Continuous Energy Management at UC San Diego

Anna Levitt, P.E.
Assistant Energy Manager
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UC San Diego: A 42 megawatt Microgrid

With a daily population of over 45,000, UC San Diego is the size and complexity of a small city.

As a research and medical institution, we have two times the energy density of commercial buildings

12 million sq. ft. of buildings, $250M/yr of building growth

UC San Diego's Climate Action Plan: The Drivers

- Climate Goals
  - UC Goals: 2000 Levels by 2014
  - AB32 Goals: 1990 Levels by 2020 and 80% Below 1990 Levels by 2050
- The Price of Carbon
  - At least $1-2 million per year
- Budget Reductions
  - $30 million per year
  - UC Working Smarter Initiative

The Plan

- Energy Efficiency
- Renewable Distributed Generation
- Biogas for Cogeneration
- Energy Storage & Grid Management
- Behavioral Change Campaigns

Cogeneration & Distributed Generation

Existing Cogeneration Plant **saves $8M annually**

Self generate > 85% of annual use

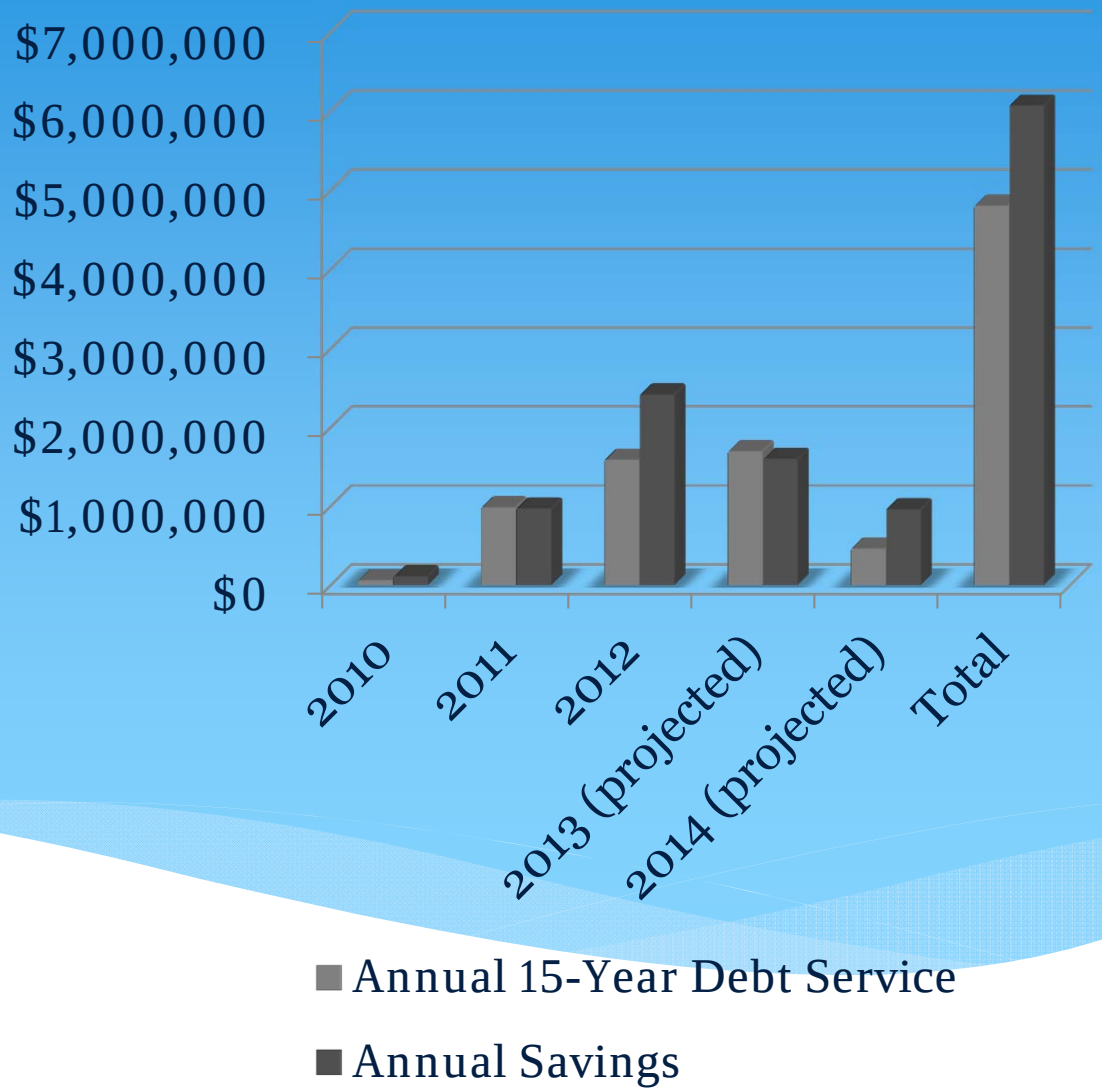
- 30 MW natural gas Cogen plant & TES
- 2.8 MW fuel cell
- 2.3 MW of Solar PV installed

Investment in Energy Efficiency

Funded by **utility incentives** and **a low interest revenue bond**

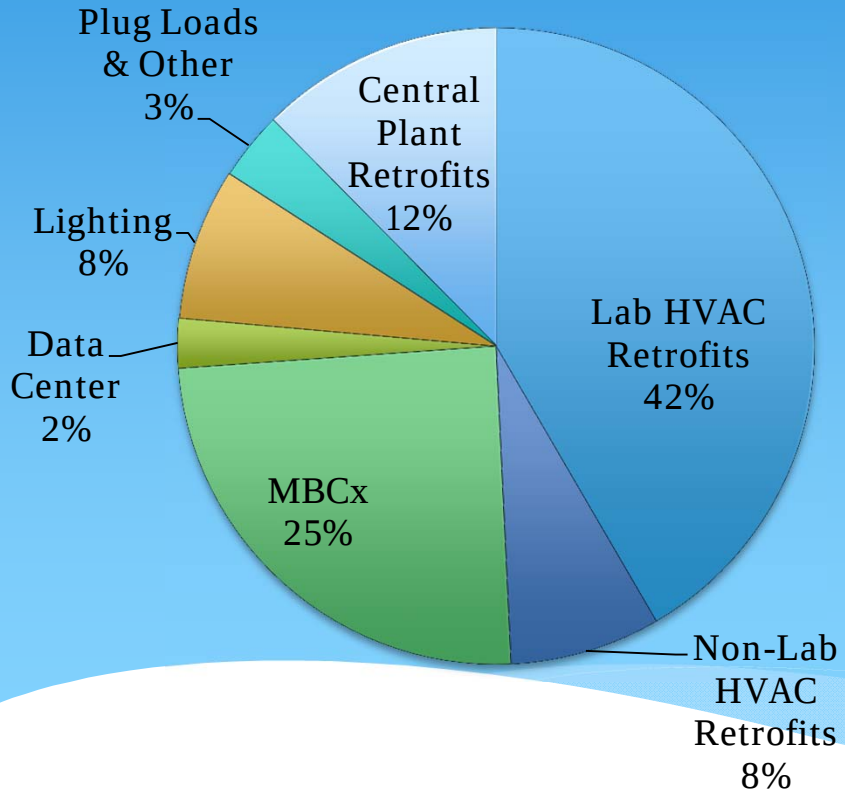
In five years, UCSD will **complete $60M of projects**, with **$12.8M in incentives**

Program will **yield $6 M in avoided annual energy costs**

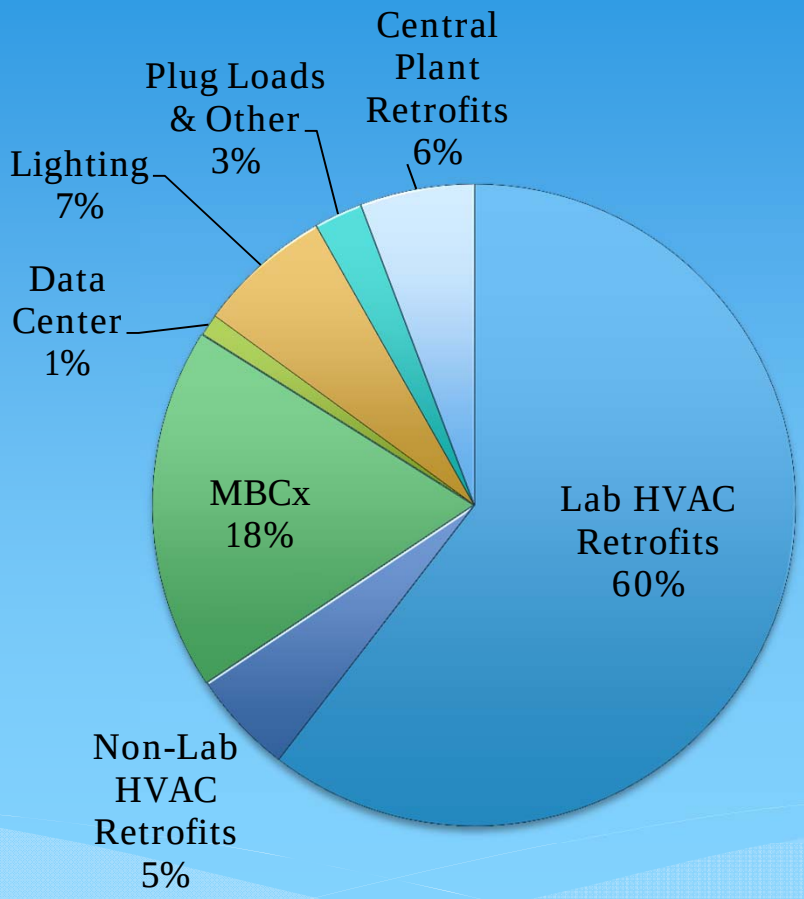


EE Program Breakdown

by Savings



by Cost



Metering

PACIFIC HALL ENERGY USAGE

Electricity Usage

485 kW

108 kW E1161

84 kW E1162

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677 kW Pacific Hall Total Usage

3.67 W/sq-ft

32.1 kWH/sq-ft year

Chilled and Hot Water Energy Usage

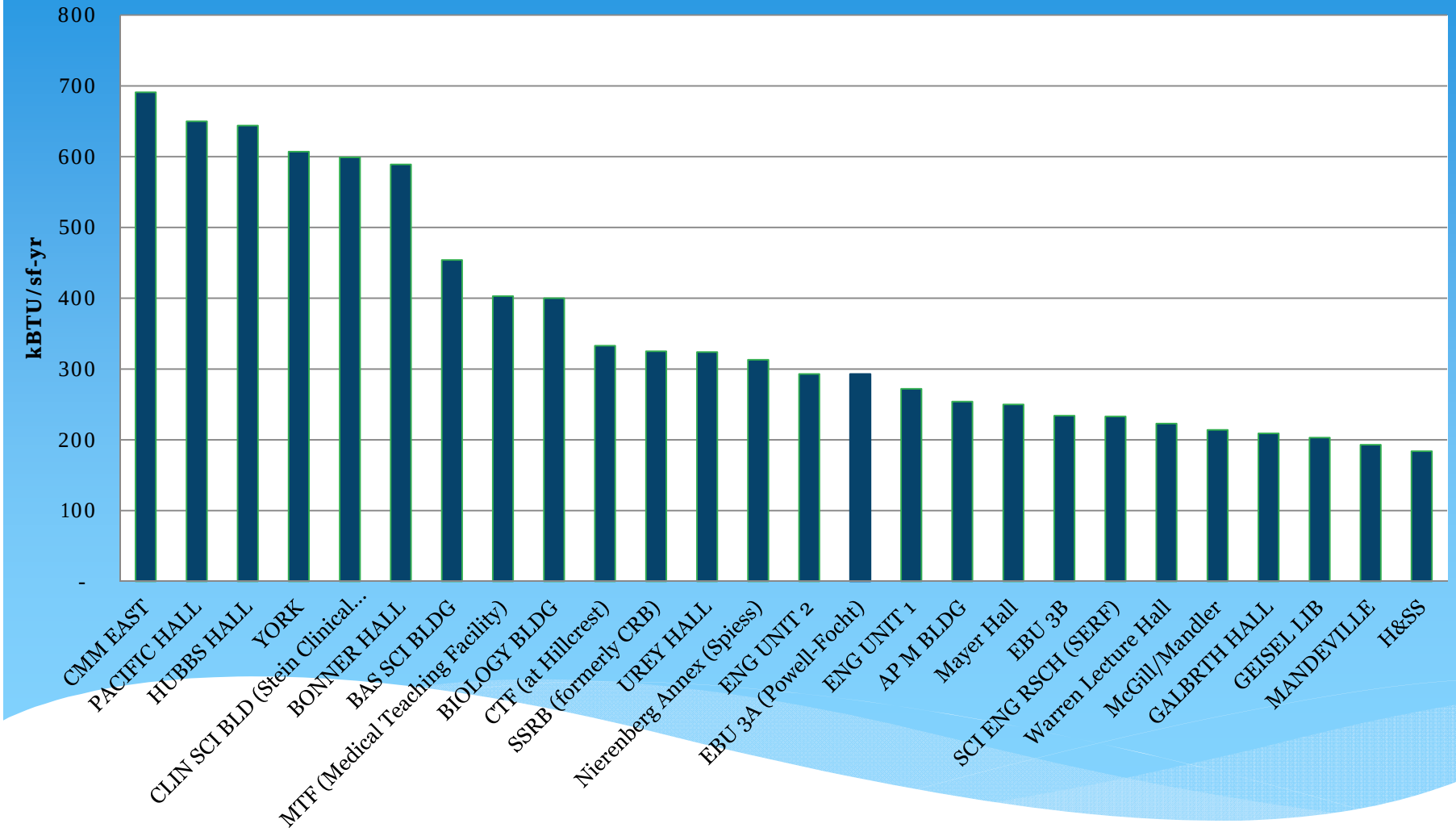
CHW MMBTUS- HR	1.50
CHW Flow	500.18
CHW Supply Temp	45.83
CHW Return Temp	51.90

HTW MMBTUS-HR	0.68
HTW Flow	85.16
HTW Supply Temp	337.98
HTW Return Temp	320.07

Pac Hall Historical BTU Data

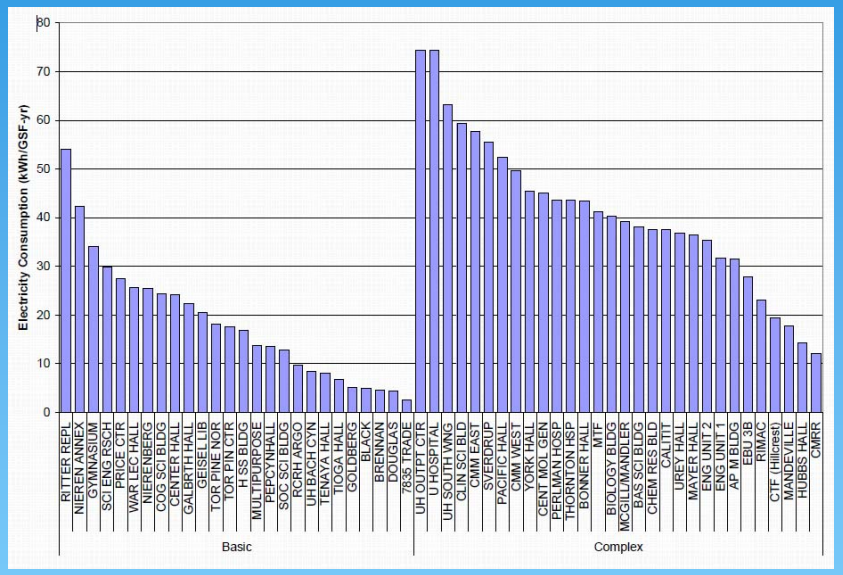
Monthly BTU Totals

Benchmarking

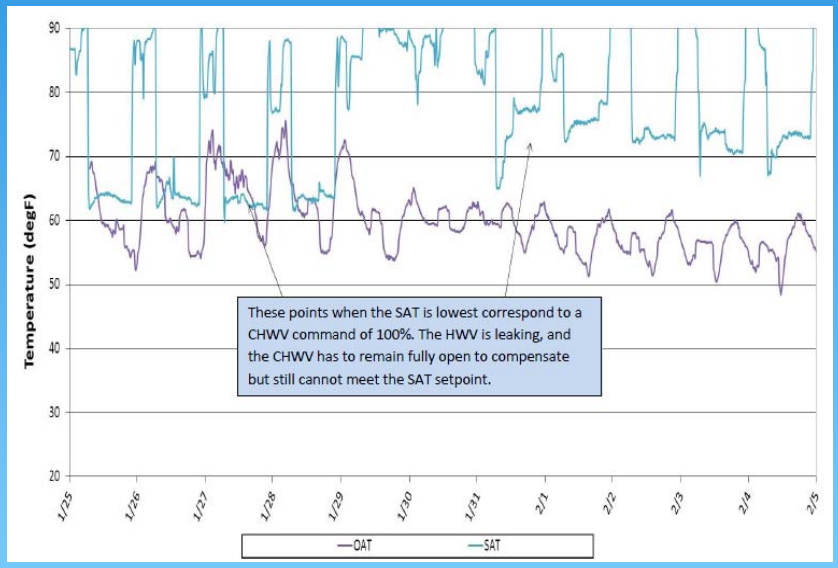


Monitoring-Based Commissioning (MBCx)

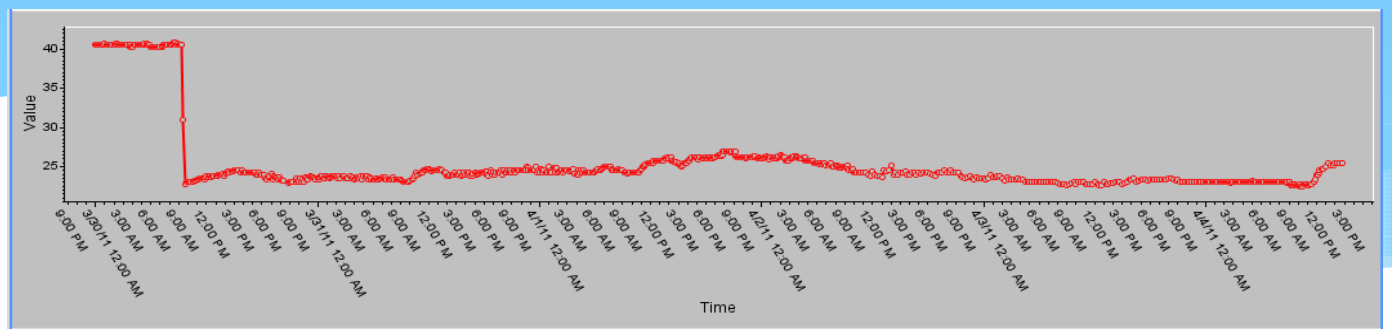
Metering & Benchmarking



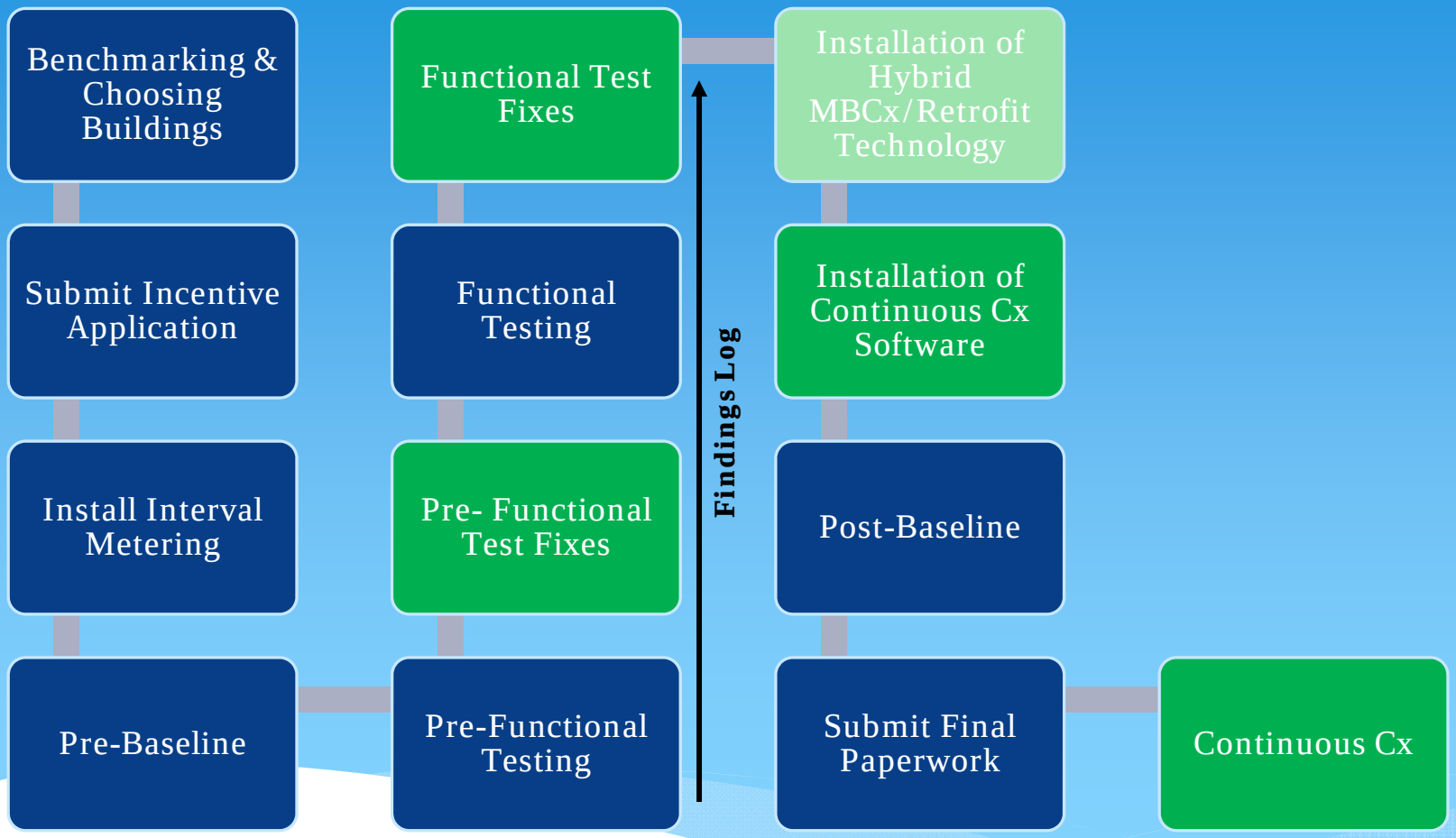
HVAC Testing, Repair, & Optimization



Energy Savings



Project Delivery



Types of Findings

Findings Category	Findings	Bonner Hall	EBU-1	AP&M	CTF	CMME	CMMW	Cognitive Science	Galbraith Hall	Geisel Library	Pacific Hall	RIMAC	Stein	Sverdrup Hall	Total
Mechanical Deficiency	Valve Leak-by	4	40	9	18	2	5	1	5	41		2	0		127
	Broken Economizer Dampers		12	6	7			6	13			5	2		51
	Broken or Unnecessary Inlet Vanes							5			4		2		11
	Fan Vibration							1		5		1			7
	Steam Condensate Return to Boiler	1			1										2
	Oxidized/Dirty Coils		18		1	1		1				1			22
Controls	Sensor Calibration/Replacement	19	41	23	5	5	4	10	28	29	17	40	15	10	246
	Loop Tuning	4	48	11	7		1		19		10	3	1	3	107
	Economizer Programming		11	4	9				1		3	4			32
	Scheduling		5	2					17			1			25
	Fan/Motor Status				3		3	4	1	11	2	1	8		33
	Lead/Lag Programming							1		2	2	3	1		9
	Simultaneous Heating/Cooling				11			1				1	3		16
	E/P Card or DDC Connectivity Issues	5	27	4		1	2	11	4	13	11	4	1		83
	Pump Reset Implementation	2		1		1	1		7	2			4		18
	Supply Air Temperature and Static Pressure Resets	3		2	8	14		5	5	3	8	5	2		55
Electrical	VFD Installation/Repair	1	13	3		1	2	4	6	1		9	9	2	51
	Electrical Breaker Issues						1	1							2
General Maintenance	Belt/Sheave Maintenance		13	5	5	1	2	6	2	6	3	6	1	2	52
	Filter Maintenance		14		7	9	9	1	2	3	7	5	5	2	64
	Duct Leakage	1	1	4	2		1	2	1	3	5	3	3		26
	Missing Insulation		4		5		1			4	2	2			18
	Condensate Pan Clogged or Not Draining		18		1		1	1	1	7		2	1		32

Types of Fixes

Measure	Number of Instances	Average Savings per Instance	Total Potential Savings	Labor Hours	Labor Cost *	Material Costs	Simple Payback (Years)
Loop Tuning	107	$ 480	$ 51,360	26	$1,950	$0	4.1
Economizer Repair**	42	$ 1,540	$ 64,680	32	$2,400	$2,000	2.9
Campus Standard Setpoints	6	$ 1,530	$ 9,180	16	$1,200	$0	0.8
Repairing Leaking or Non-Operating Valves	143	$ 1,680	$ 240,240	10	$750	$1,200	1.2
Scheduling	25	$ 5,740	$ 143,500	4	$300	$0	0.1
Supply Air Temperature and Static Pressure Resets	55	$ 1,280	$ 70,400	40	$3,000	$0	2.3
Differential Pressure Resets	18	$ 230	$ 4,140	14	$1,050	$0	4.6
Adding AHU VFDs	27	$ 9,340	$ 252,180	78	$5,850	$7,500	1.4
Adding Pump VFDs	10	$ 11,200	$ 112,000	12	$900	$7,501	0.8
Condensate Return	2	$ 4,410	$ 8,820	10	$750	$2,500	0.7

****Each economizer may have multiple issues to in need of repair, so 2 issues per economizer are assumed.**

MBCx Project Results

	2011	2012	2013 (so far)	Total
No. of Projects	4	4	2	**10**
kWh/yr	874,373	1,544,071	892,444	**3,310,888**
therms/yr	118,280	222,656	195,245	**536,181**
savings	$ 212,560	$ 387,905	$ 284,766	**$ 885,231**
incentive	$ 328,130	$ 593,233	$ 409,432	**$ 1,330,794**
cost	$ 1,170,833	$ 1,686,369	$ 1,109,923	**$ 3,967,124**
simple payback (yrs)	4.0	2.8	2.5	**3.0**

- Simple Paybacks: 7 months to 16.9 years
- Total Cost: $2.30 to $6.13 per GSF
- Metering: 10% to 27% of Total Cost

Lab Building HVAC Retrofits

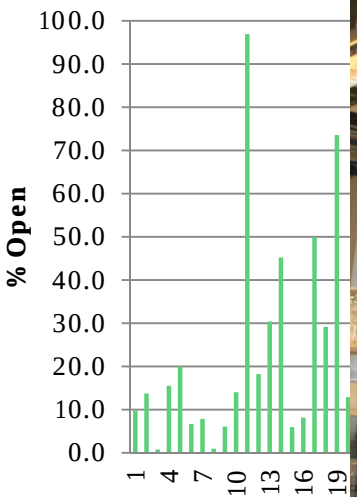
- 60% of the $60 million program
- 42% of the $6 million saved
- Variable air volume, demand-based HVAC control

Case Study: Pacific Hall

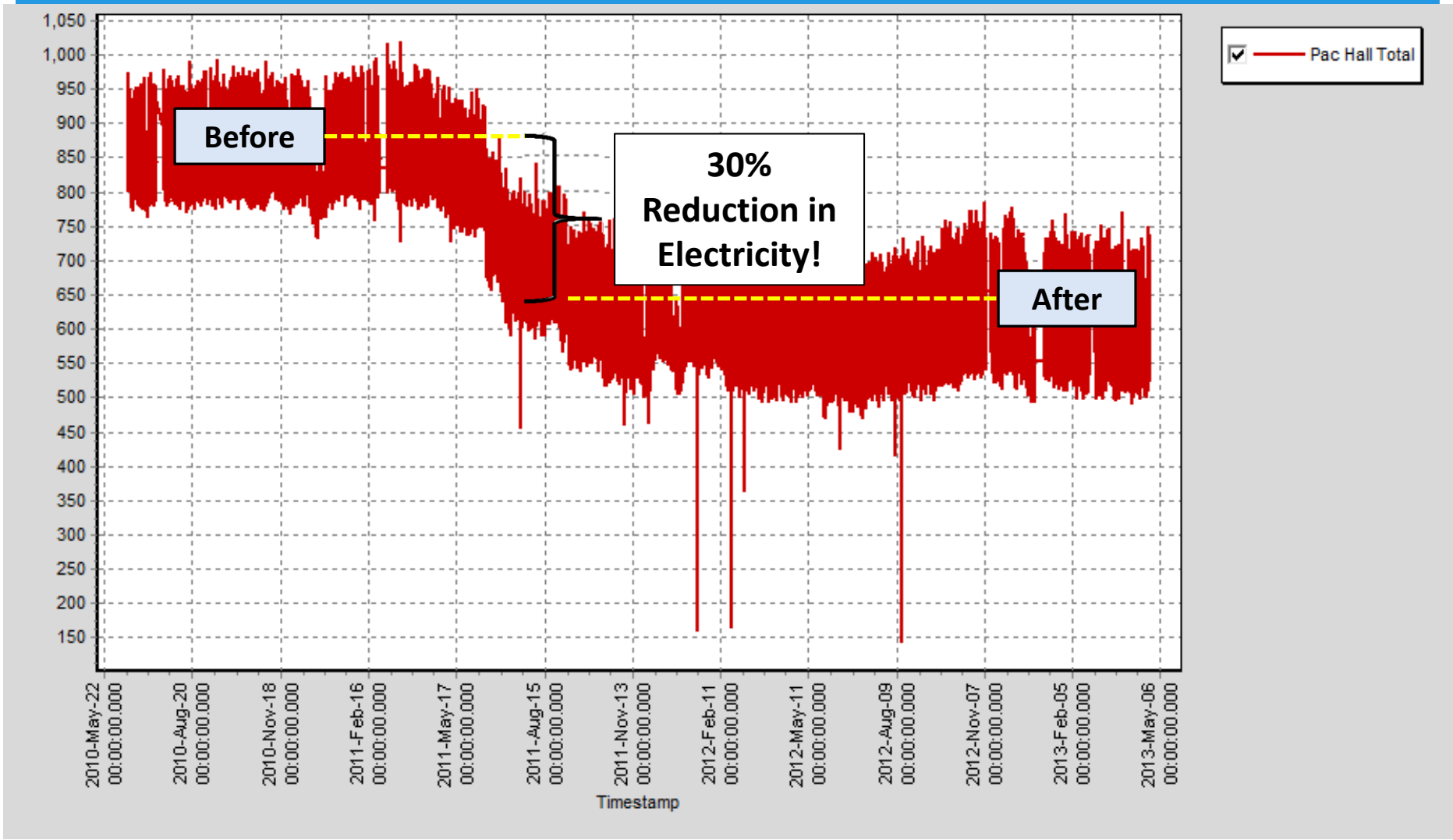
- Built in 1993
- 185,000 GSF
- Chemistry & Biology Research Labs
- 230 chemical fume hoods
- Annual Energy Bill: $1.3M (at mixed cogen + SDG&E rates)

Case Study: Pacific Hall

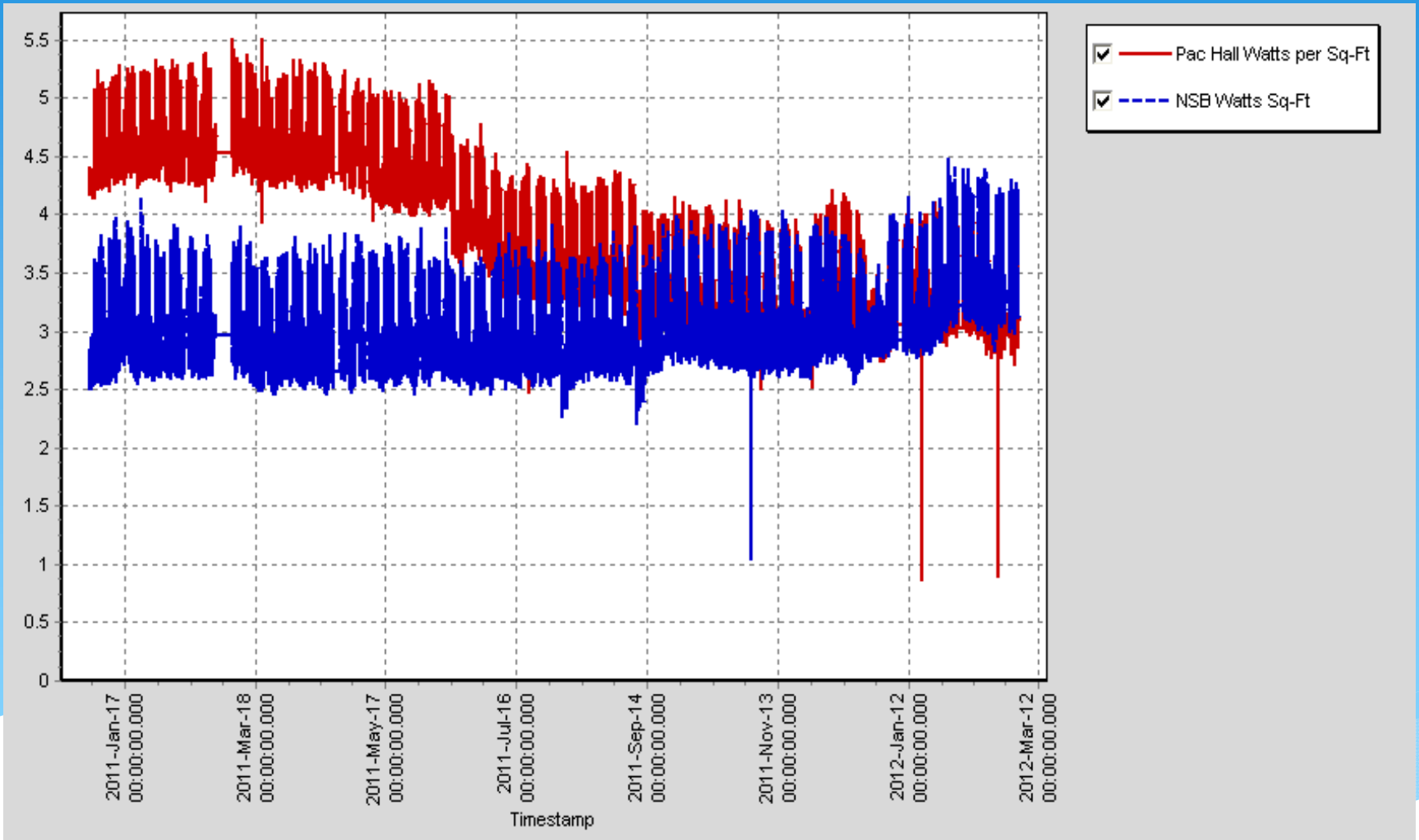
- Optimized air change rates
  - (12-15 ACH to 4-6 ACH)
- Occupancy sensors
- Fume hoo
- Incorporat



Pacific Hall Results



Pacific Hall's New Baseline

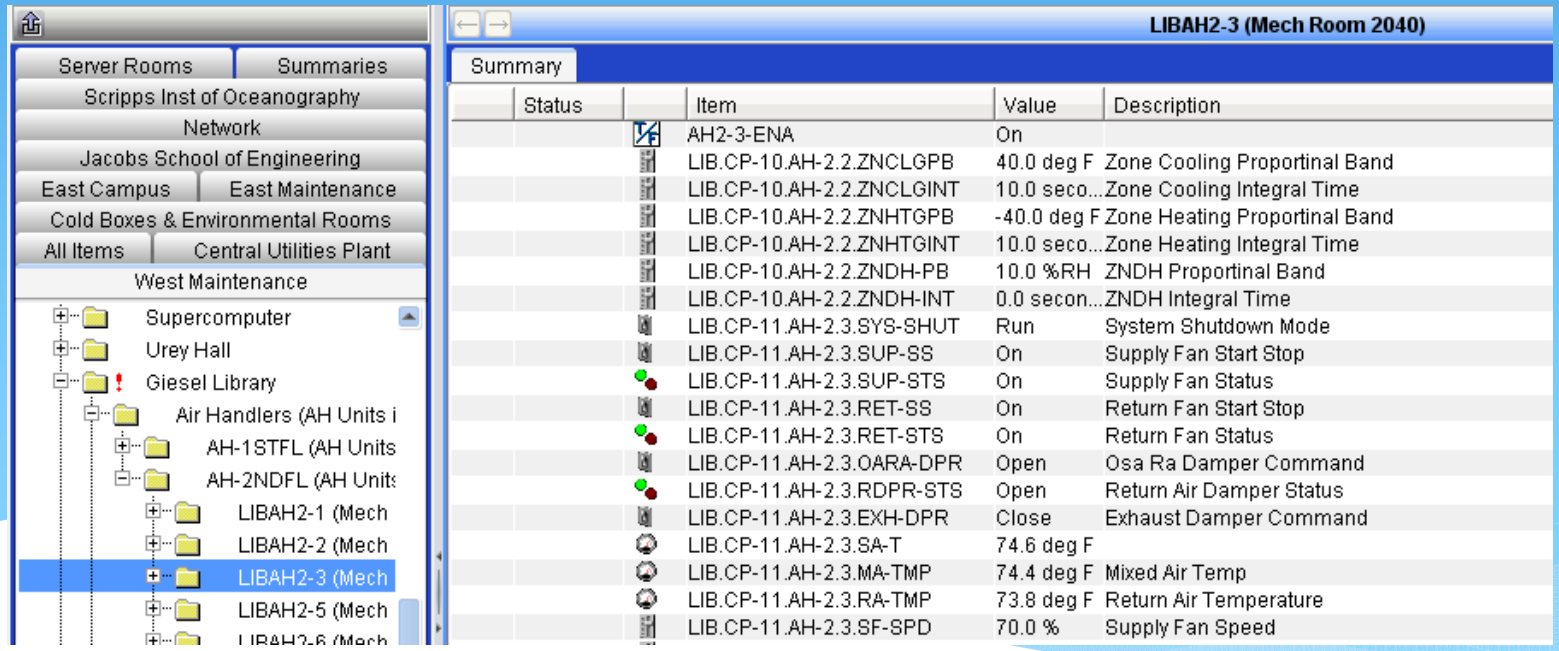


MBCx / Retrofit Hybrids

- Vigilent HVAC Control – Poor Man's VAV
- Cypress Wireless Pneumatic Thermostats

Vigilent Control Installation

- Install new motors and VFDs on every AHU Fan
- Upgraded Johnson Controls BMS to BACNet Compatible Extended Architecture
- Tied Vigilent Server t0 Johnson Controls via BACNet

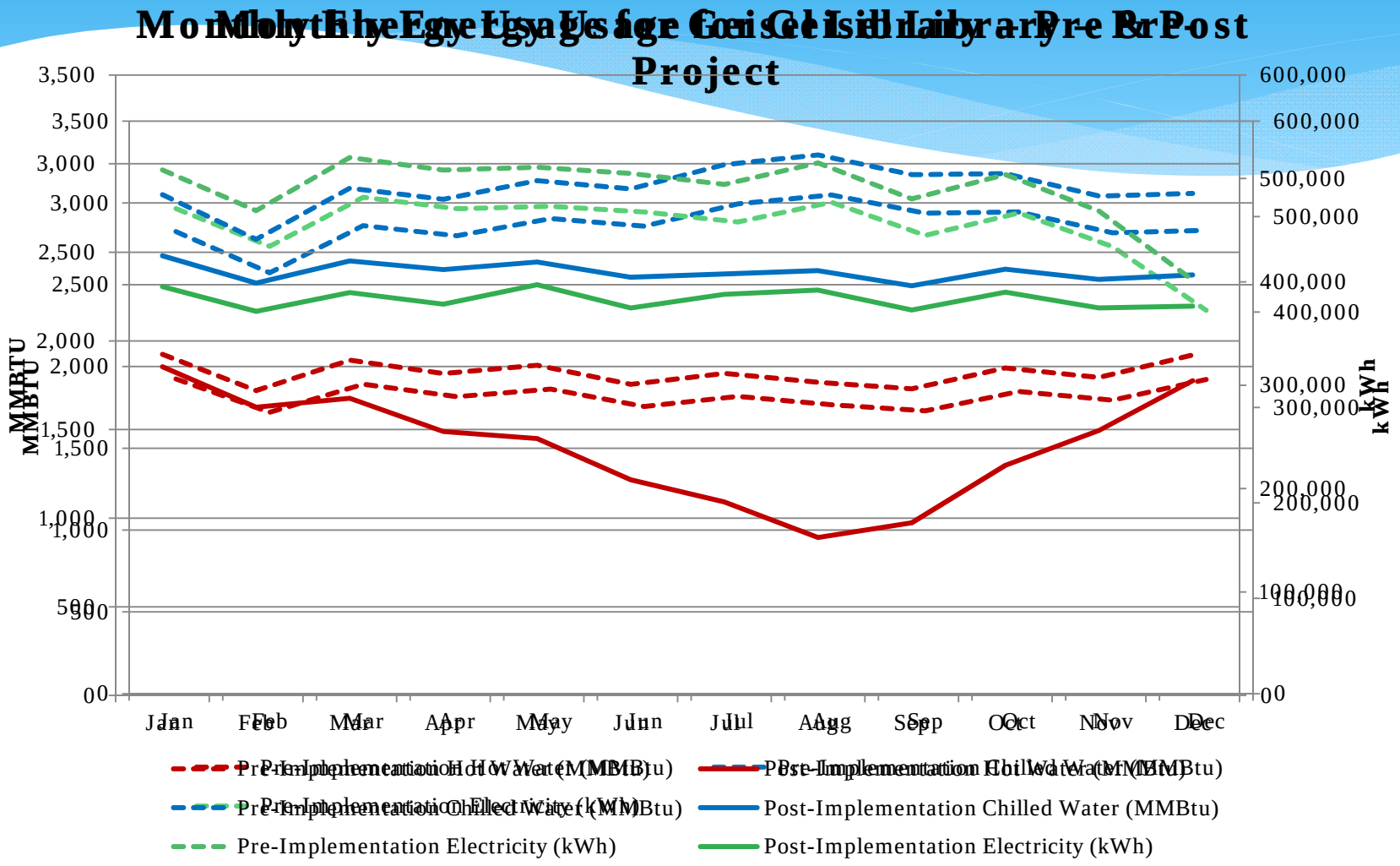


Vigilent HVAC Control System

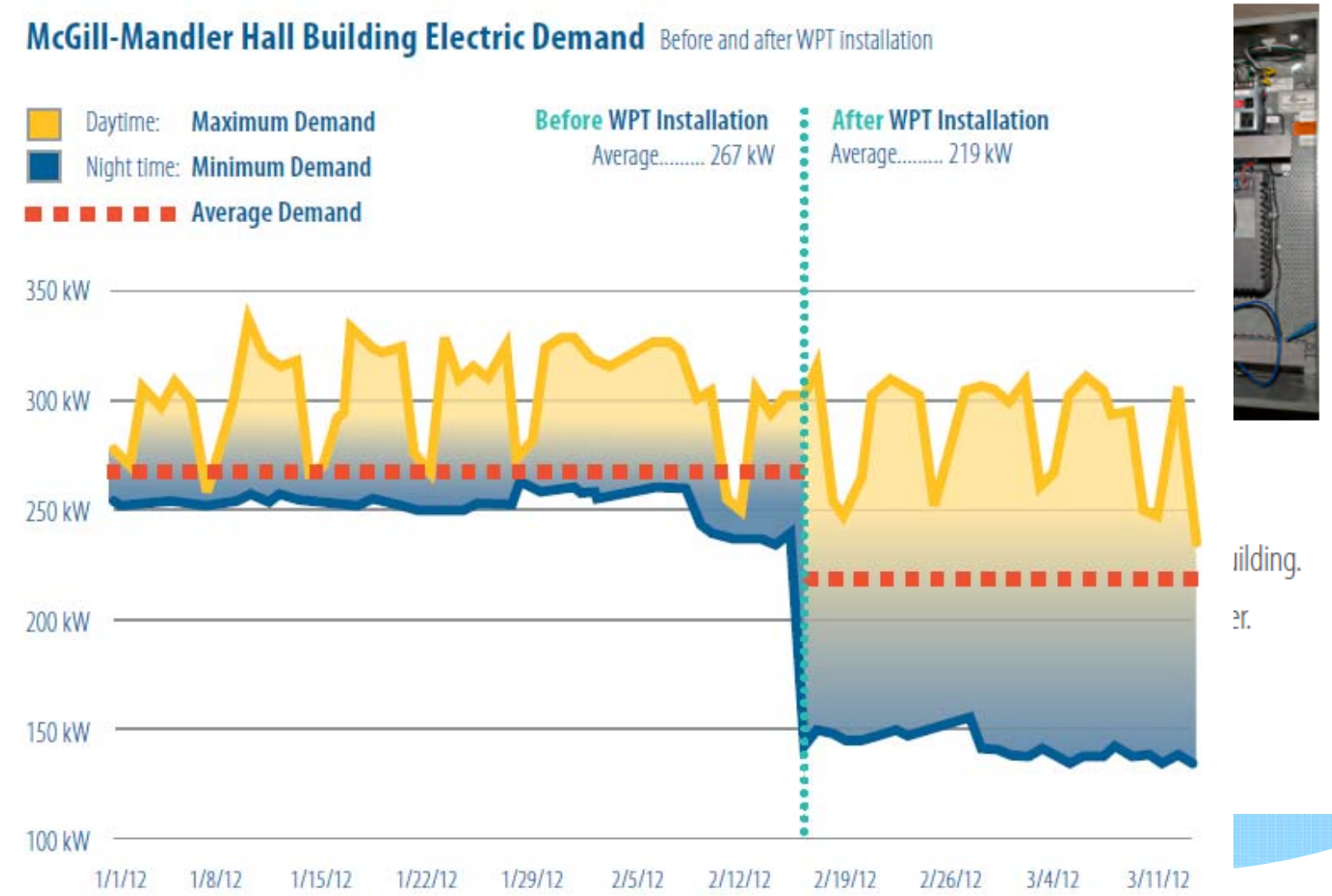
- Watches all zone temperatures
- If 3 or more zones are unsatisfied, it increase fan speed
- If fewer than 3 zones are unsatisfied, it slows fan speed
- Assumes that when most zone temps > setpoint, AHU is in "cooling mode", and vice versa
- Minimum fan speed to maintain min ventilation requirements, or higher, based on comfort needs

Cold	Good	Watch	Hot	Unreliable	LEGEND			
	Current Values		Current Setpoints				Auto-Cal	
Location	Top	Bottom	Low	High	MAC	Profile	Low	High
Room 475 W	78.6	-	72.1	78.1	00-DF-B2	SENSOR	☑ 72.1	☑ 78.1
Room 182 W	75.9	-	70.8	76.8	00-CB-42	SENSOR	☑ 70.8	☑ 76.8
Room 278 W	75.9	-	67.5	75.0	00-E0-37	SENSOR	☑ 67.5	☑ 75.0
Room 490 W	75.9	-	70.4	76.4	00-CB-77	SENSOR	☑ 70.4	☑ 76.4

Vigilent Energy Savings



Cypress Wireless Pneumatic Tstats



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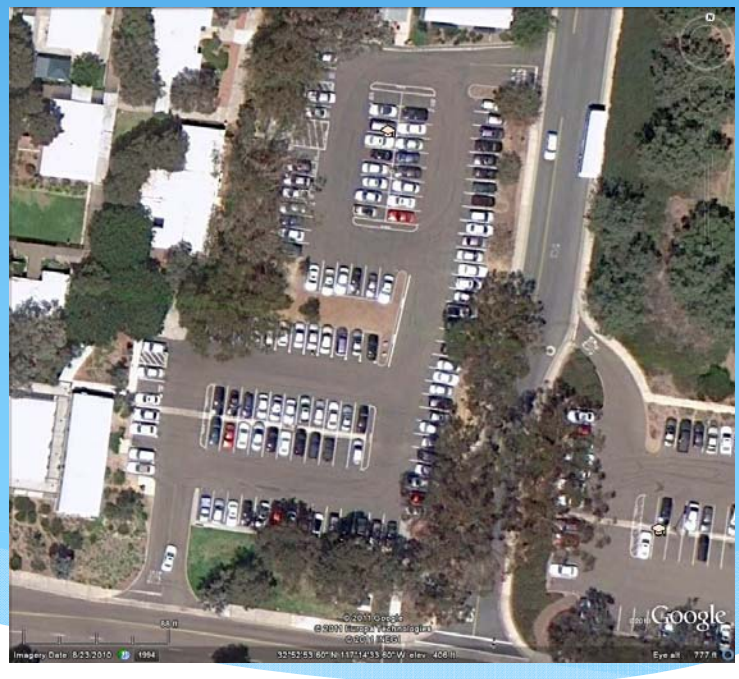
Lessons Learned

- Periodic Checking of Energy Data
- Ongoing Findings Log Tracking
- Tight Coordination with HVAC Techs & Ongoing Construction Projects
- Unforeseen Variables Impacting Energy
  - Exhaust Stack Velocity Requirements
  - High Heat Load Rooms Driving SAT & SP
- Worth Additional $ to Cover Project Management
- Creative Technology Justification
- Contracting of MBCx Repairs

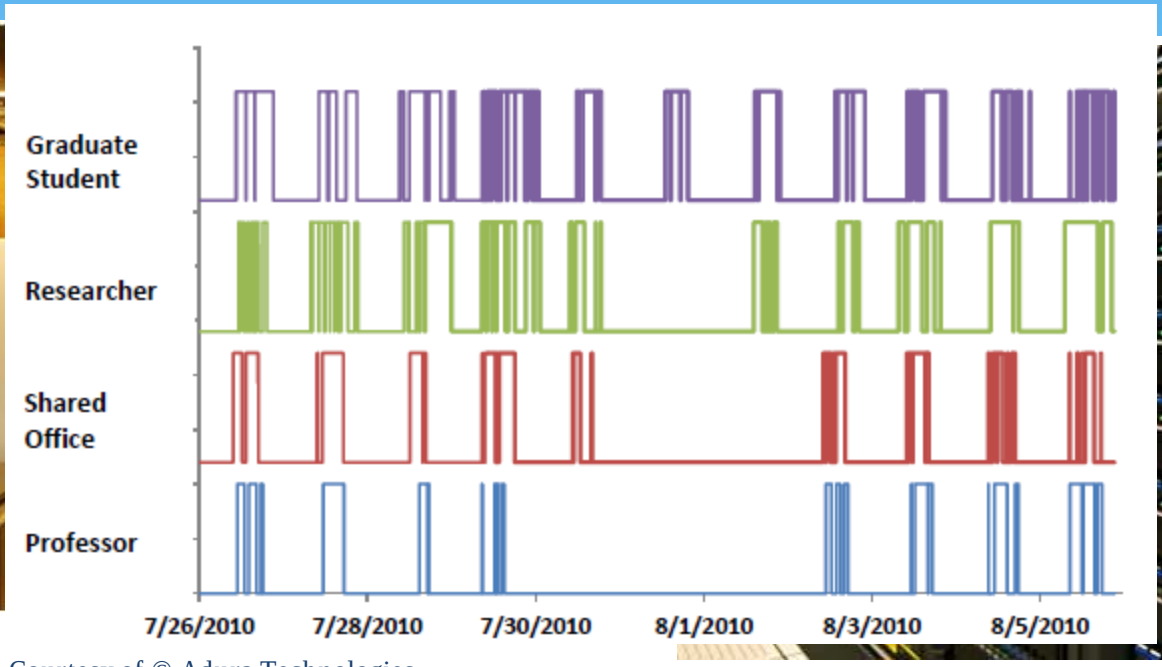
Additional Energy Efficiency Projects

- Central Plant Heat Recovery ($1M saved per year)
- Light Fixture & Control Retrofits ($200K saved per year)
- Bi-level Parking Lot Lighting



Future Projects

- Wireless lighting control
- Room temperature biology sample storage & freezer management
- Wireless occupancy-based HVAC control



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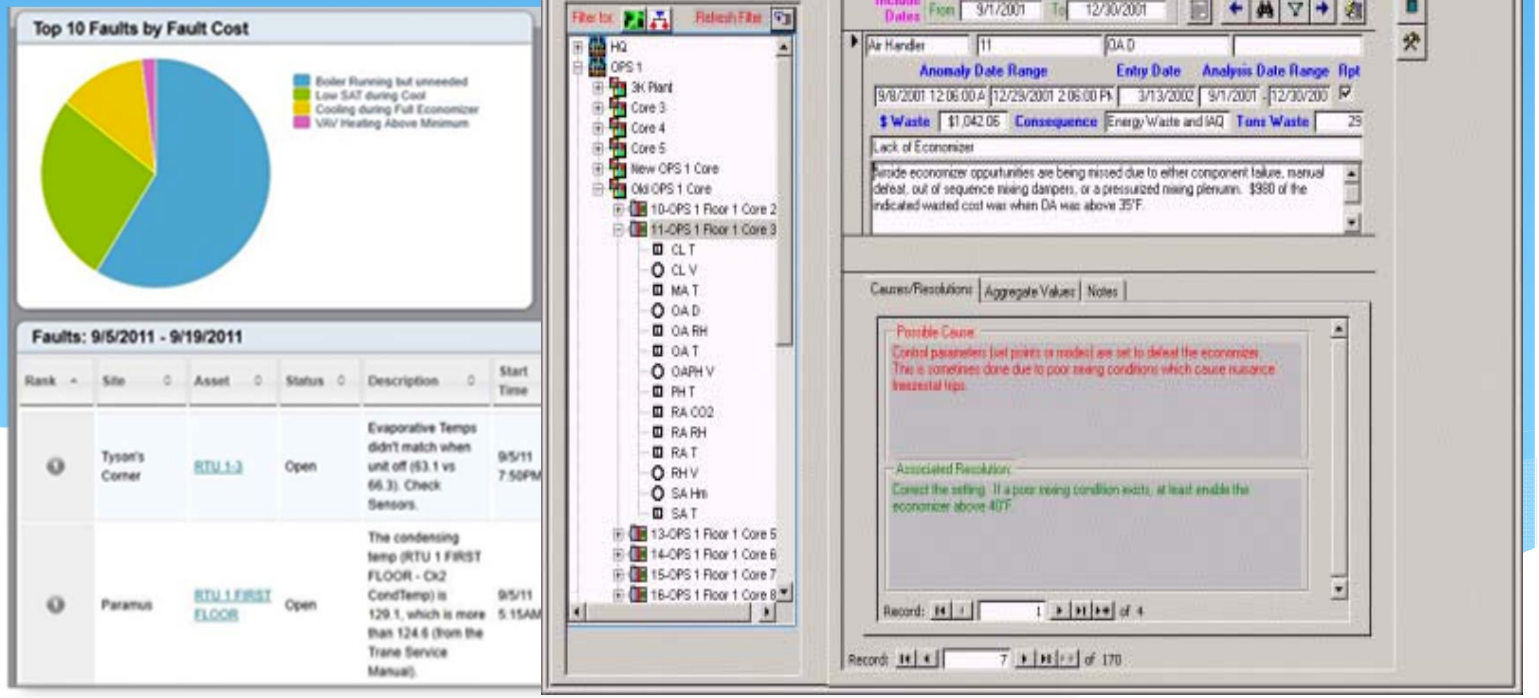
Continuous Commissioning

- FDD Software to Assist Energy Managers
  - EfficiencySMART/Insight (Enernoc)
  - PACRAT (Facility Dynamics)
  - Scientific Conservation (GE)
  - IGS Buildings Clockworks
  - Cimetrics



Anna Levitt
alevitt@ucsd.edu
858-534-8336