

Energy & Climate Action

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Overview

- **Energy**
 - Conservation Initiatives & Projects
 - Alternative Energy
- **Climate Action**
 - Emission Sources
 - Mitigation Projects



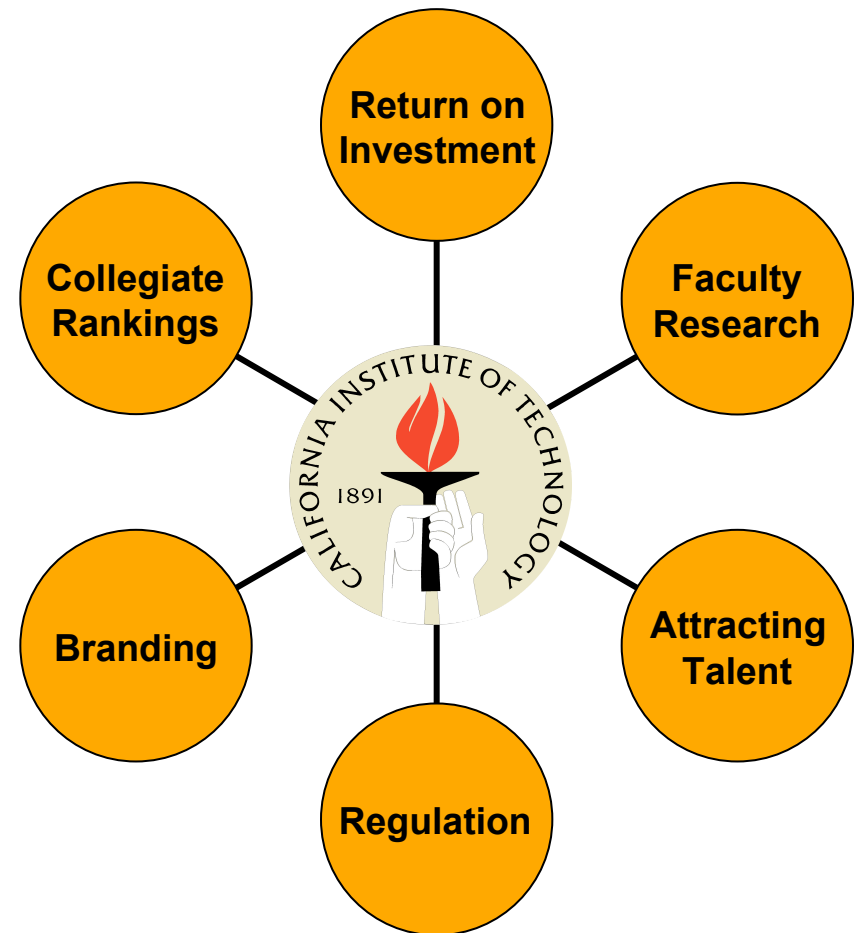
SUSTAINABILITY
AT CALTECH



Relevance to Caltech

Enhancing Caltech's core mission of research and education by:

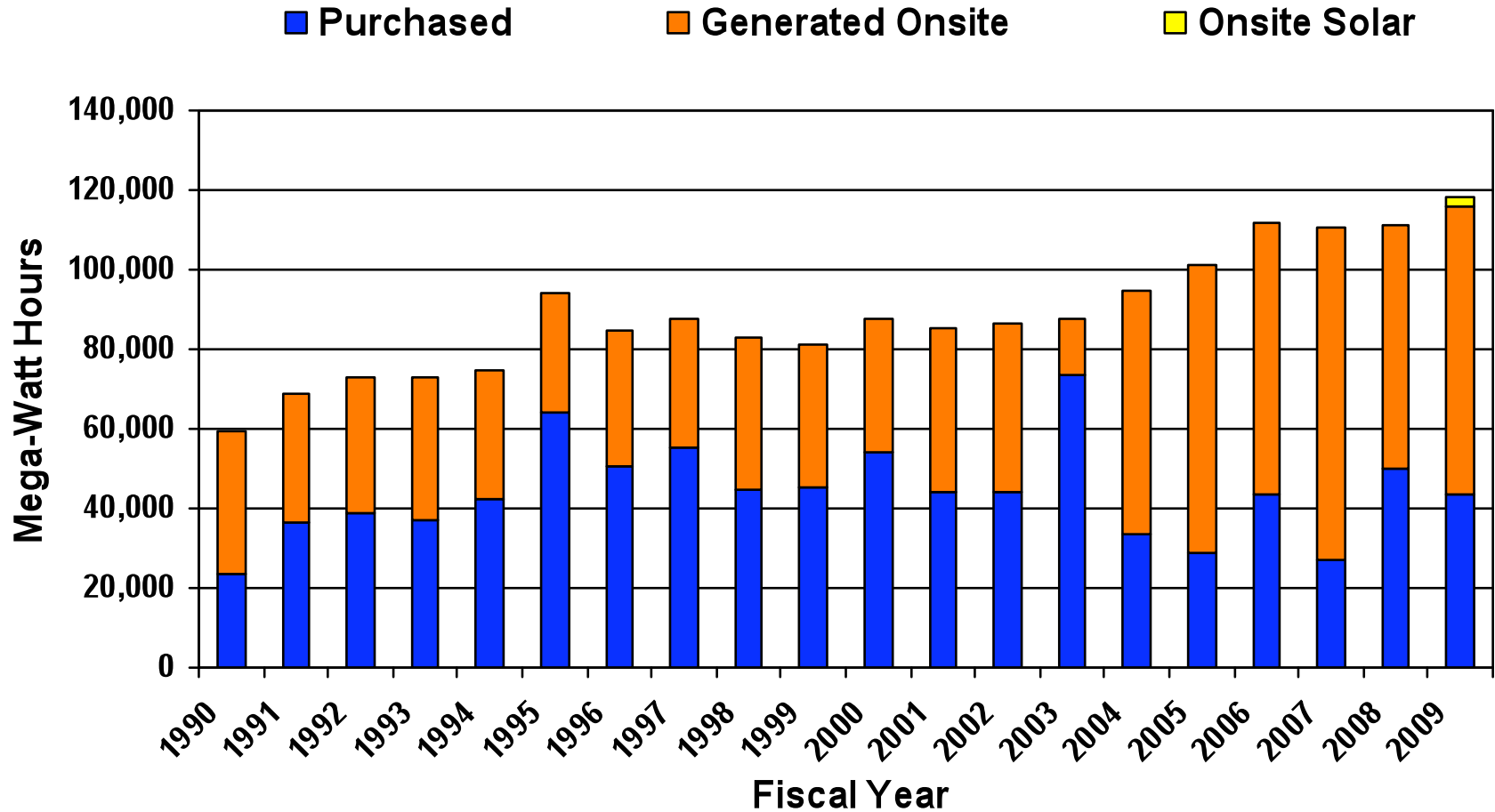
- reducing Caltech's environmental impact
- promoting stewardship within the Caltech community





Energy

Electricity Consumption by Source



Demand Side Management

- **Actions that influence the quantity or patterns of energy use.**



Retro-Commissioning (RCx)

Retro-Commissioning

- A process to optimize building system performance

Benefits of Retro-Commissioning

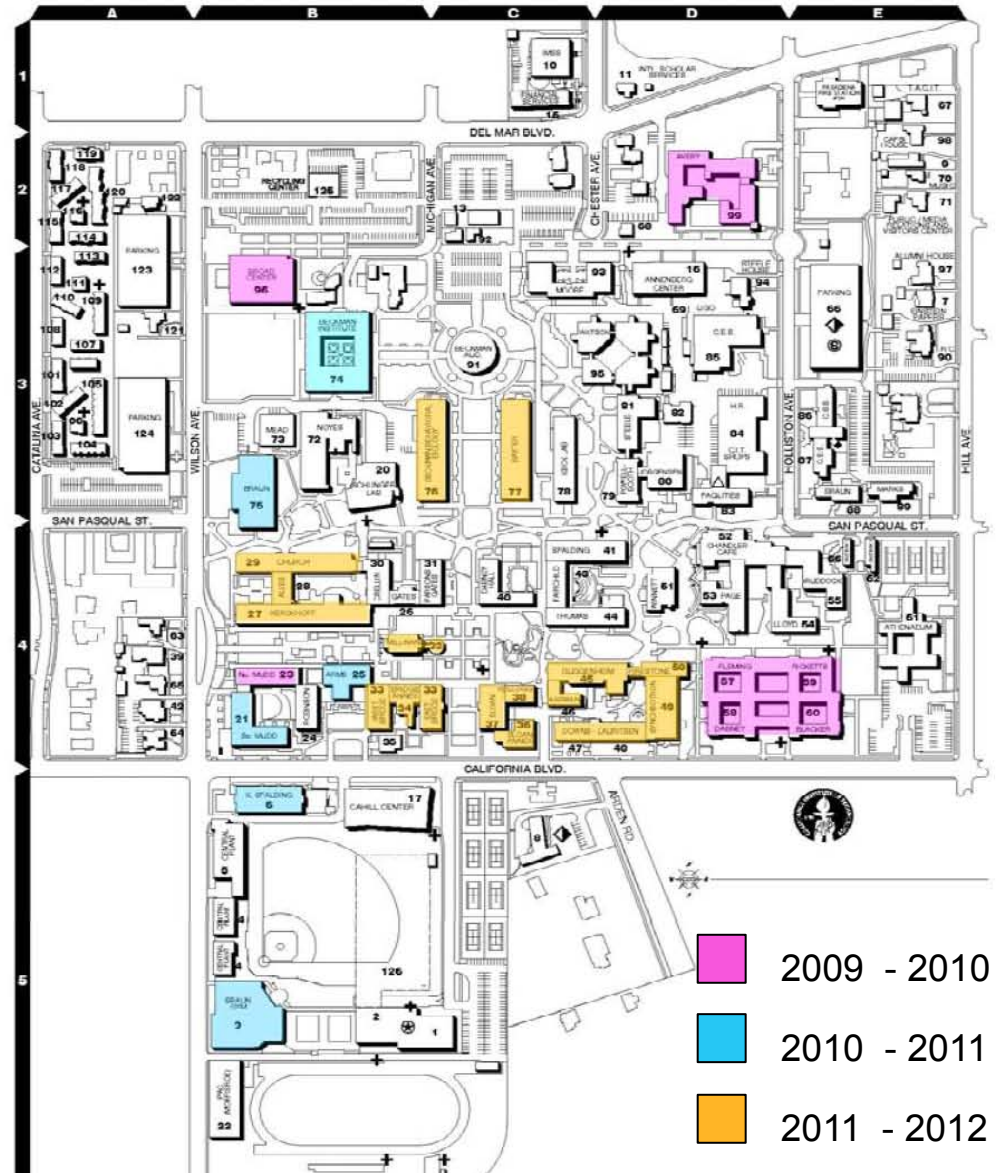
- Typical annual energy savings: 5% - 10%
- Fewer occupant complaints/issues
- Improved Indoor Air Quality and working environment

Currently underway in 30 buildings representing
50% of the campus building square footage



Retro-Commissioning Plan

- Fume Hood Optimization
- Chilled and Hot water valves
- Building Sequence of Operation Optimization
- Scheduling Adjustments
- Coil cleaning
- Duct leakage repair
- High Efficiency fans
- Wireless thermostats
- CO2 monitoring to reduce excess ventilation
- Lighting Upgrades



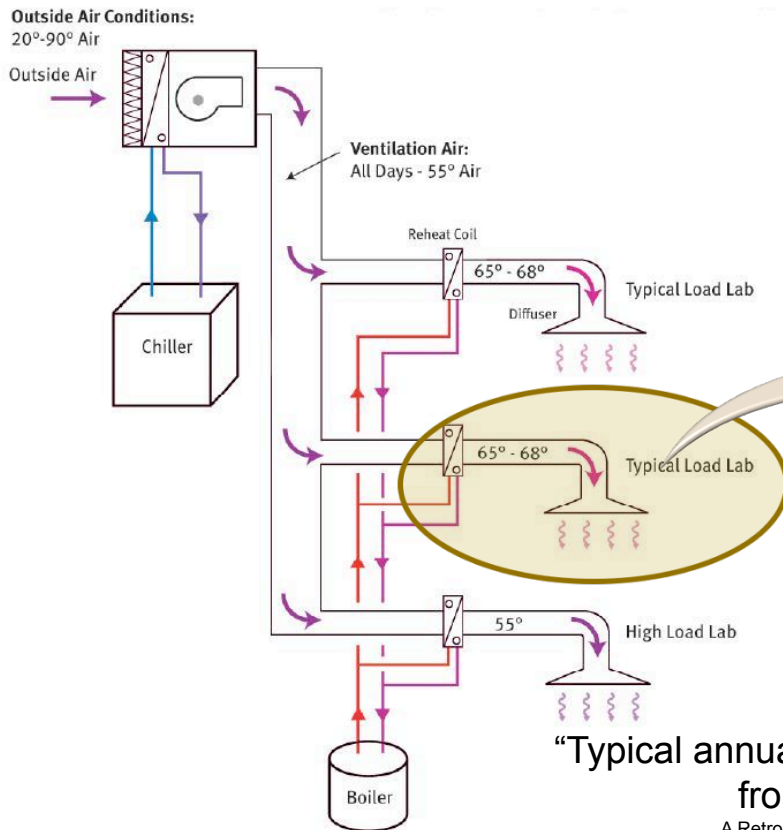
VAV (Variable Air Volume) HVAC Systems

Standard Lab VAV Reheat System

Supply Air Must be cooled to satisfy Highest Heat Load – Re-Heat is incorporated through re-heat coil in VAV box to warm supply air to appropriate zone demand.

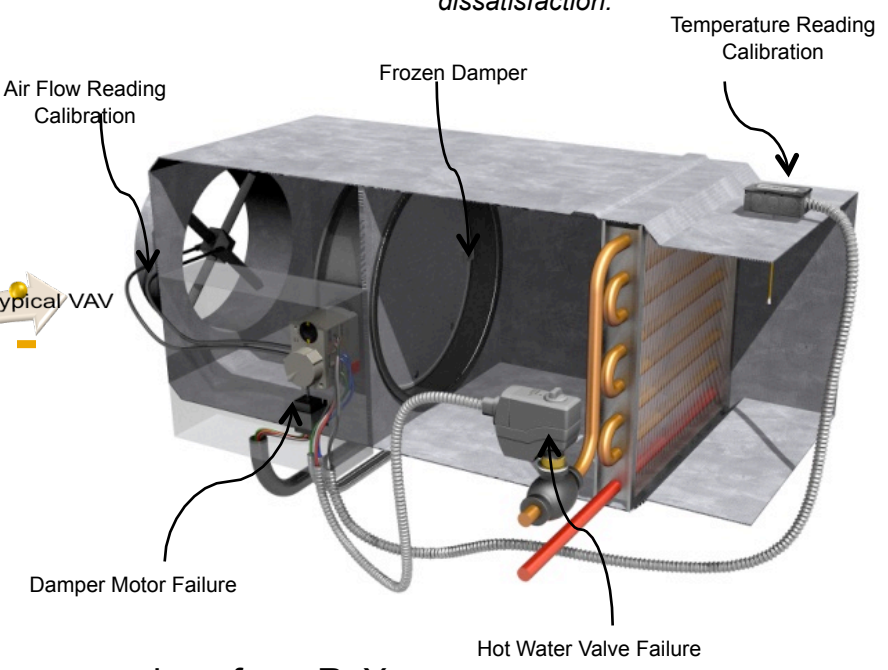
Possible Points of Failure – Typical VAV

Over time the identified points below are subject to failure resulting in system inefficiencies and/or occupant dissatisfaction.



Air Flow Reading Calibration

Typical VAV

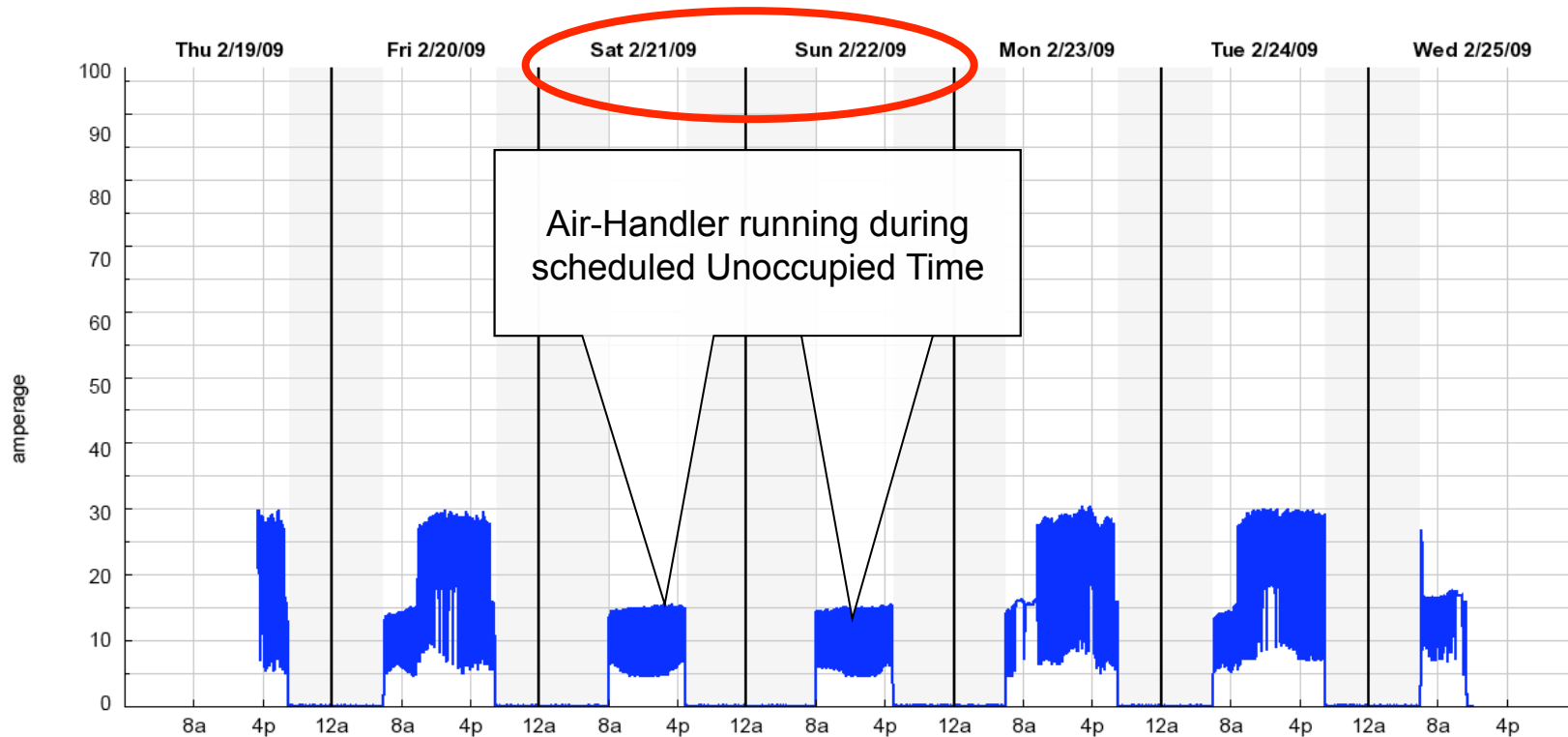


“Typical annual energy savings from RcX range
from \$0.11 - \$0.72 / sqft”

A Retro-commissioning guide for building owners, EPA



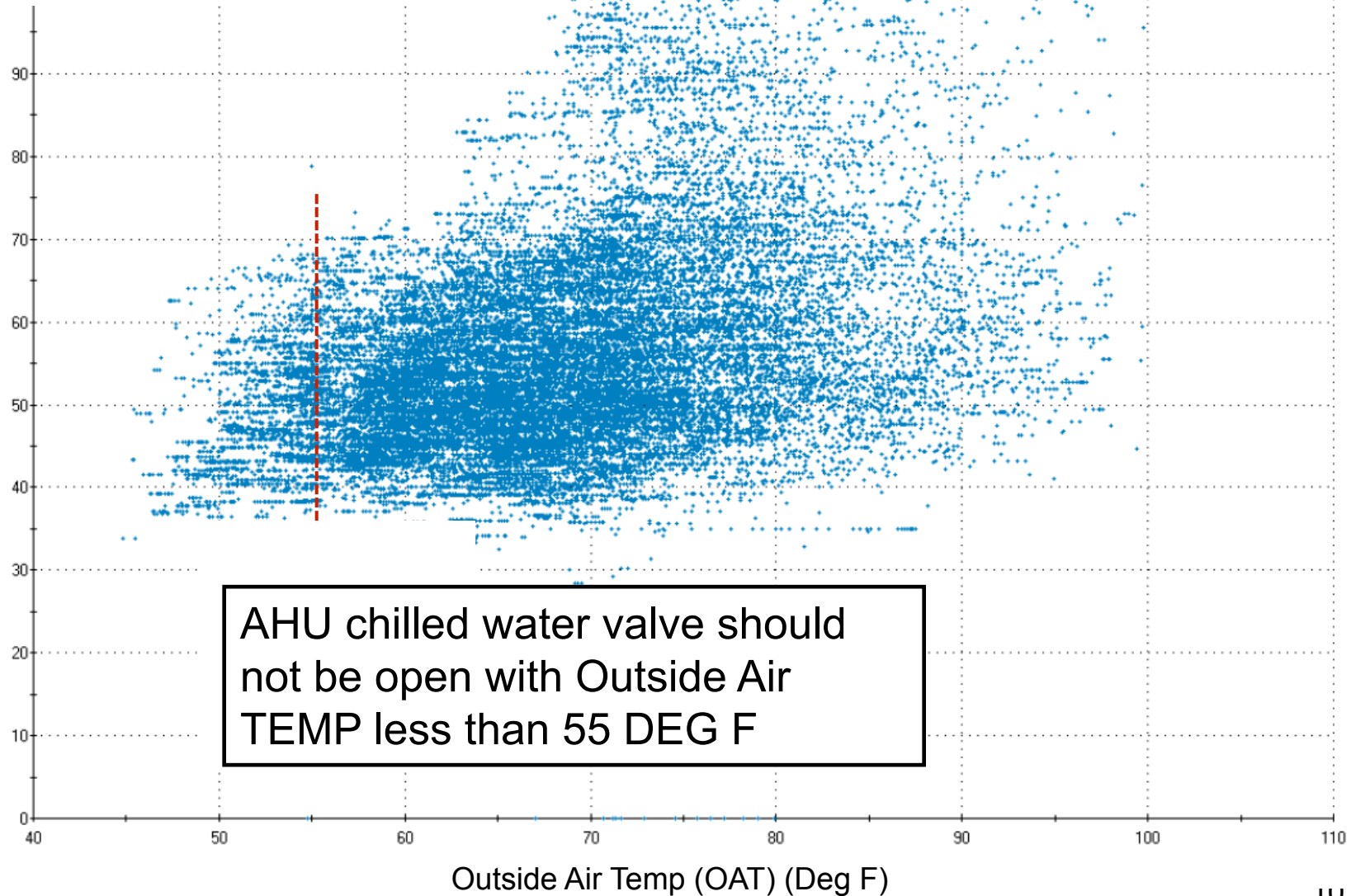
RCx Findings – HVAC Running Weekends



RCx Findings

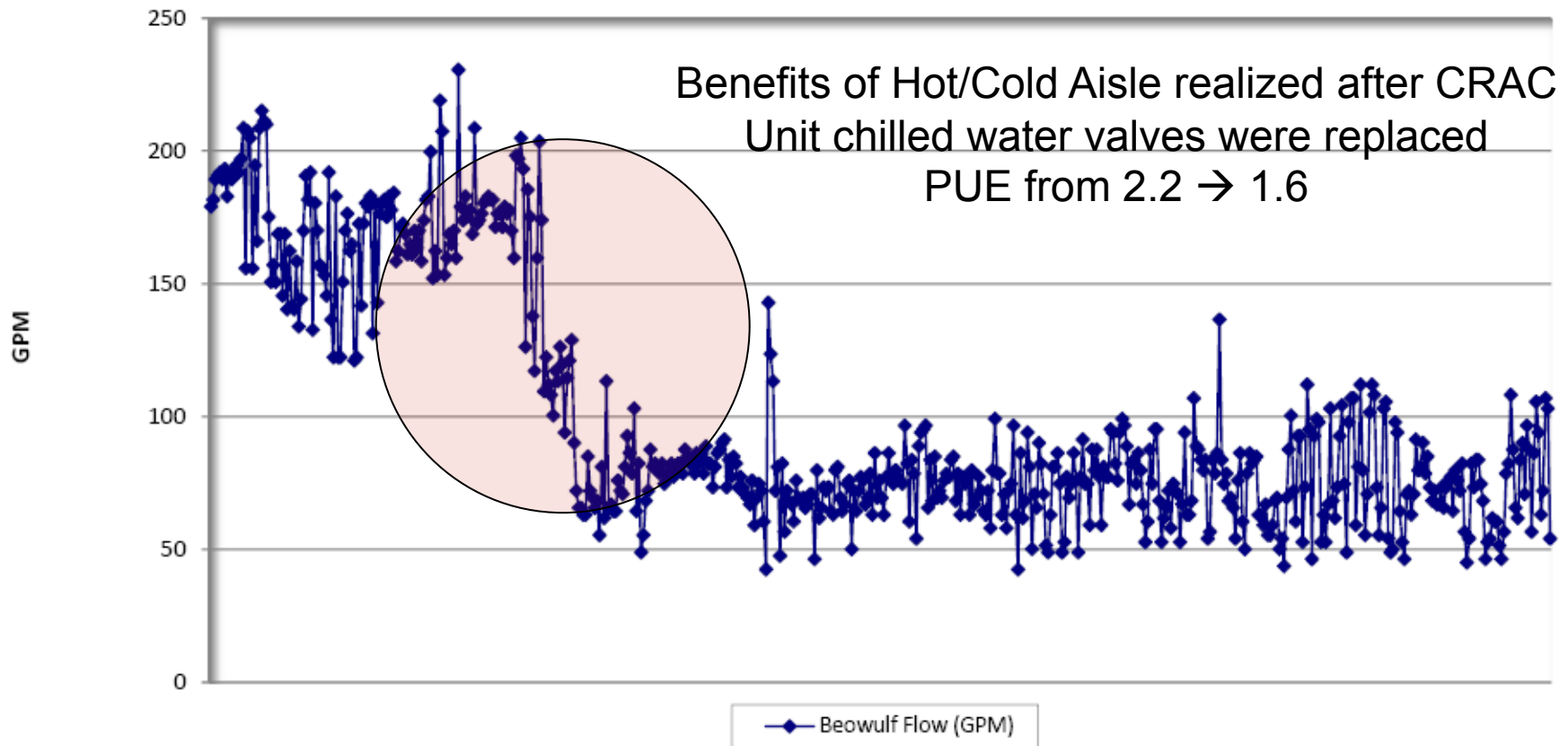
Air-Handler – Excessive Cooling

Valve Command (% Open)



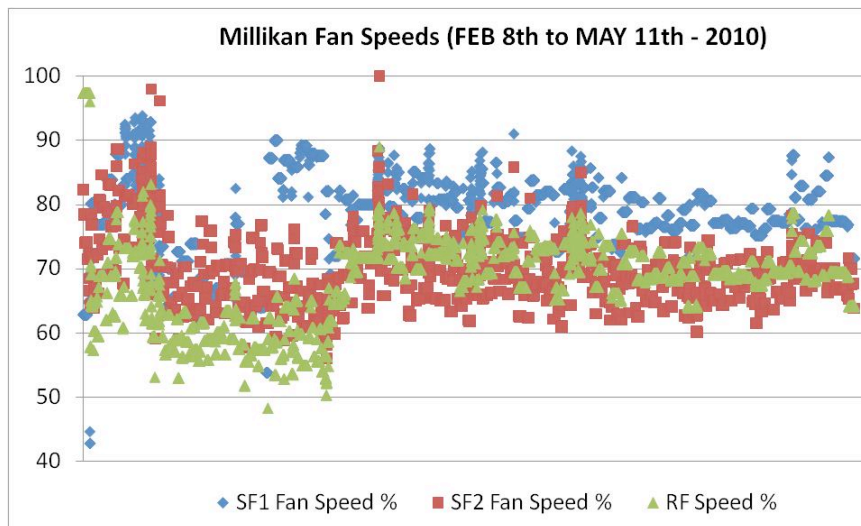
BEOWULF HVAC Upgrade

BEOWULF Chilled Water Flow Demand (GPM) - June 3 through June 7, 2010
(Control Valves Replaced on Friday June 4th, 2010)



Verification of Performance

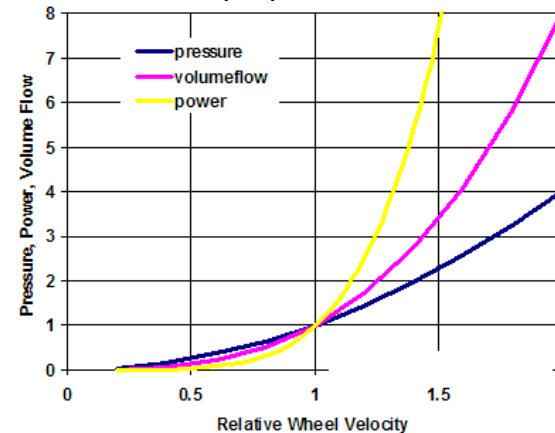
All Millikan fans were at 100% Speed all the time prior to the energy project



331,400 Annual kWh Savings from VFD operation

FAN Law 1c:

Power is proportional to the cube of shaft speed



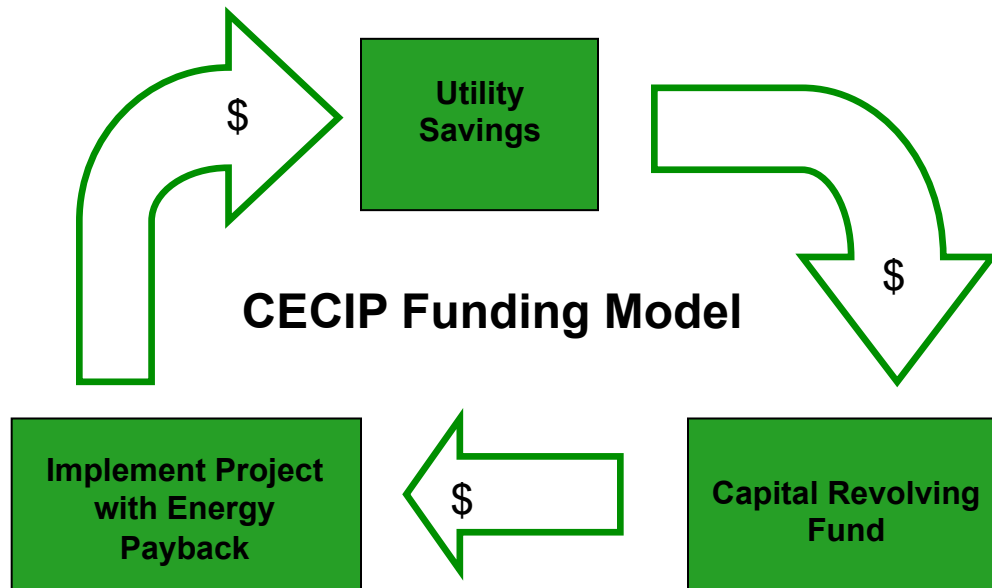
$$\frac{P_1}{P_2} = \left(\frac{N_1}{N_2}\right)^3$$

10% Speed reduction is approximately a 30% power reduction, *the cube root effect*



Energy Conservation Economics

Caltech Energy Conservation Investment Program (CECIP)

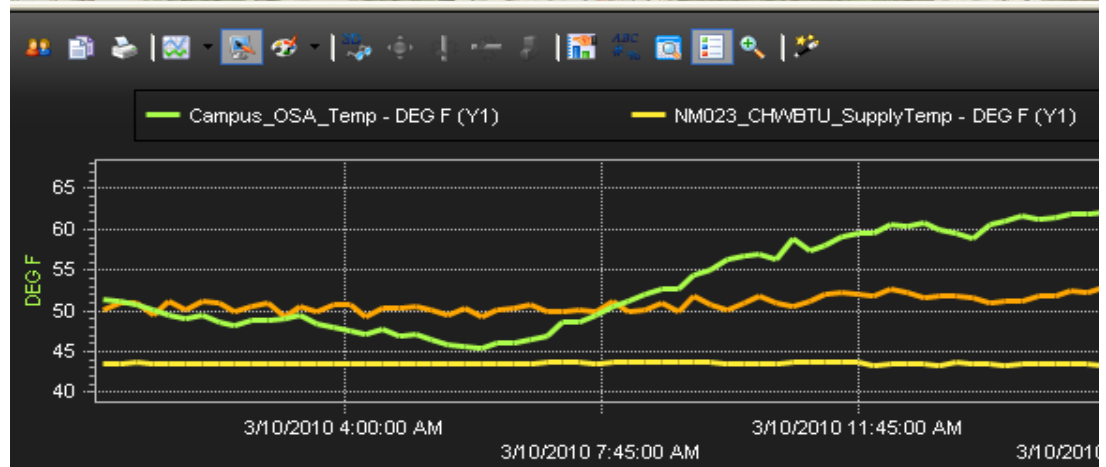
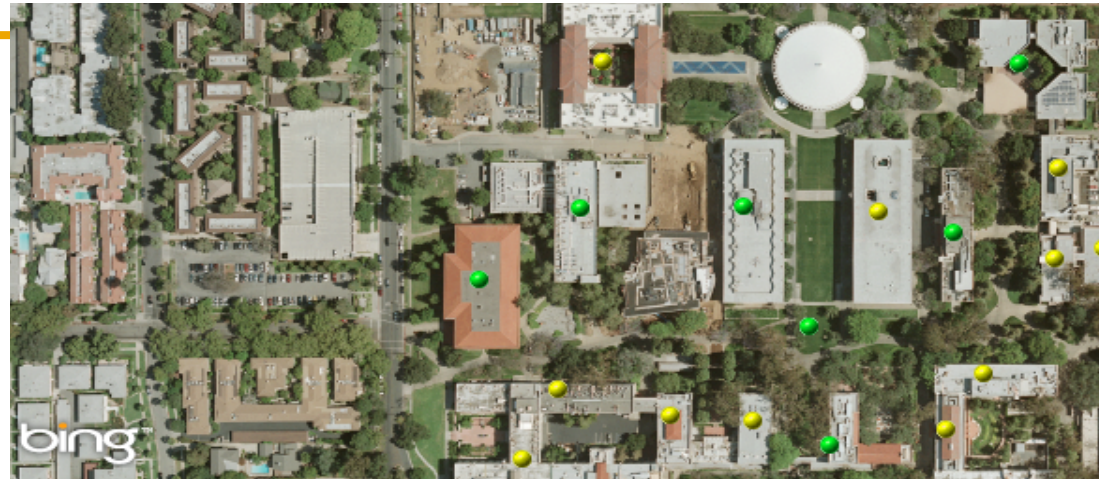
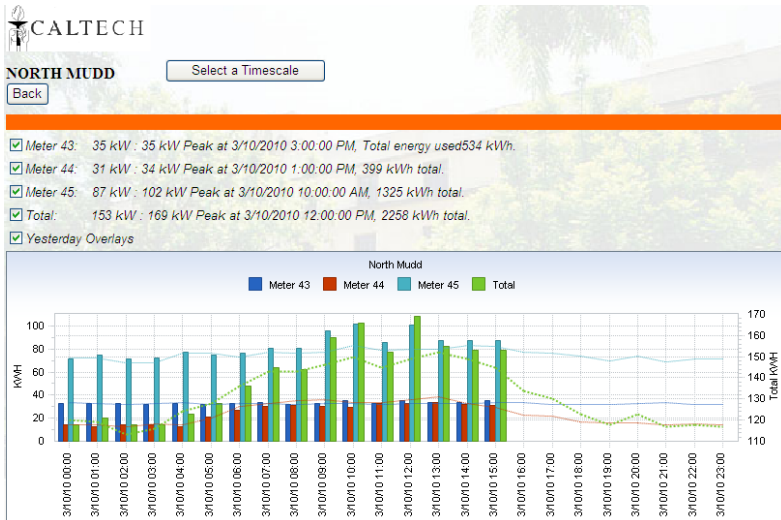


- Limited to 6 yr payback or better
- Verified by Caltech Energy Manager and 3rd party consultant from PWP

In two program years:
\$1M+ rebates & Incentives from PWP
\$1M+ annual avoided utility costs



Caltech Enterprise Energy Management



<http://sustainability.caltech.edu/energy>

- GIS base map
- Building automation data
- Power monitoring and reporting
- Demand side management
- Automated utility billing



Supply Side

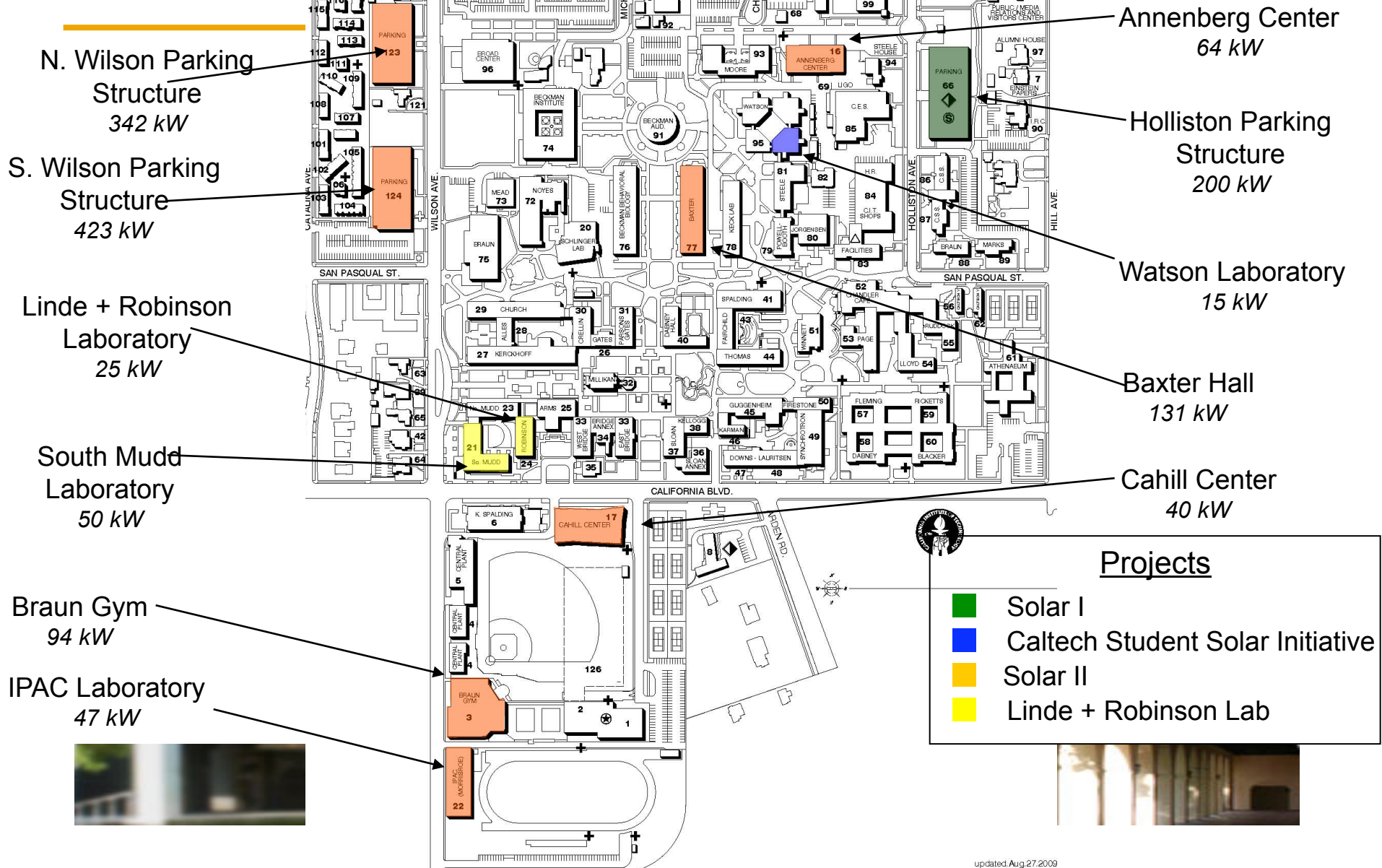


Caltech is its own micro-grid with a diverse portfolio of energy generators.

The portfolio supports the energy needs of Caltech while being less carbon intensive than traditional purchased electrical power



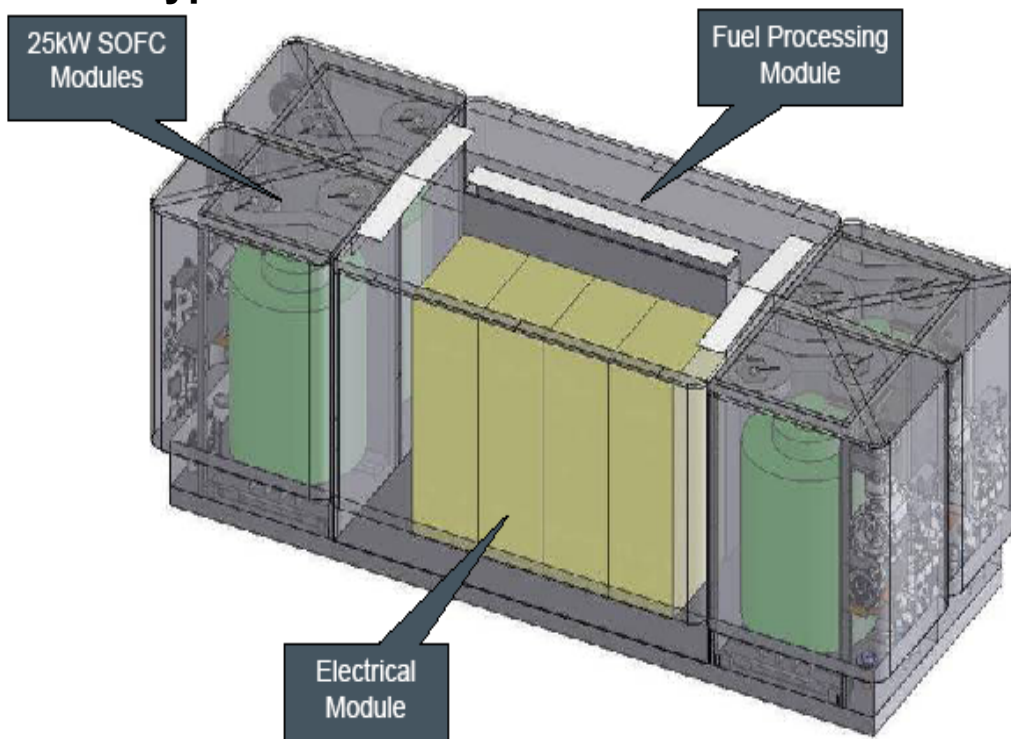
Caltech Solar Photovoltaic



Fuel Cells – 20 Units – 2 MW

Bloomenergy

Typical 100 KW unit



- 10 year contract
- Power Purchase Agreement
- No Caltech investment except enabling costs
- No AQMD permit
- No heat recovery
- Install Fall 2010



Caltech Sources of Electricity

Cleaner and more predictable costs

Source	Cost ¹ (\$/kWh)	Escalation	Percent of Consumption		Carbon Content (MTCE/GWh) FY 11
			FY 09 116 GWh	FY 11 127 GWh	
Pasadena Water and Power	.18	Unknown; Politically sensitive; Best guess 5-10%	38%	22%	700 - 800
Cogeneration	0.05 - 0.06 ²	Depends on price of gas	62%	63%	600
Solar 1	.104	3.9% fixed for 15 years	<0.5%	2%	0
Solar II	.105	3.5% fixed for 20 years	0%		0
Fuel Cell 2 MW	.138	5% fixed for 10 years	0%	13%	350

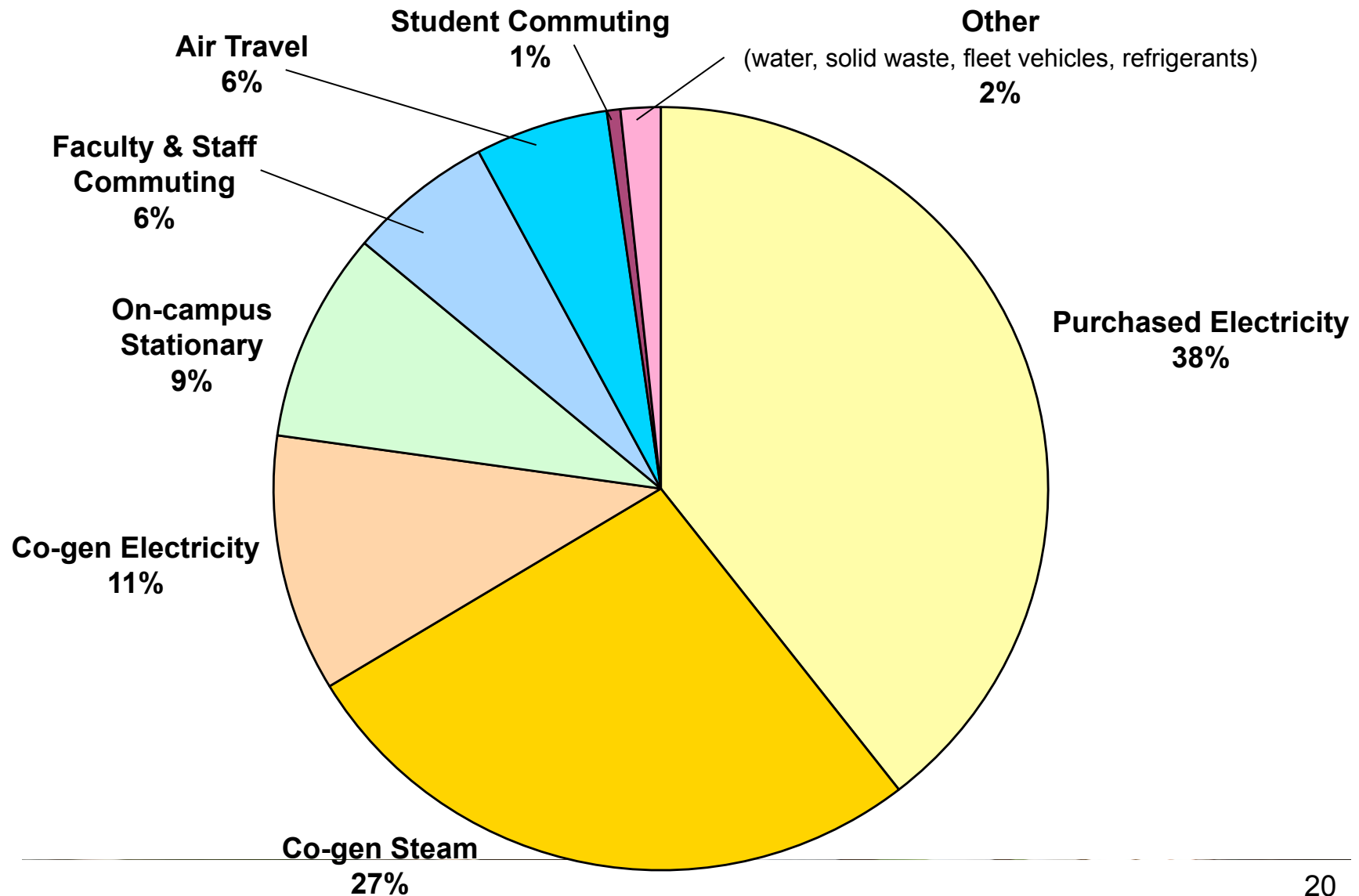
¹ Includes cost of capital and fuel

² @ \$7 - \$9 NYMEX; Burner tip is NYMEX plus ~\$1.25

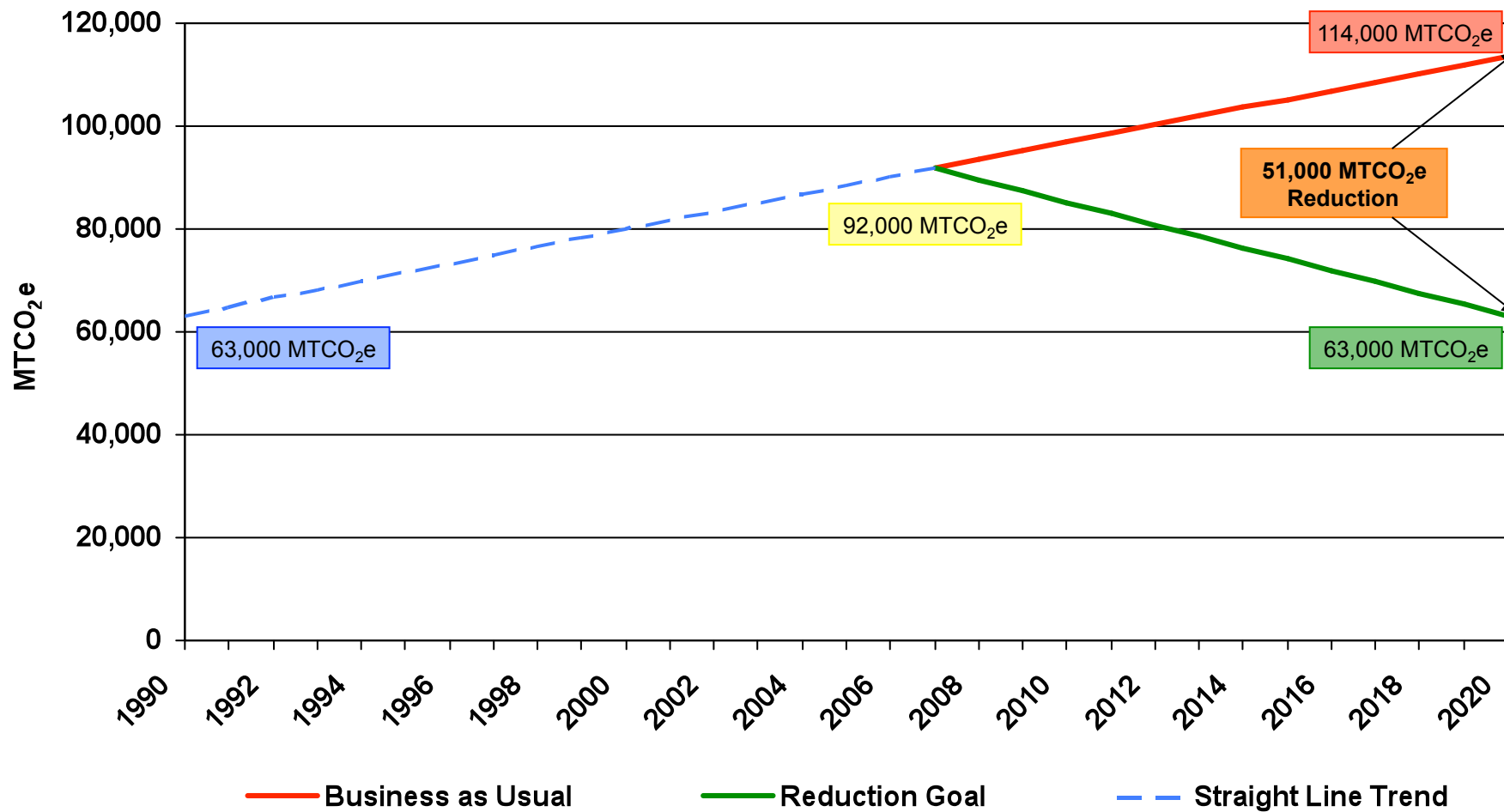


Climate Action

2008 Emissions Sources (MTCO₂e)



Projected Emissions & Reduction Goal



Reduction Projects – Focus Areas

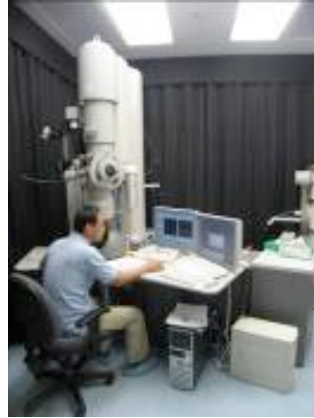
- **Increase building & facility energy efficiency**
 - Retro-commissioning
 - Optimize energy performance in new construction & major renovations
 - Laboratories, high performance computing centers
- **Establish a conservation ethic within community**
 - Elevated to a high priority through staff trainings
 - Real-time building energy dashboard
 - Energy Star procurement standard
- **Reduce the carbon intensity of the power supply**
 - On-campus solar installations, fuel cell installations
 - Influence city of Pasadena
 - Purchase remote green power
- **Promote less carbon intensive transportation alternatives**
 - Commuter incentive programs
 - Fuel efficient vehicles: fleet, commuter subsidies
 - Virtual meeting technology



Reduction Projects – Summary

Project Category	Annual MTCO ₂ e Reduction	Annualized Return per MTCO ₂ e Avoided
Completed, Ongoing, Probable Projects	14,000	\$130
Anticipated or Possible Projects	42,000	\$140
Potential Additional Projects and Activities	5,900	TBD
Offset Projects	75,000	(\$70)





Questions?

www.sustainability.caltech.edu

