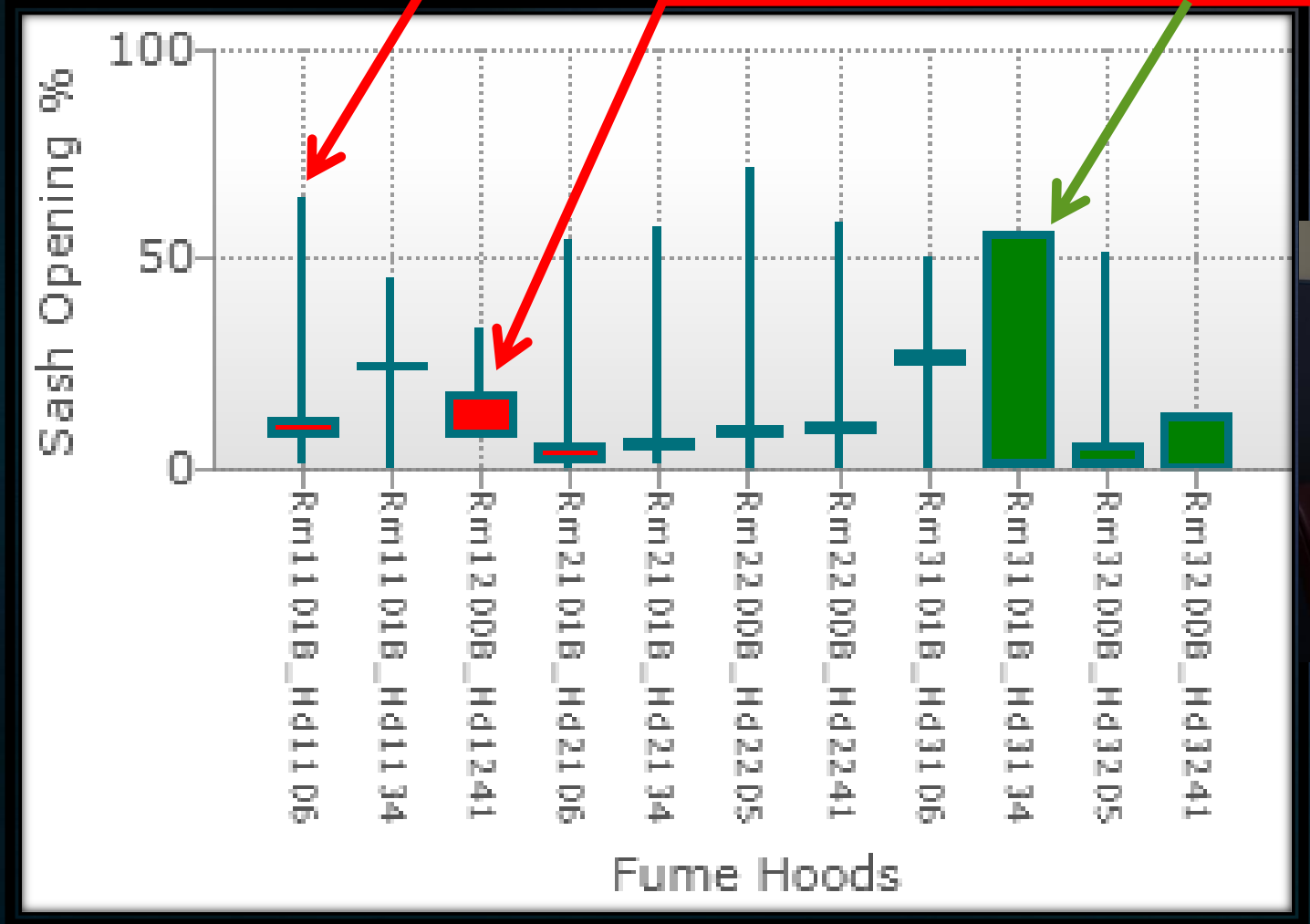


Visualization of lab HVAC use

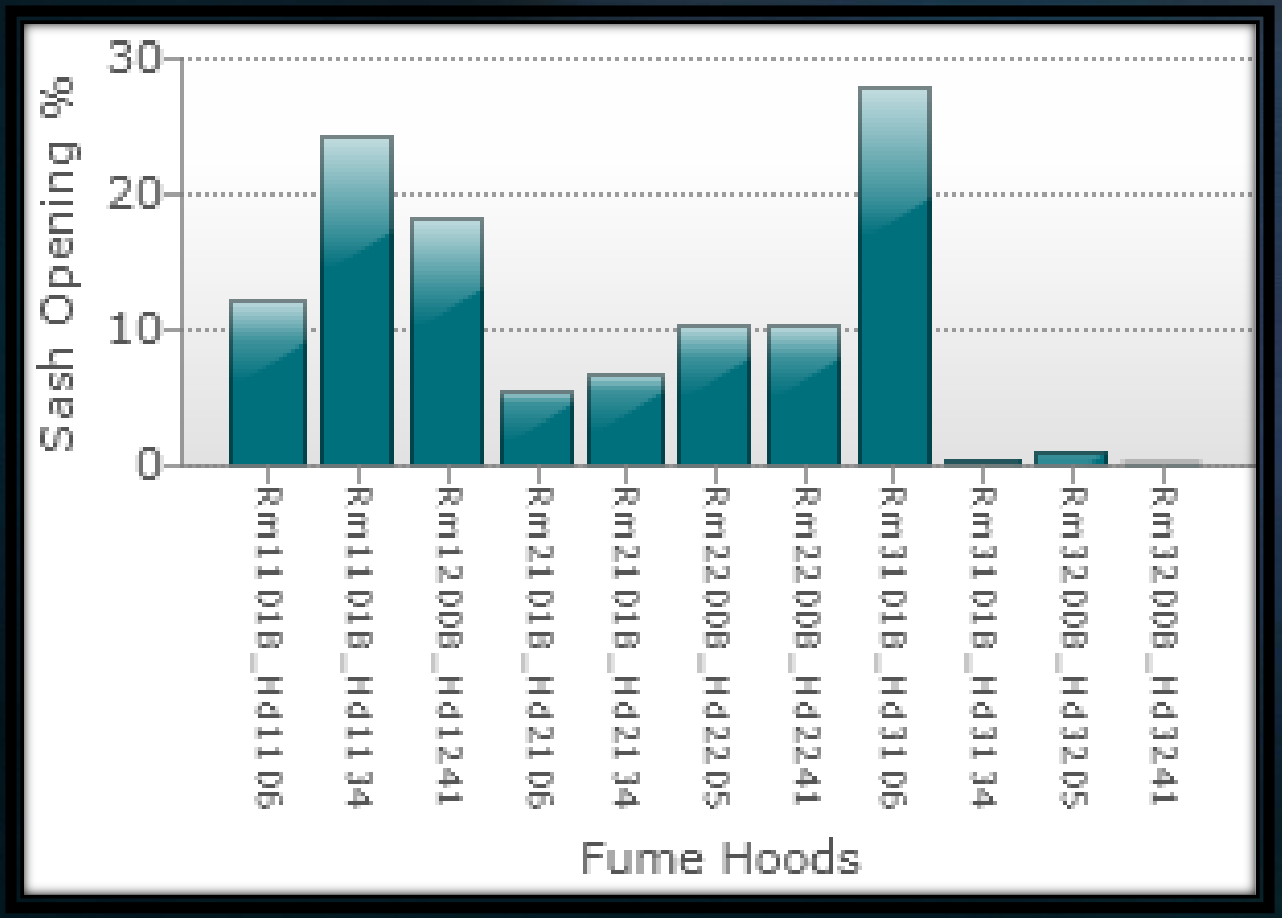
Monitoring Fume Hood Usage

- Fume hood usage range
- This hood shows usage between 0% open and 65% open

- Change in average sash position from the month prior
- Red indicates poorer average green indicates improved average sash management



How many hoods are in use right now in your lab and how far open are the sashes?



Smart Labs are not just controls and sensors.

Smart Labs provide real time feedback as well as monthly reporting data that is actionable.

Return on investment is directly affected by lab practices.

Hewitt Hall vs. Gross Hall

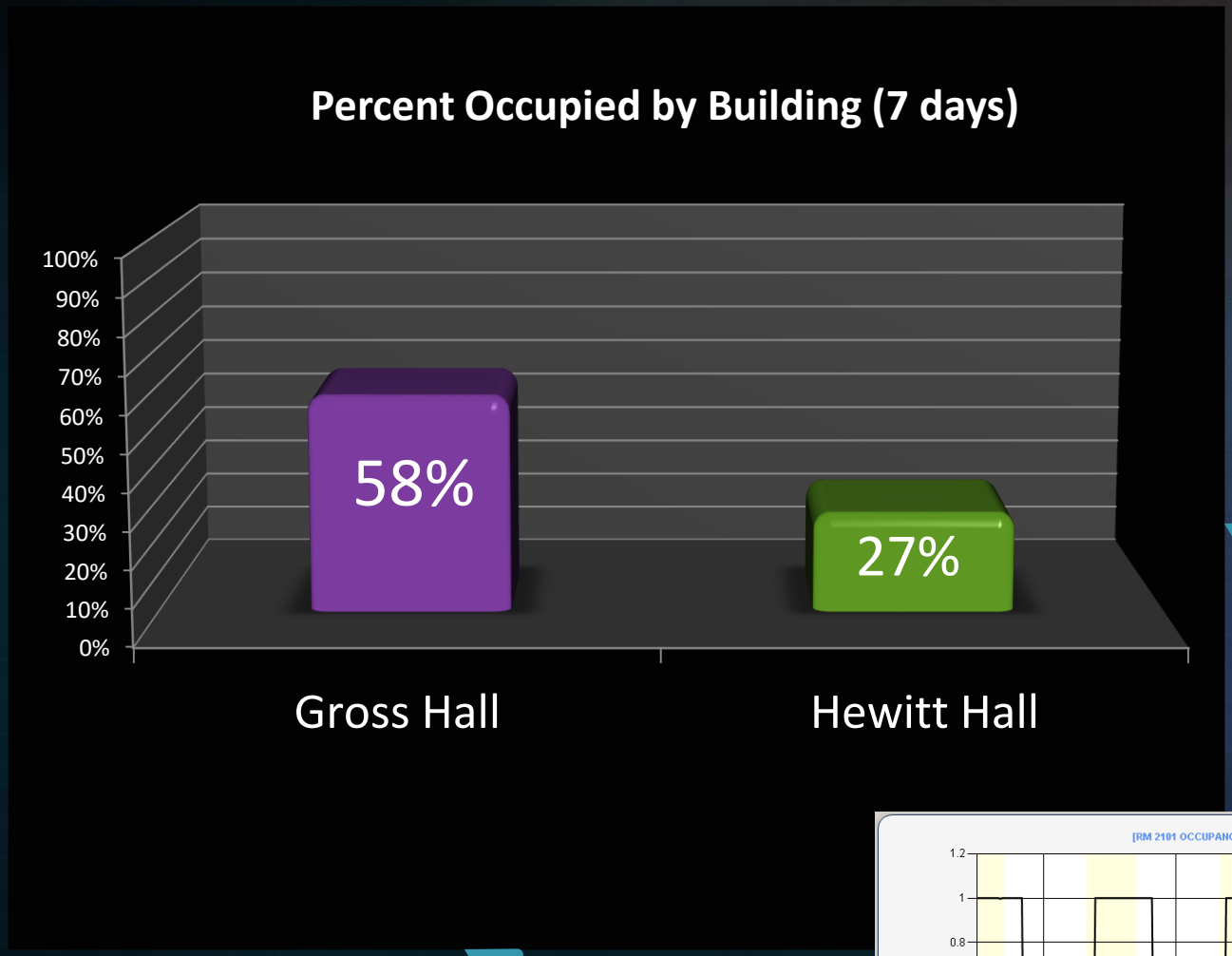
Designed in 2001

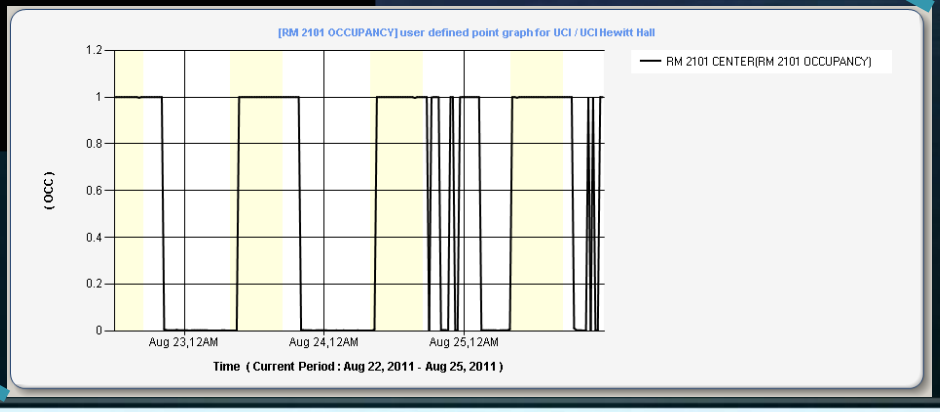
- Exceeded Title 24 by 23.7%
- Biomedical research
- Lighting upgrade in 2009
- Exhaust Stack Discharge Velocity Reduction in 2009
- Re-Commissioned in 2010
- 76,905 Square Feet

Designed in 2009

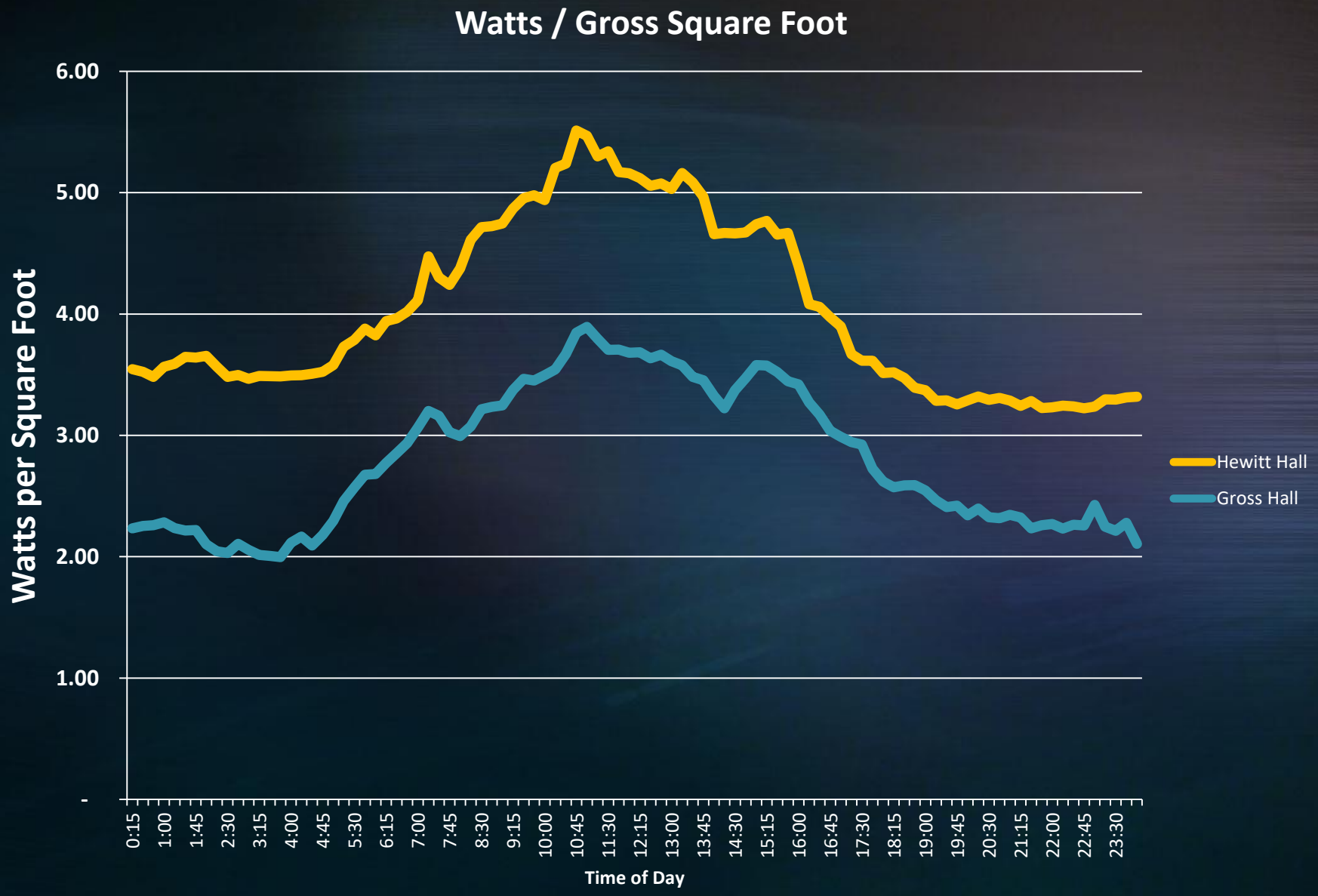
- Exceeded Title 24 by 50.4%
- Biomedical Research
- Submitted to USGBC for LEED Platinum certification
- 94,705 Square Feet

Gross Hall's Lab Utilization Is Nearly Twice Hewitt Hall's



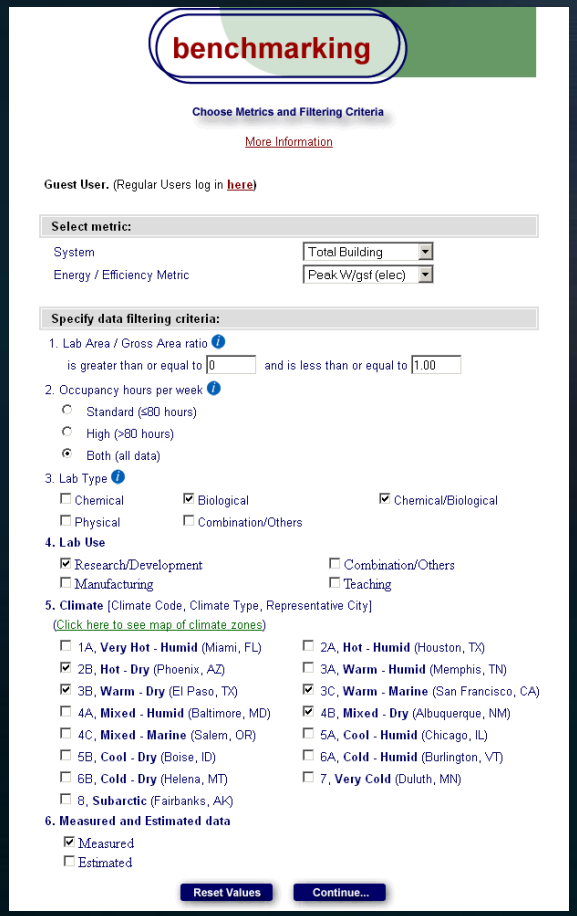


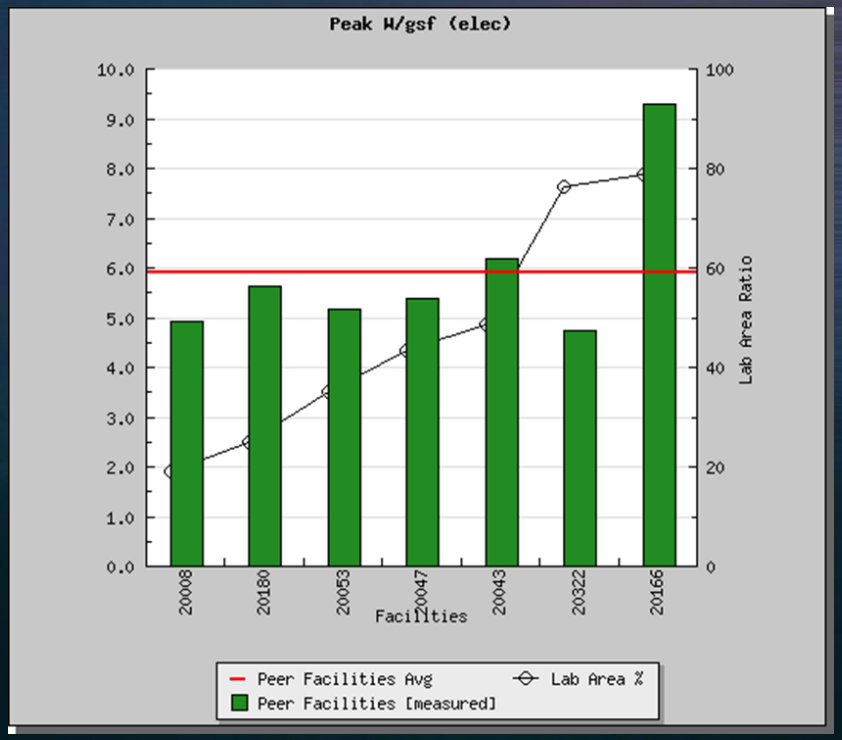
Building Load Per Square Foot



Benchmarking

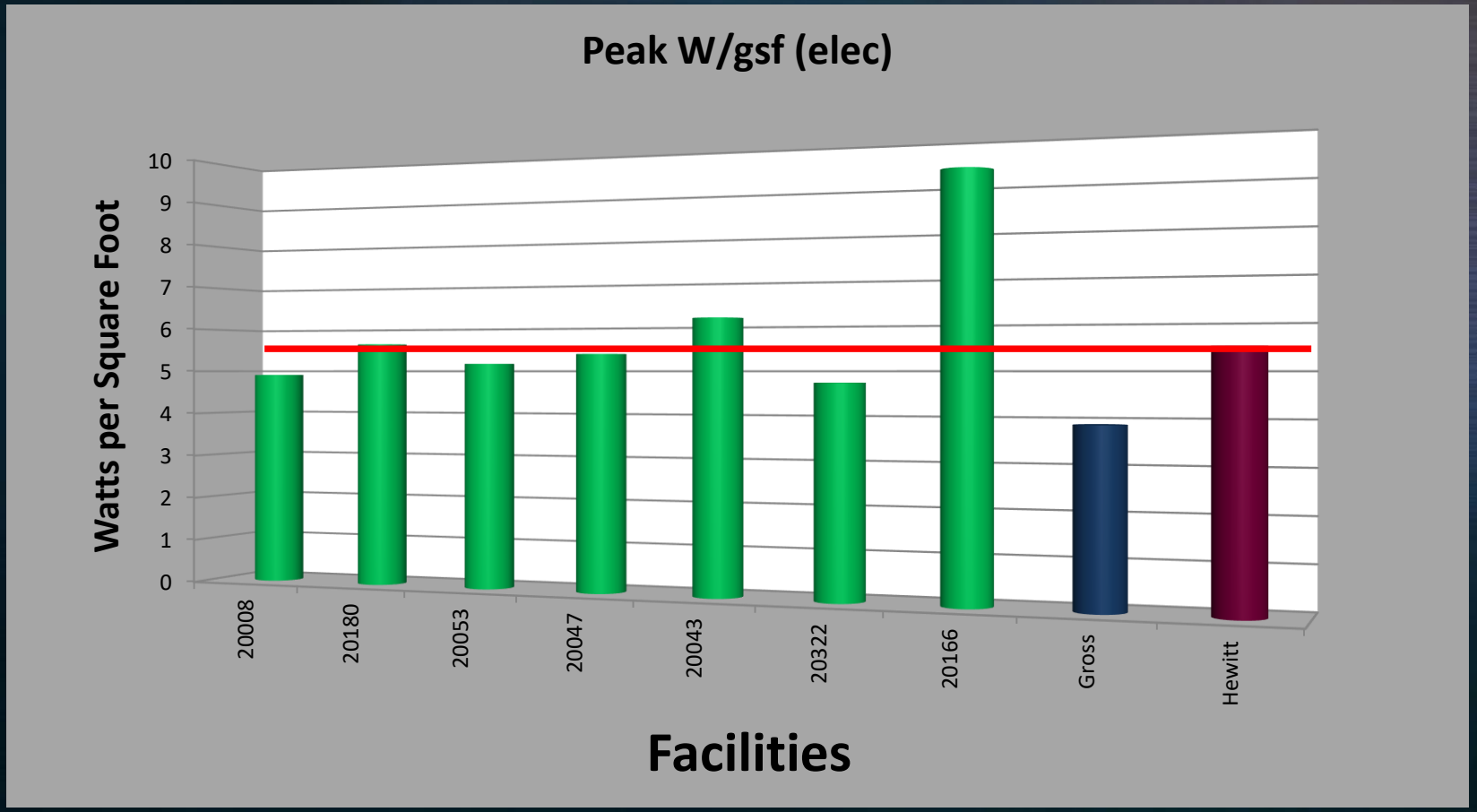
- It is easy to see how campus labs compare to each other but what about across the country?
- http://labs21benchmarking.lbl.gov/CompareData.php

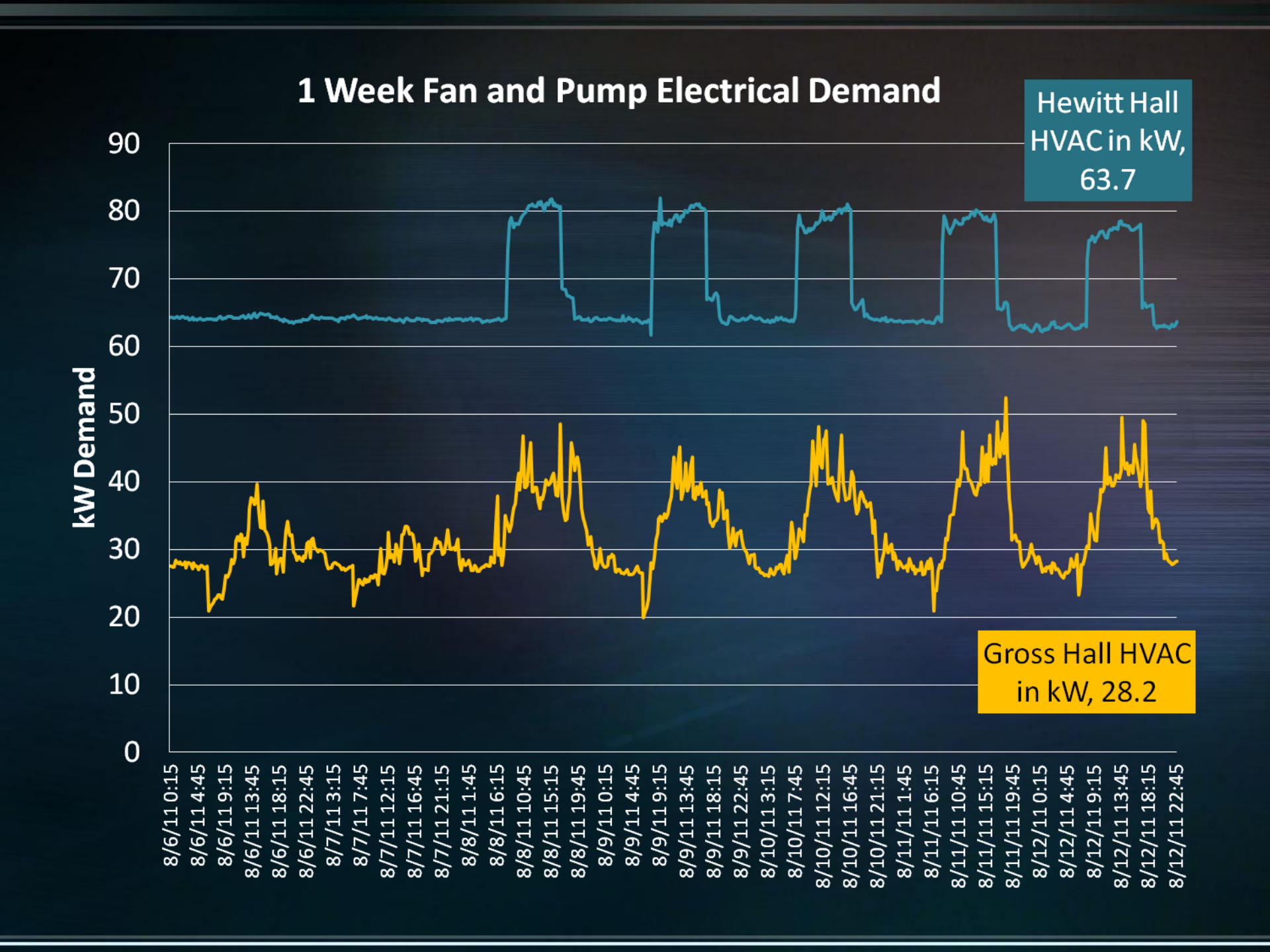




Adding Hewitt and Gross Halls

- Hewitt is right at the average
- Gross Hall beats the most efficient lab benchmarked by 18%




1 Week Fan and Pump Electrical Demand
Hewitt Hall HVAC in kW, 63.7
Gross Hall HVAC in kW, 28.2
kW Demand
90
80
70
60
50
40
30
20
10
0
8/6/11 0:15
8/6/11 4:45
8/6/11 9:15
8/6/11 13:45
8/6/11 18:15
8/6/11 22:45
8/7/11 3:15
8/7/11 7:45
8/7/11 12:15
8/7/11 16:45
8/7/11 21:15
8/8/11 1:45
8/8/11 6:15
8/8/11 10:45
8/8/11 15:15
8/8/11 19:45
8/9/11 0:15
8/9/11 4:45
8/9/11 9:15
8/9/11 13:45
8/9/11 18:15
8/9/11 22:45
8/10/11 3:15
8/10/11 7:45
8/10/11 12:15
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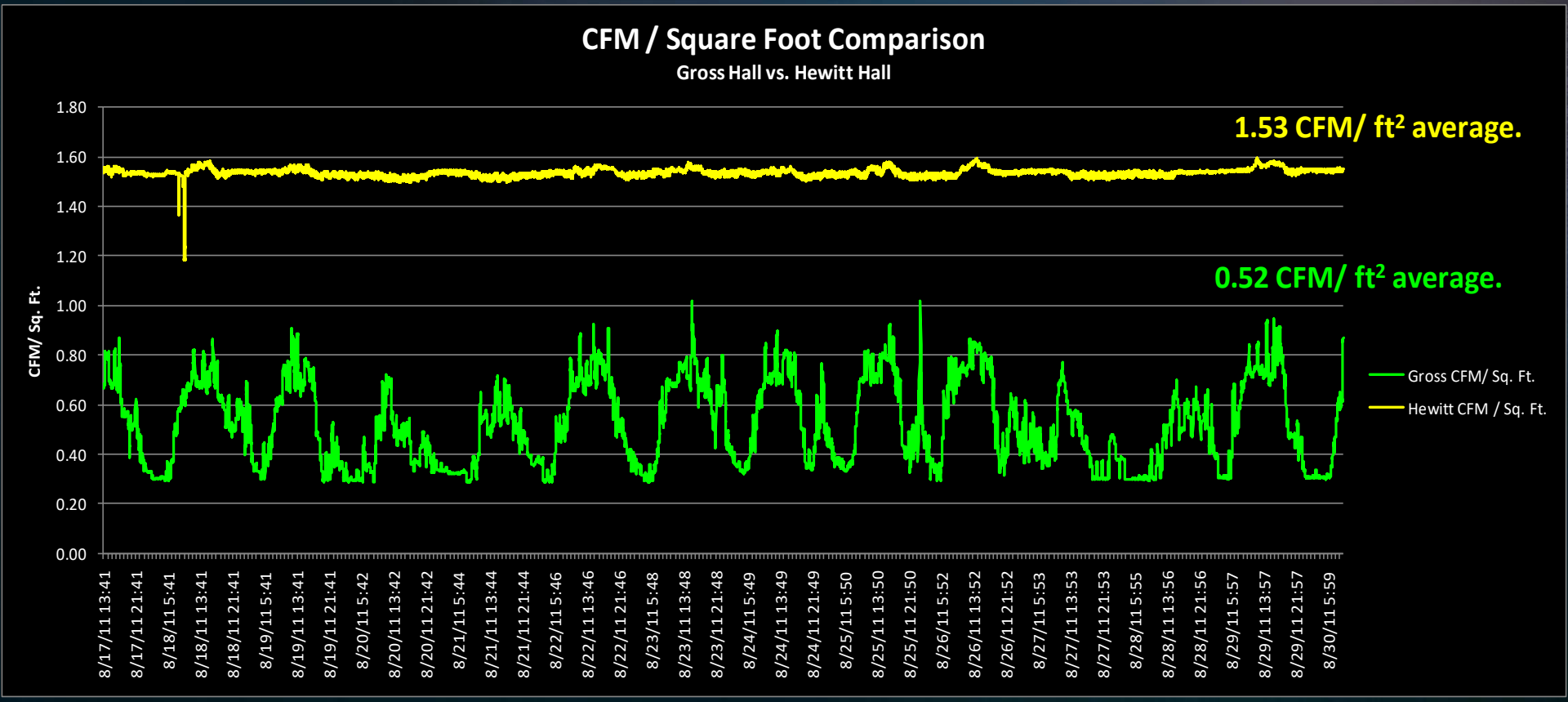
8/10/11 21:15
8/11/11 1:45
8/11/11 6:15
8/11/11 10:45
8/11/11 15:15
8/11/11 19:45
8/12/11 0:15
8/12/11 4:45
8/12/11 9:15
8/12/11 13:45
8/12/11 18:15
8/12/11 22:45

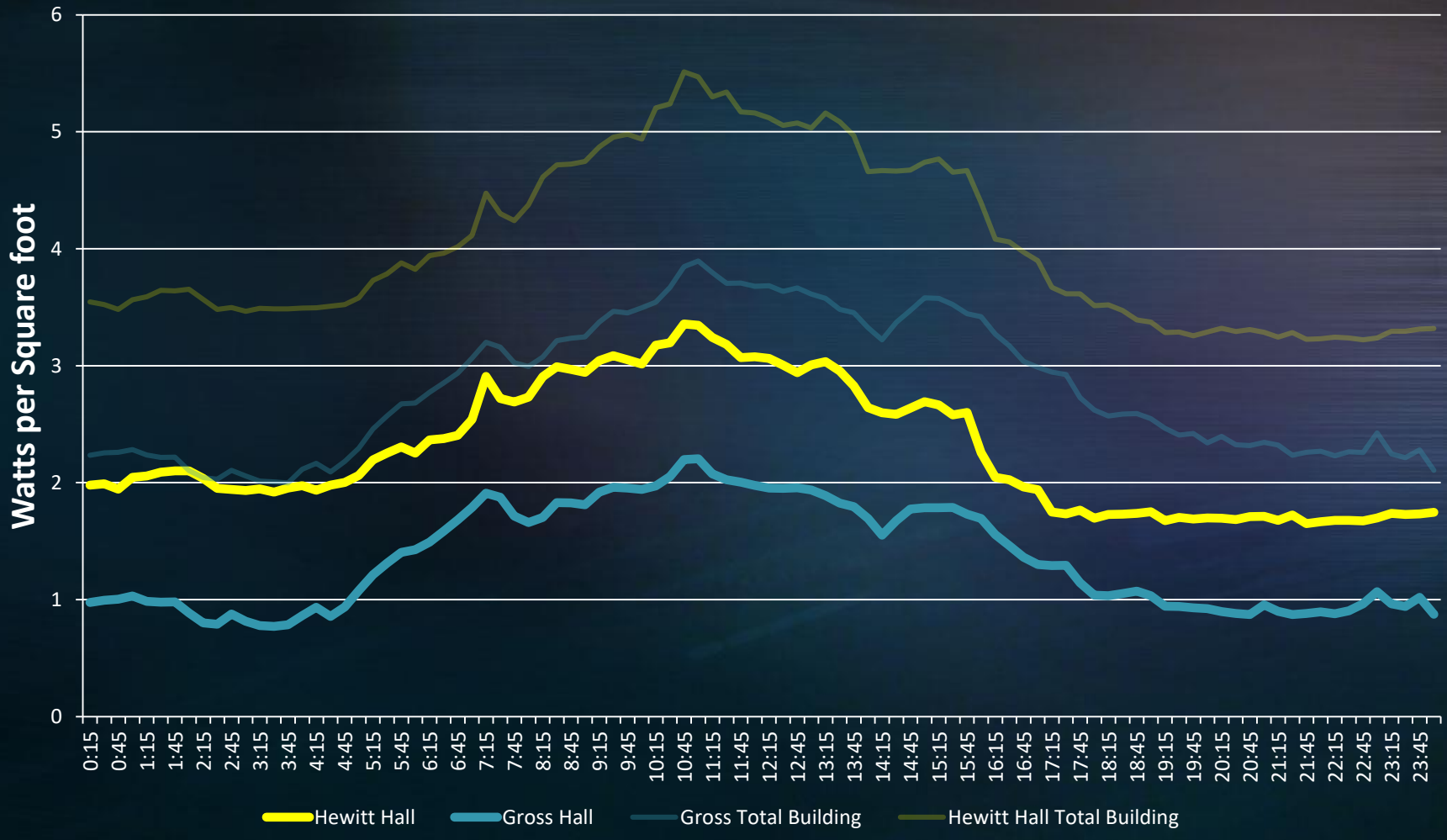
Lab Air Flow vs. Time

The HVAC savings of 1 CFM/ft2 at $4-5 per CFM can reduce operational significantly.

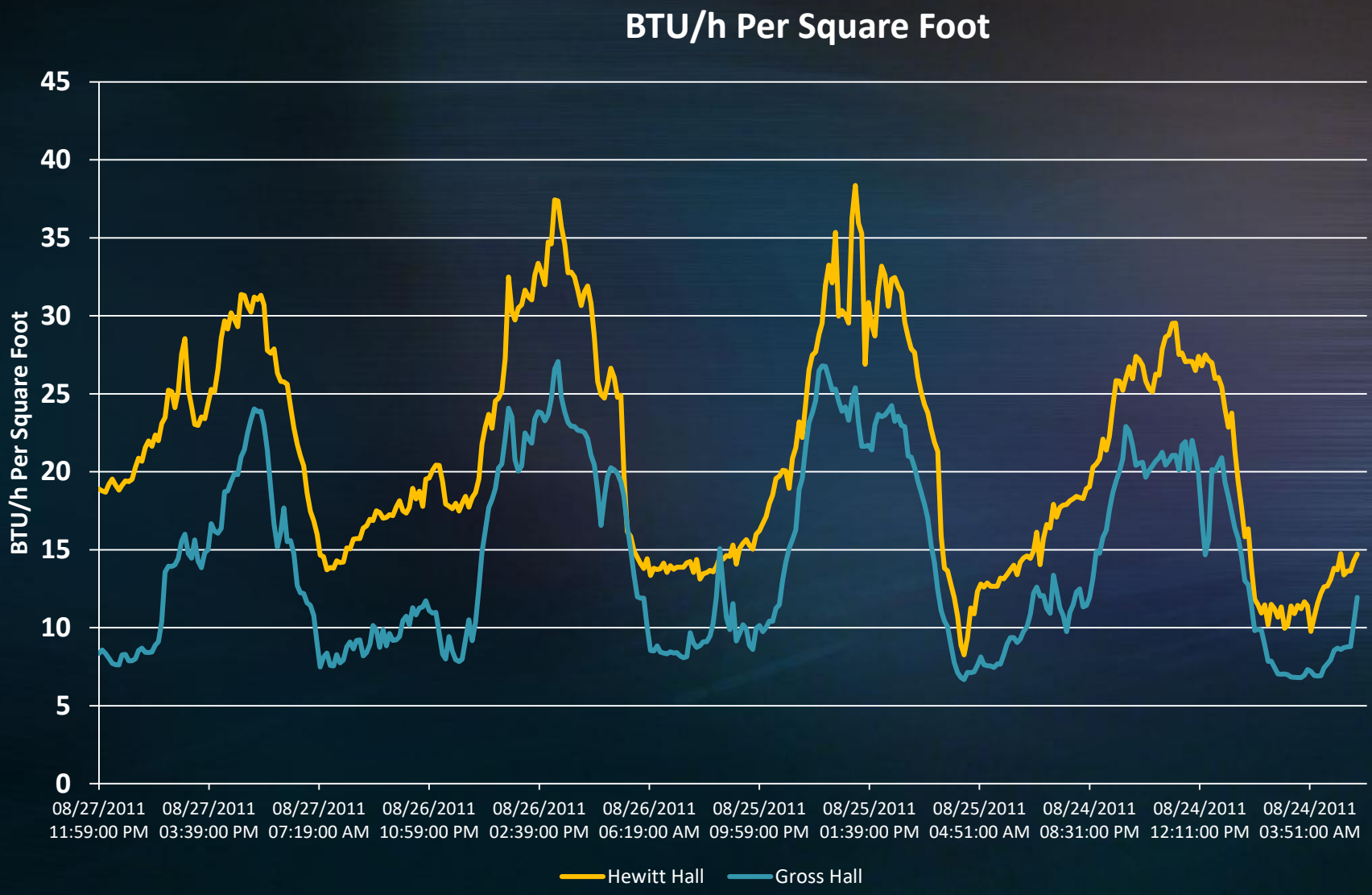
A 1 CFM reduction at Hewitt Hall in just the open lab bays would reduce operational cost by $83,250 per year



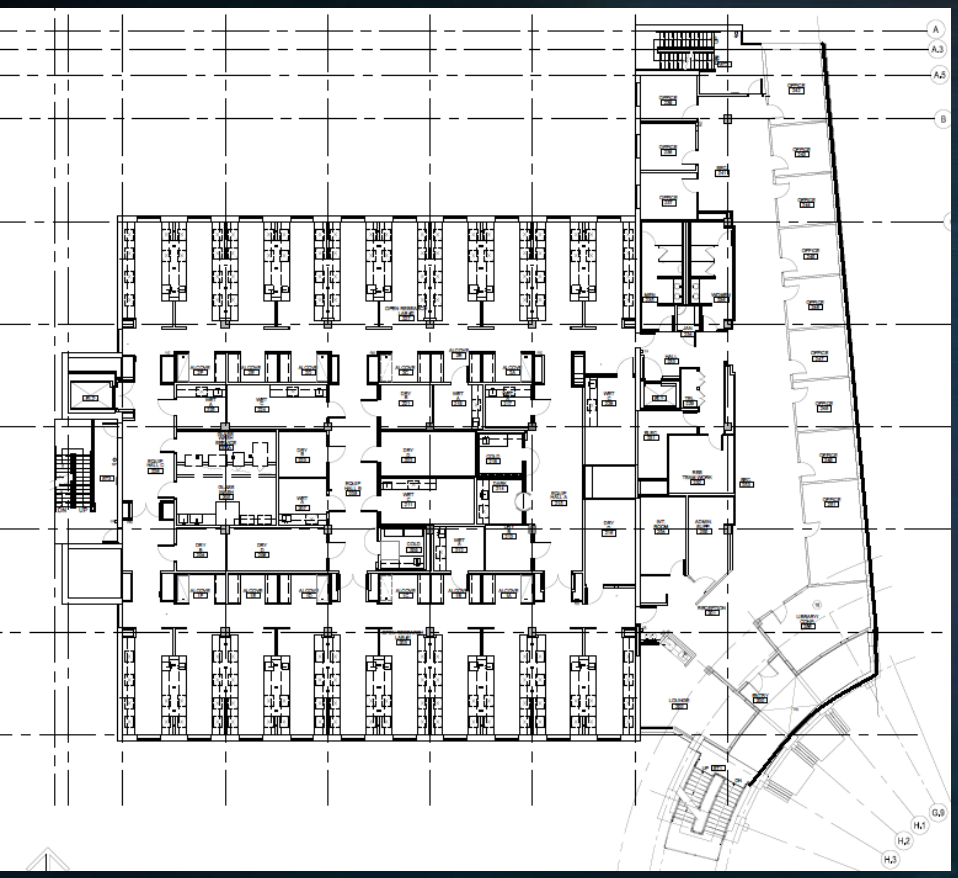
AHU + EF + Pumps + Chilled Water = Building Square Feet

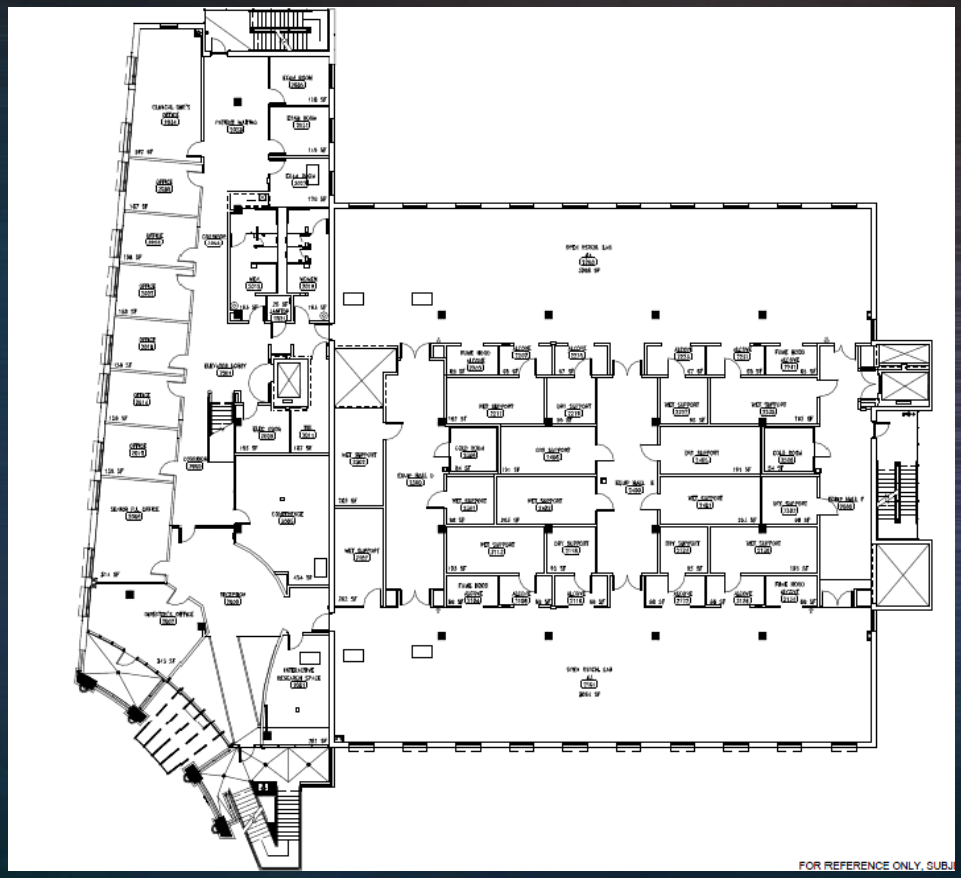


Chilled Water Use



Comparing 2 Similar Floors





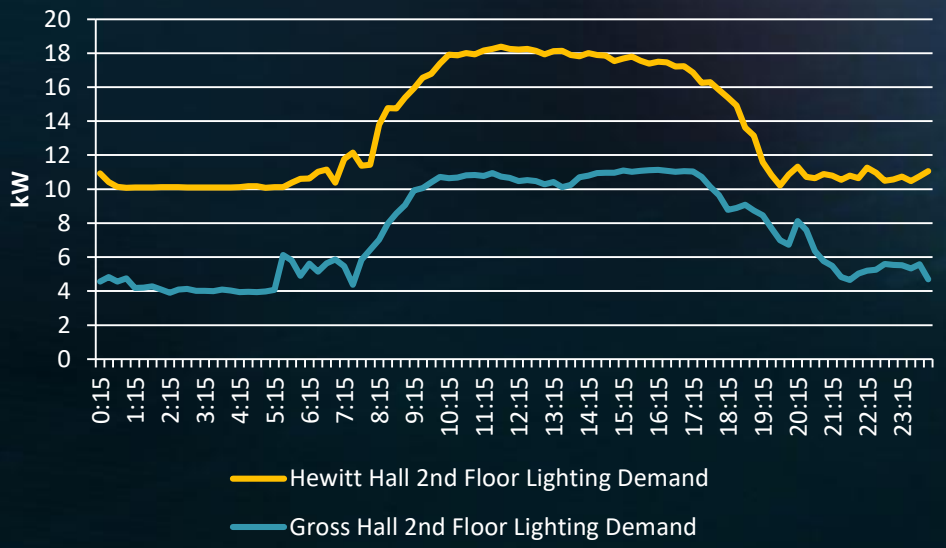
Hewitt Hall vs. Gross Hall

2nd Floor

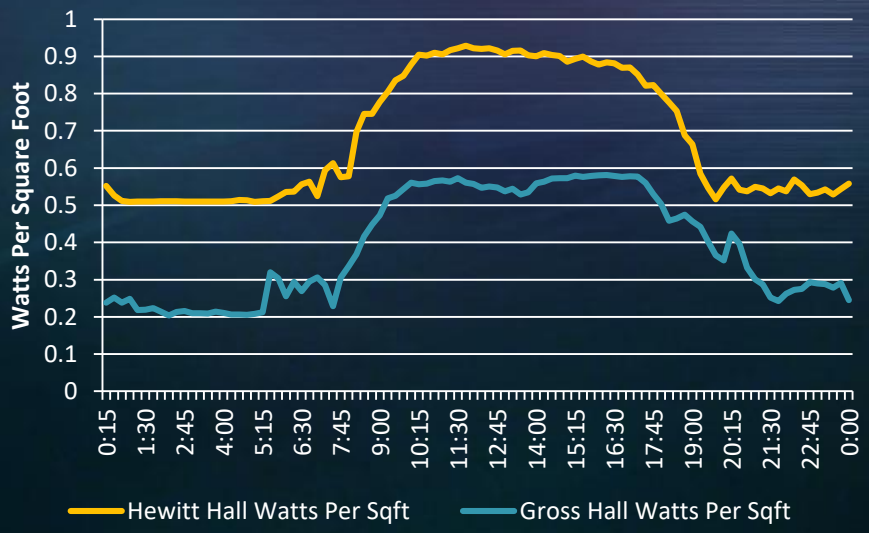
Lighting

Previous Best Practice	Space Type	Gross Hall
0.9 watts/sqft	Offices	**0.49** watts/sqft
1.1 watts/sqft	Labs	**0.66** watts/sqft
1 watts/sqft	Overall Conditioned Space	**0.61** watts/sqft

24 Hour Demand Curves



24 Hour Actual Watts Per SQFT



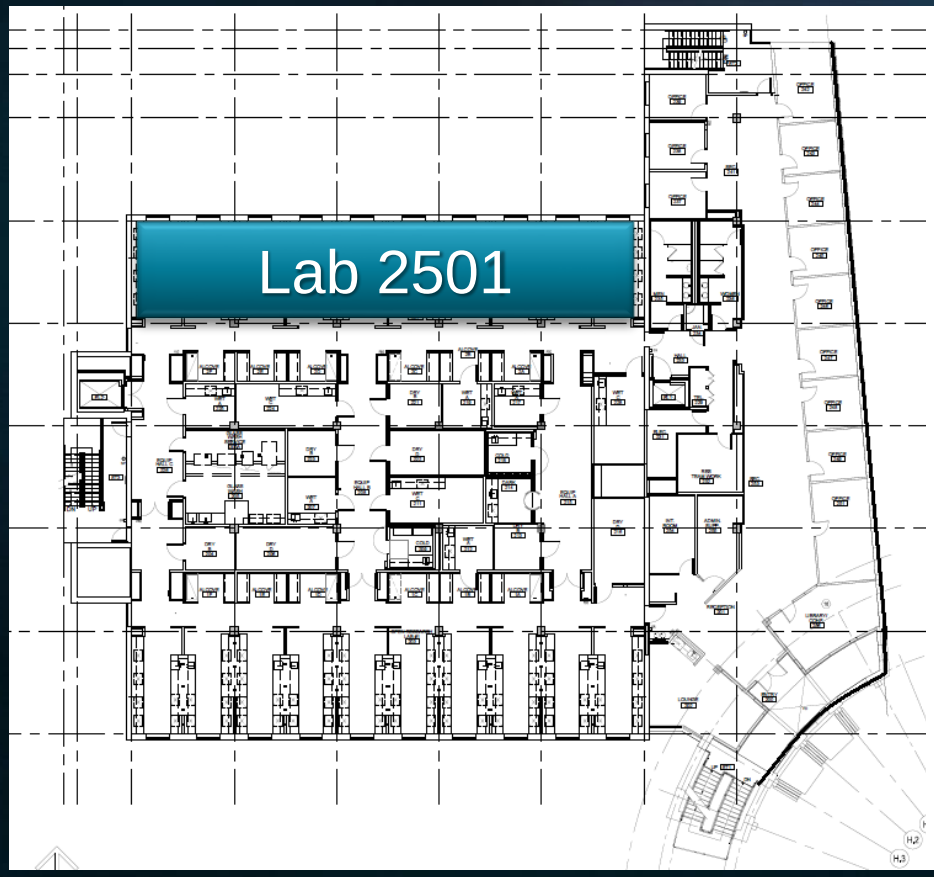
Lab Air Supply and Exhaust

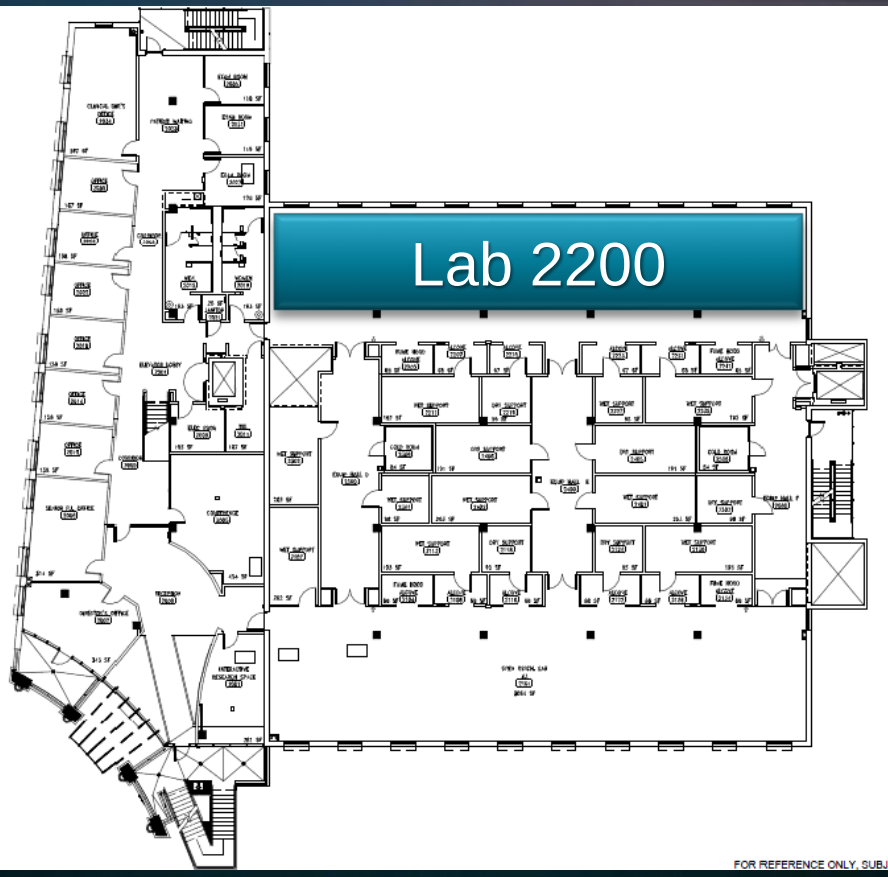
Hewitt Hall 2nd Floor

- 6 Air changes per hour minimum
- No set back during unoccupied periods
- Zone presence sensors on fume hoods

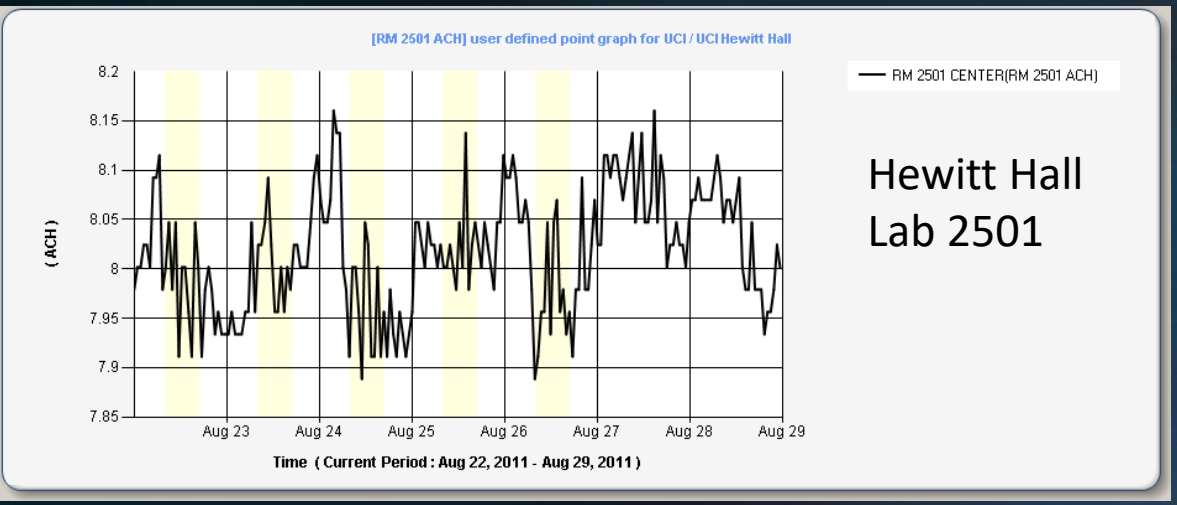
Gross Hall 2nd Floor

- 4 Air changes per hour minimum occupied
- 2 Air Changes per hour minimum unoccupied
- Zone presence sensors on fume hoods
- Centralized Demand Controlled Ventilation system adjusting ACH for indoor air quality.





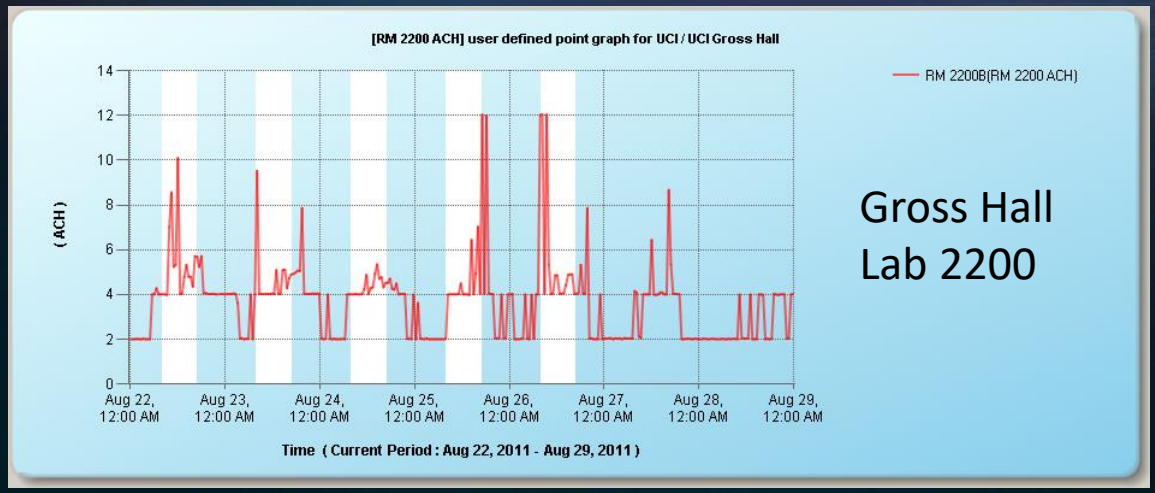
Evidence of where the buildings HVAC energy savings are achieved



Hewitt Hall
Lab 2501

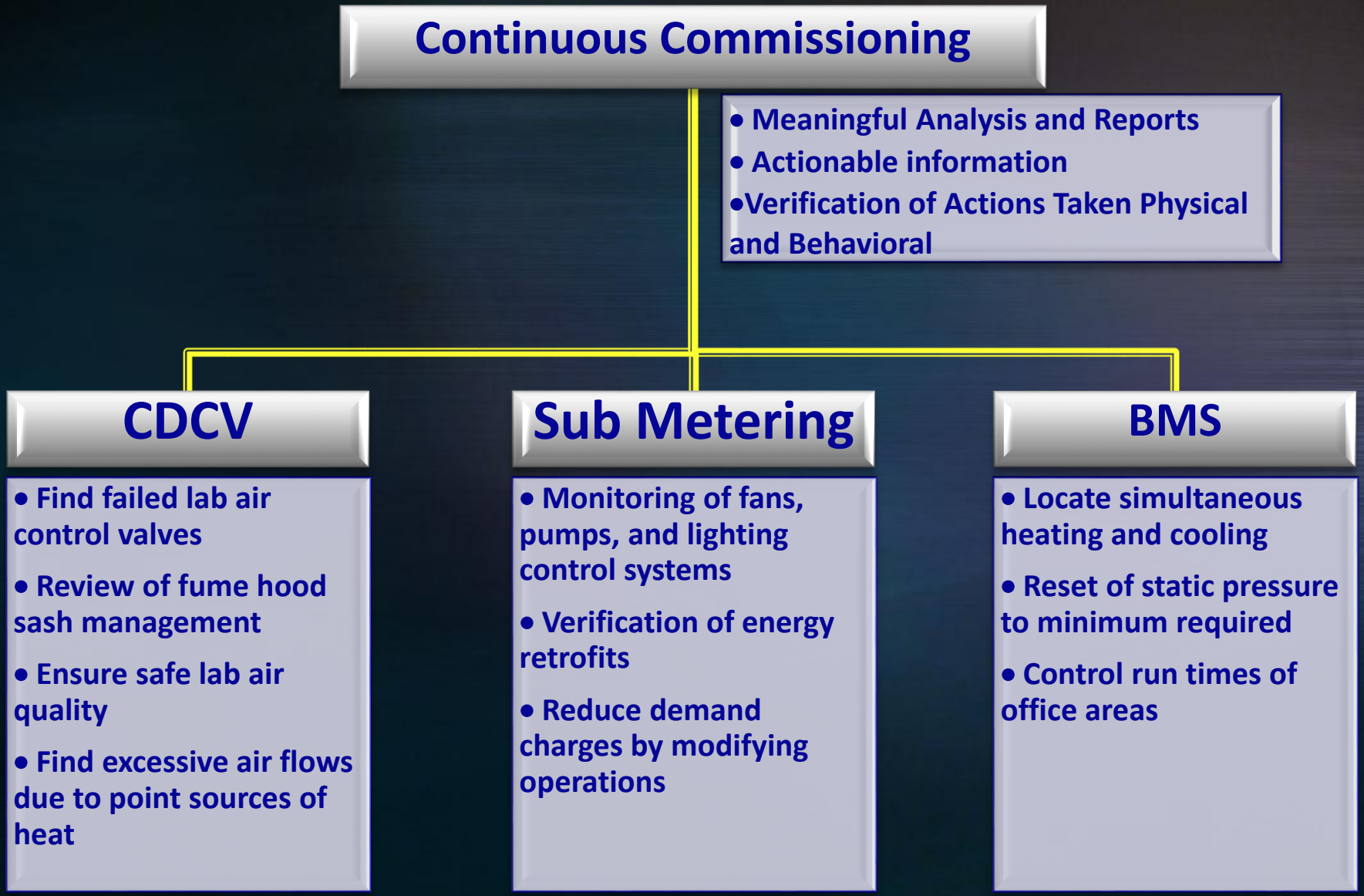
- Air change rates are dependent on sash position and thermal demand.
- Lab 2501 averages 8 air changes per hour

- Air change rates are dynamic responding to occupancy, IAQ, sash position, and thermal demands
- Lab 2200 averages 4 air changes per hour



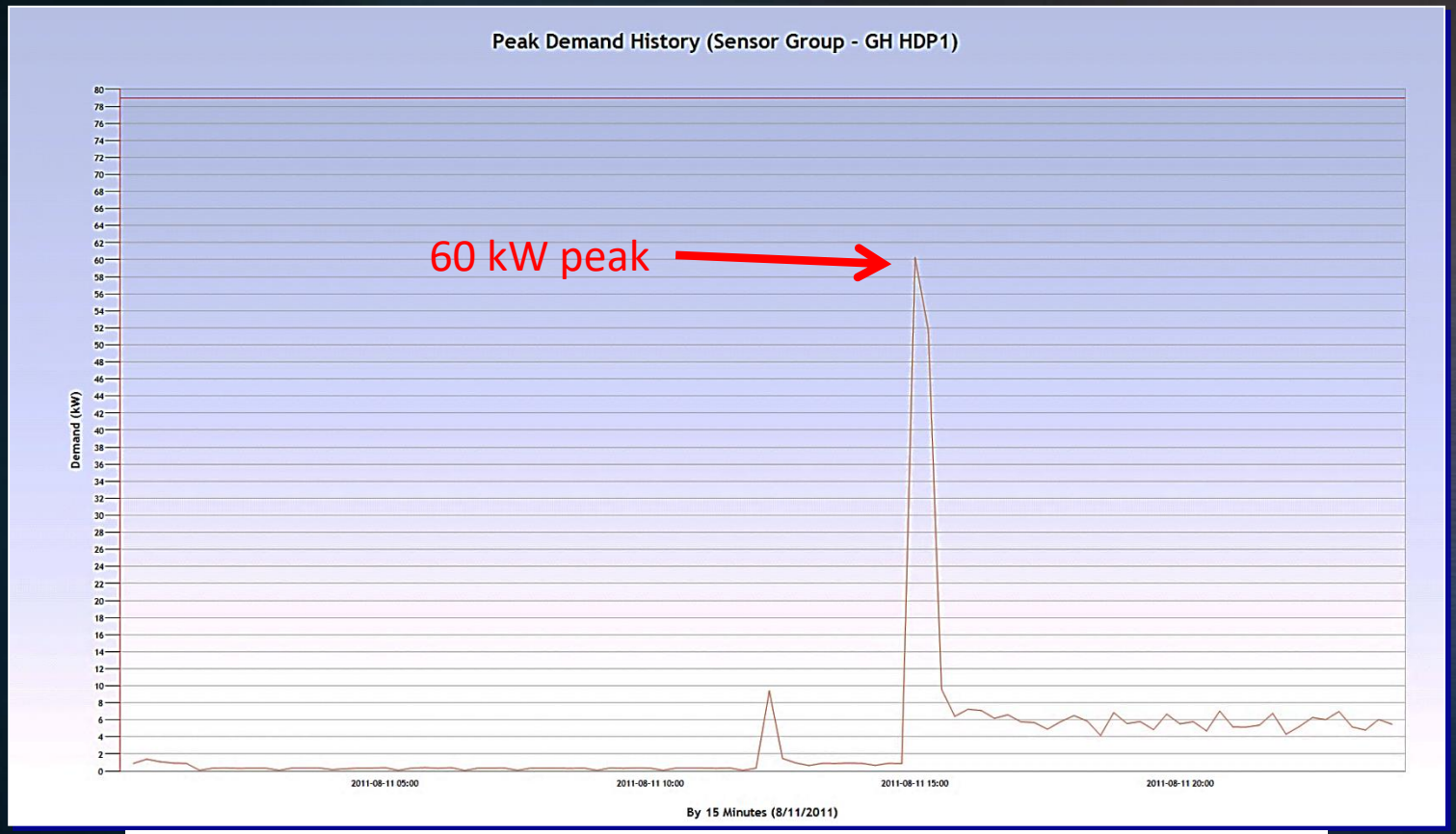
Gross Hall
Lab 2200

Continuous Commissioning



Zone level resolution can lead to peak demand savings

Autoclave In Gross Hall

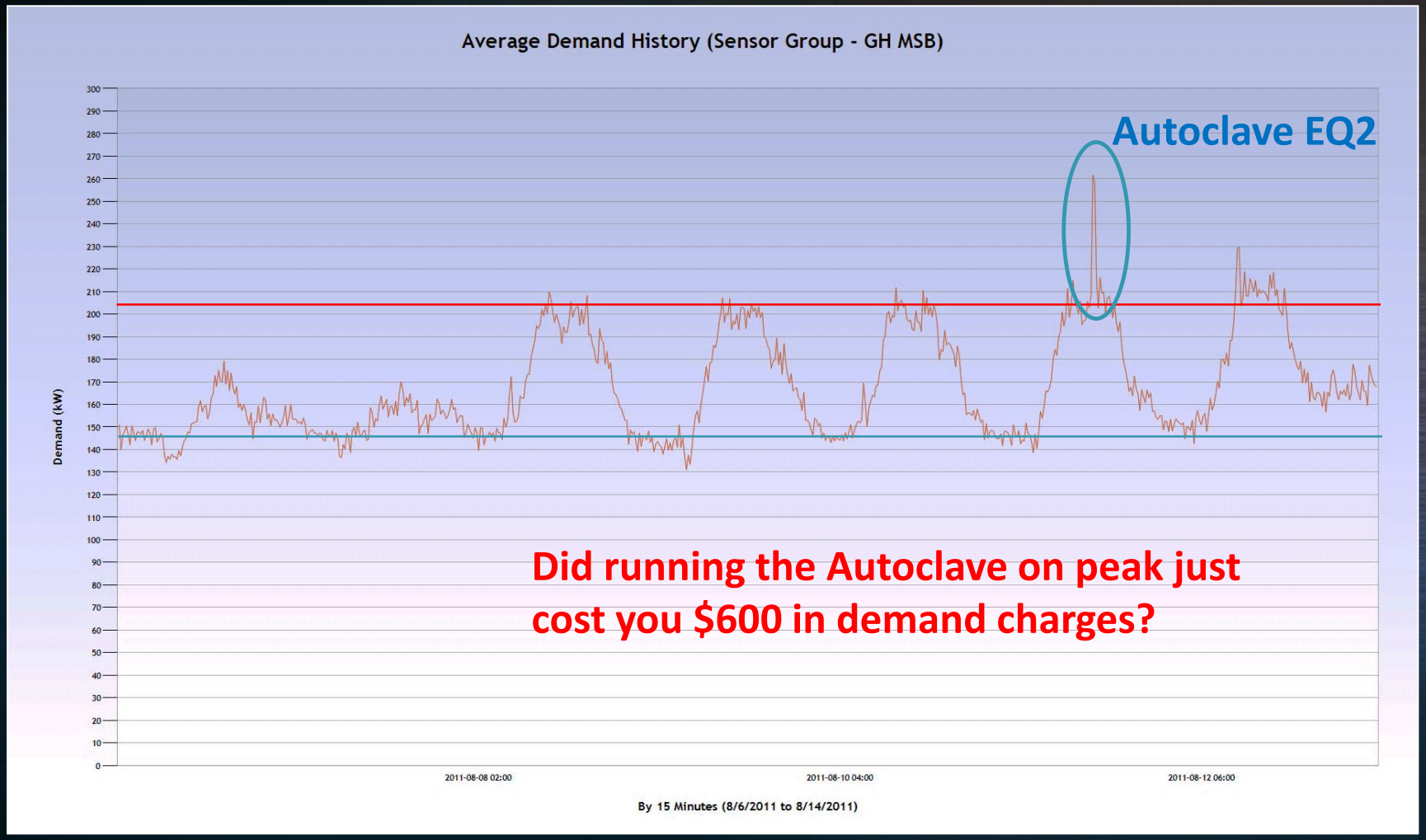


HDP1

Panel Name	Floor	Parent Panel	MSB Circuit	Voltage	Configuration	VA (A)	VA (B)	VA (C)	VA Detail	I(A)	% of Panel	% Measured
EQ2	1	HDP1	HDP1	480	Wye	24,942	24,942	24,942	74,825	90	58.4%	100%
EQ4	1	HDP1	HDP1	480	Wye	10,254	10,254	10,254	30,761	37	24.0%	100%
EQ3	1	HDP1	HDP1	480	Wye	7,482	7,482	7,482	22,447	27	17.5%	100%
Total						**42,678**	**42,678**	**42,678**	**128,033**	**154**	**100%**	**100%**

HDP1 is a distribution board on the 1st Floor. It is responsible for feeding several equipment loads, autoclave units EQ2, EQ3, and EQ4. HDP1 is fed directly from the main switchboard at 480/277 volts. The board maximum current rating is 225 amps. The largest load on HDP1 is the medium autoclave EQ2, which is rated at 75kVA.

Zone level resolution can lead to peak demand savings



Gross Hall average site demand ranges from a baseline of 148kW to an average peak of 205 kW

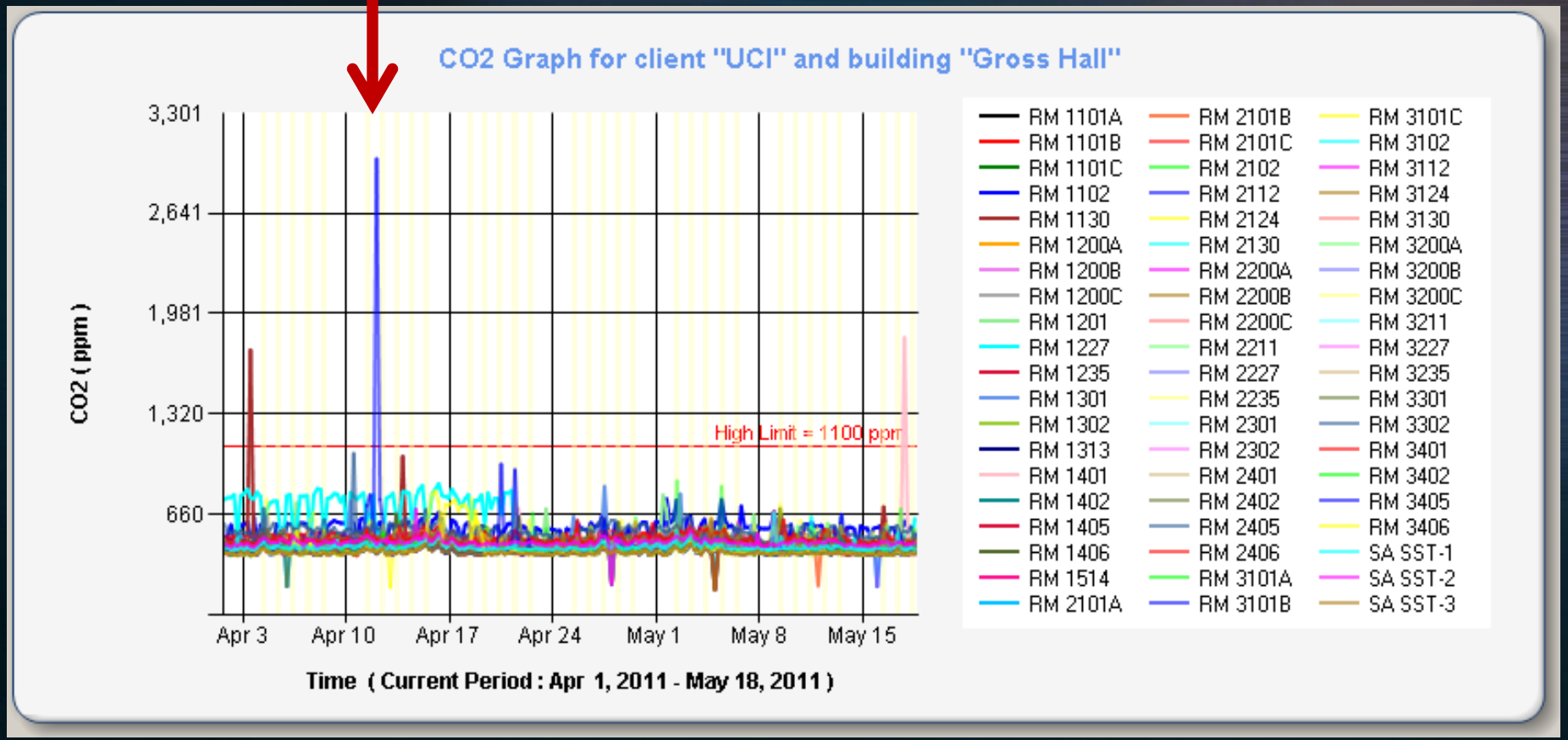
Troubleshooting a CO2 leak with the CDCV System

Researcher connects 4 tanks of CO2 to the lab distribution system and within 8 hours they are empty.

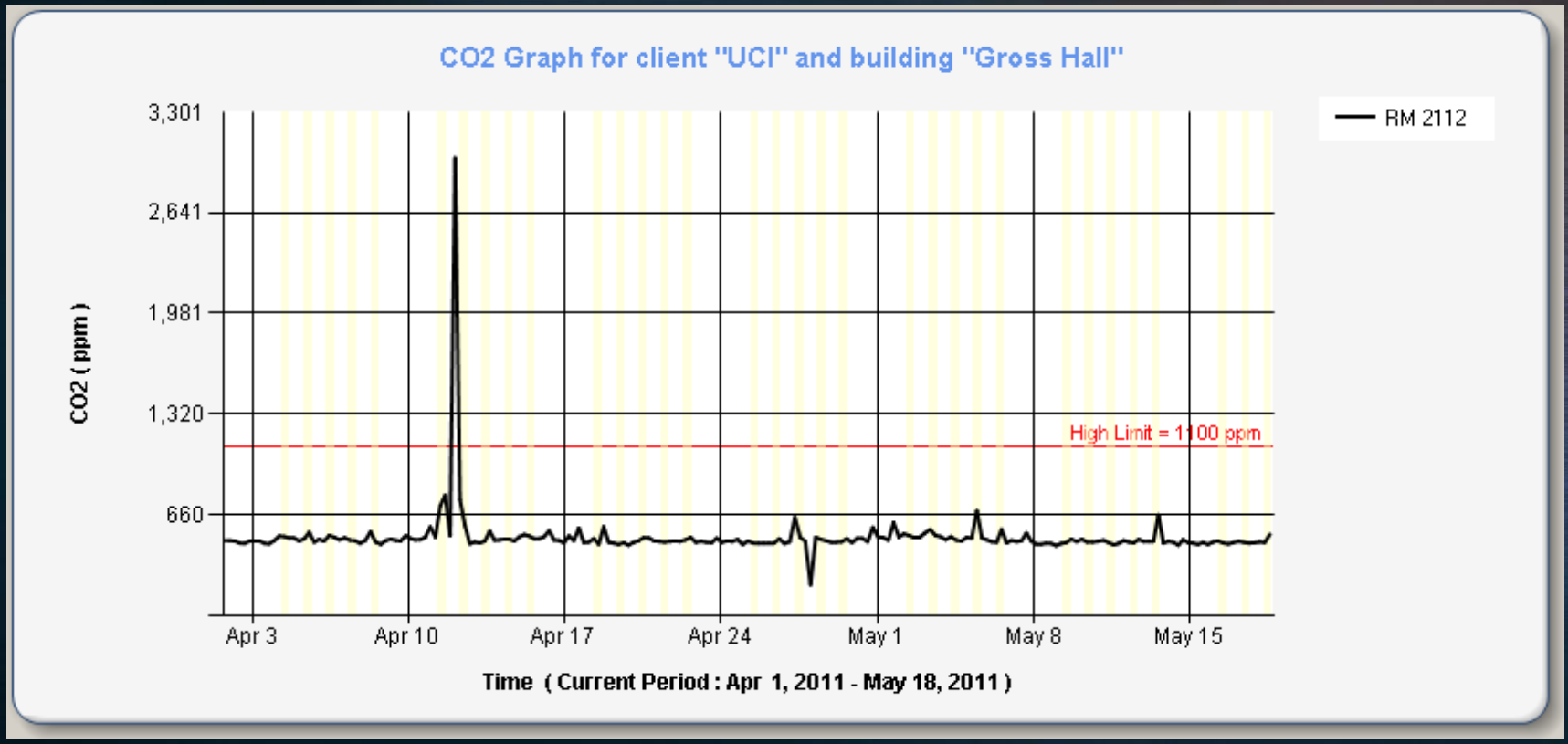
To find the leak the research staff could have spent hours soaping lines and connections and wasting additional gas listening for the leak.

Researcher first plotted all rooms for CO2

Suspected location of CO2 leak

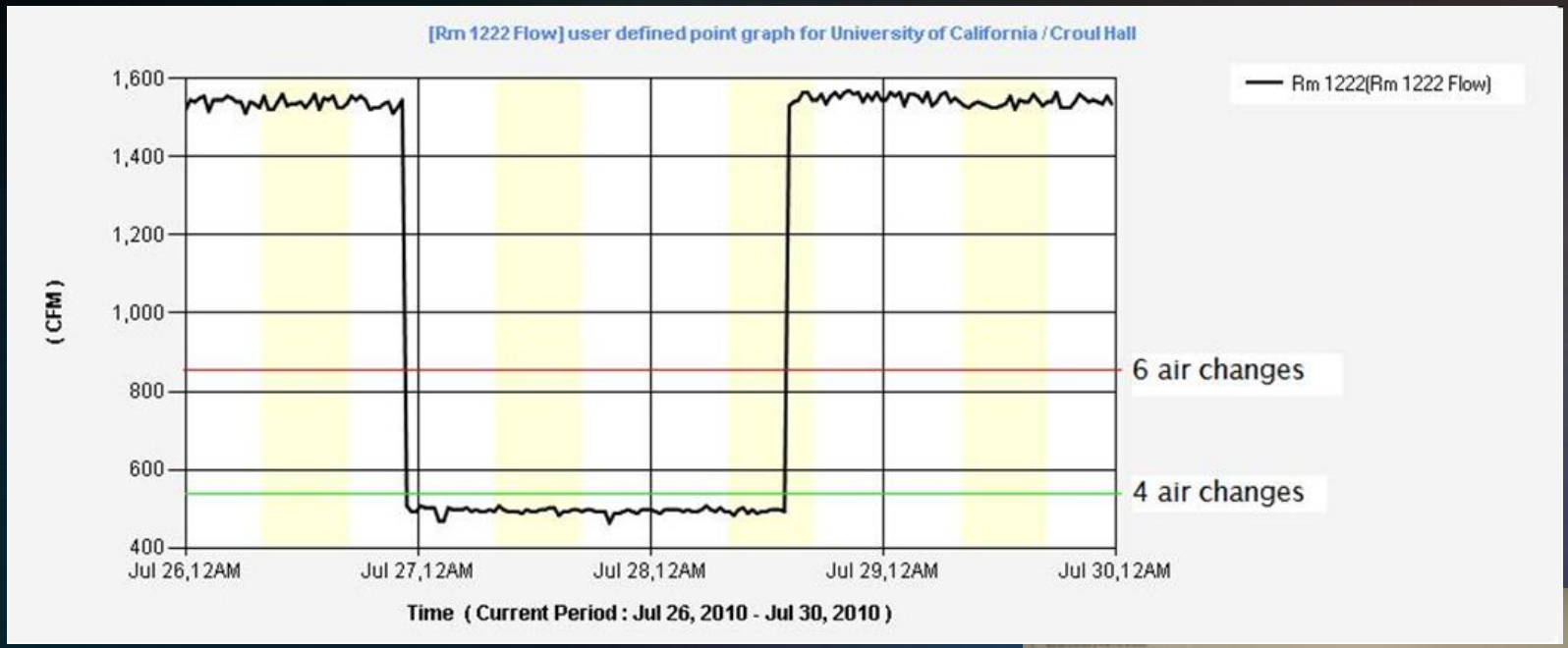


The PI then plotted the room with the suspected CO2 leak:



It was quickly located and repaired

Discovery of Lab Equipment Driving Thermal Demand

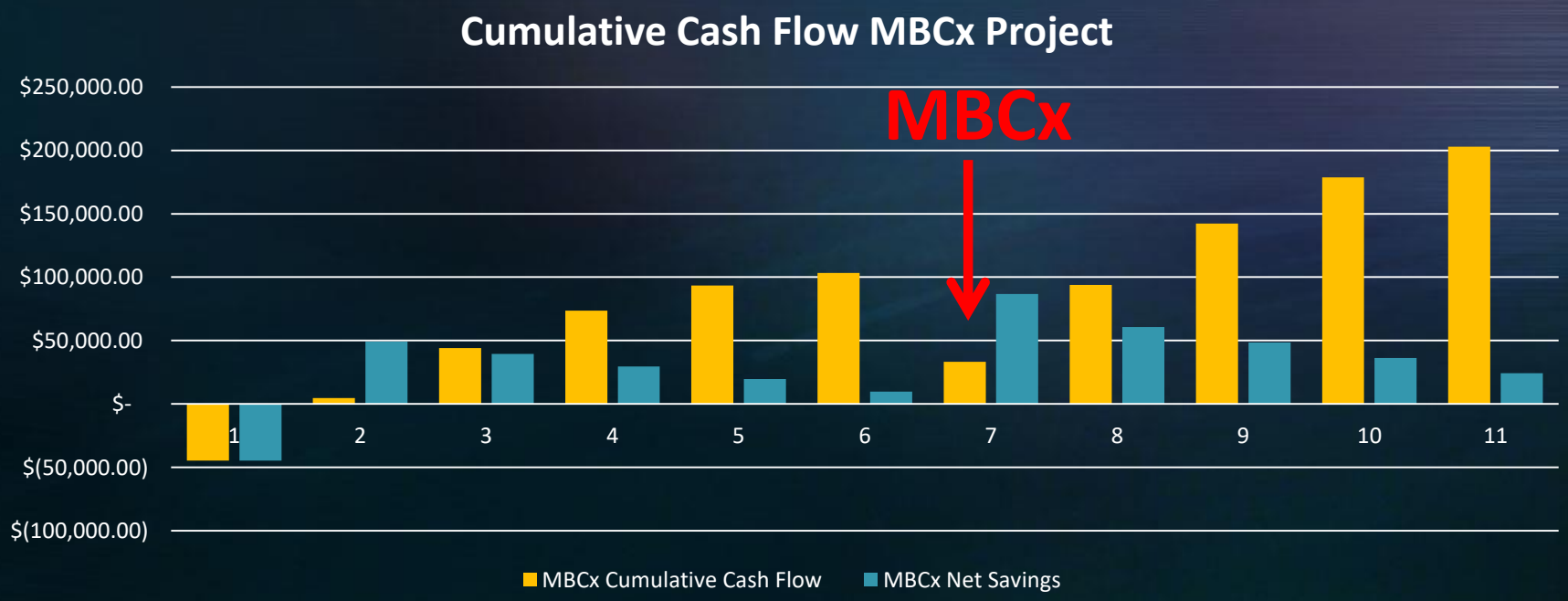


The Knowledge Center has been used to locate lab equipment placed too close or under thermostats

Return on Investment

Commissioning

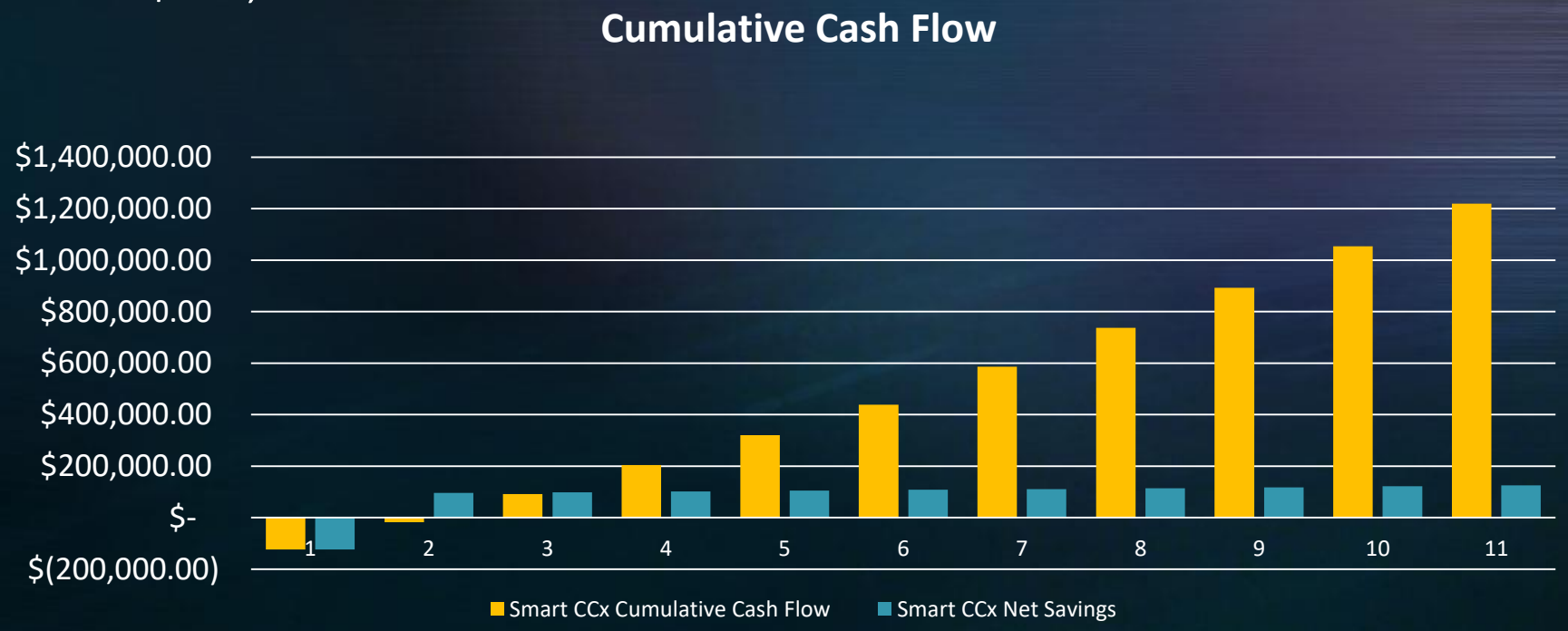
- Cx, Rx, MBCx is approximately $2 per SqFt
- Hewitt Hall MBCx $131,309
- Net present value for 10 years (MBCx every 5 years) Hewitt Hall $113,590



Return on Investment

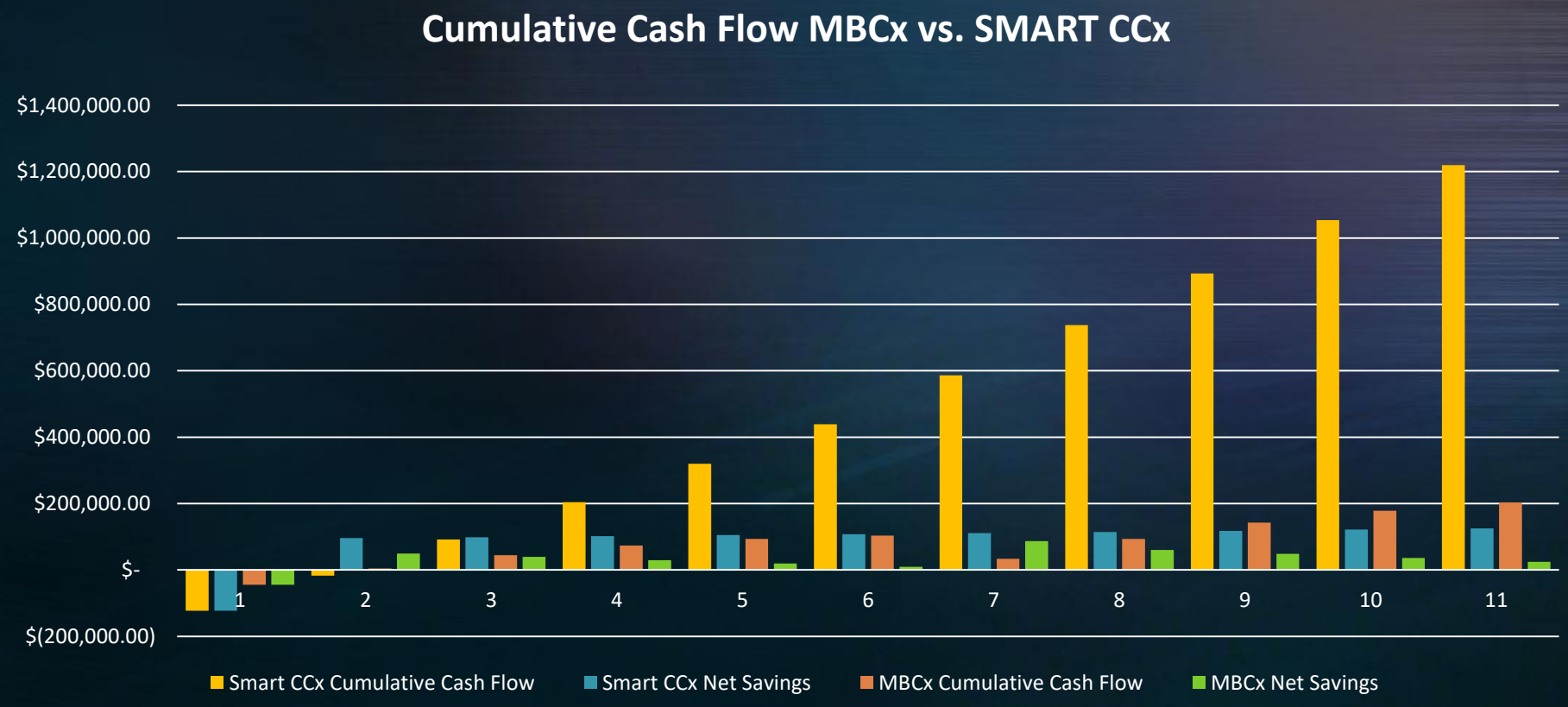
Sub metering and monitoring your lab can be very competitive with the cost of a single commissioning effort.

- CDCV ~$3.12 per SqFt
- Sub metering $0.20 per SqFt
- Hewitt Hall Sub Metering and CDCV $302,888
- Net present value for Hewitt Hall continuous commissioning (10 years) $665,903



Return on Investment

Smart CCx although a larger initial investment provides for greater long term savings as well as strategic analysis, monitoring, and savings that can not be accomplished with traditional MBCx



Questions?