University of Hawai'i at Mānoa FMO

The Climate Registry

University of Hawaii at Mānoa Energy Strategy 2008-2015

University of Hawai'i at Mānoa

Hawaiian Electric Company, Inc.
Giving you the power

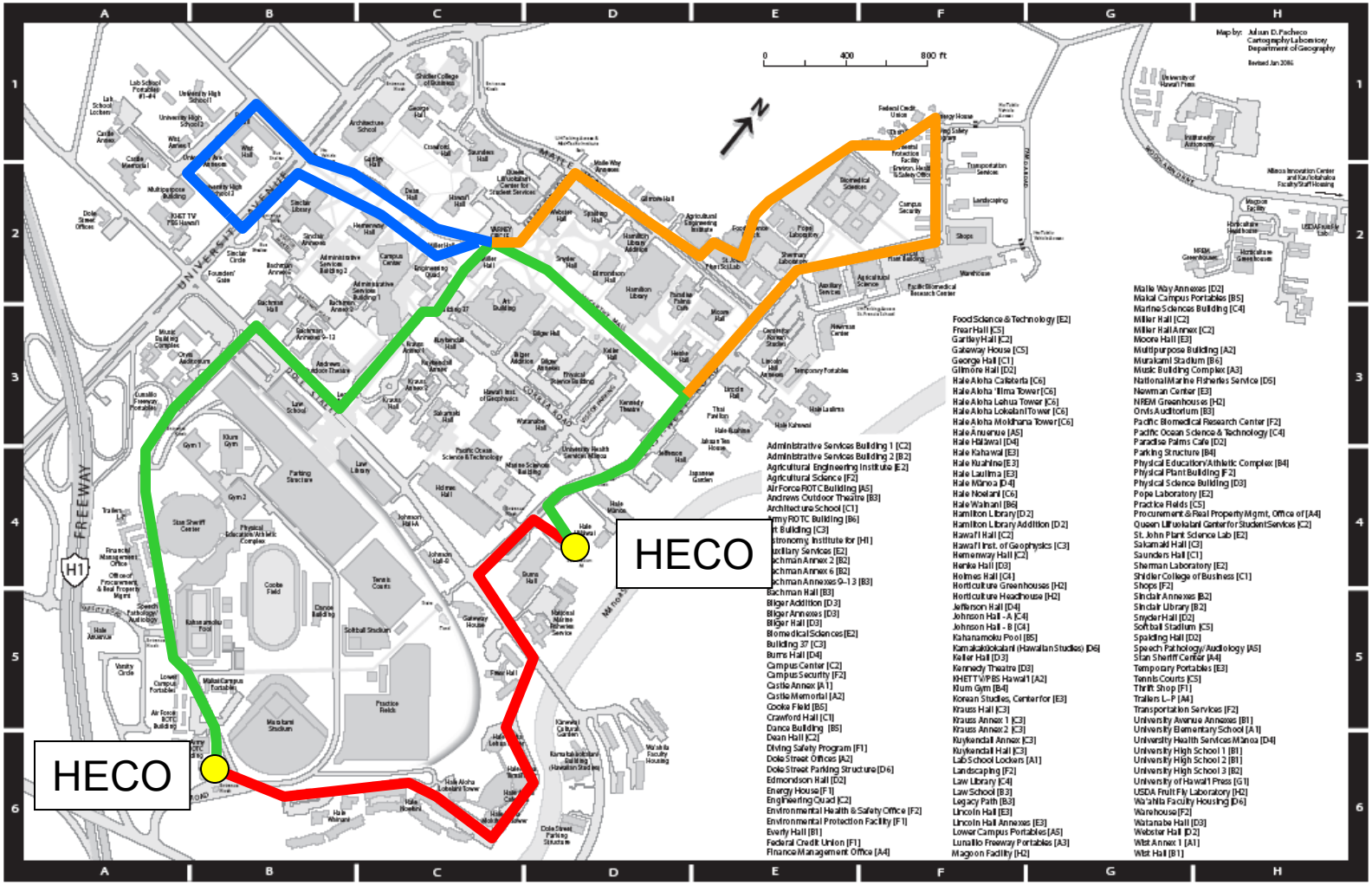
Challenges and Responses

- Aging Plant
  - High Cost GSF^{-1}
- Rising Cost kWh^{-1}
  - HVAC Renewal and Chill Water Plant Upgrades
  - EMCS Expansion
  - Metering
  - Weekend/Holiday HVAC Reductions
- High User Demands
  - Sustainable Saunders
  - Delighting/De-lamping
  - "Turn it off"
- Future Initiatives
  - Demand Response
  - Cx and RCx
  - Performance Contracting
  - Alternative Energy and Power Purchasing Agreements

Facilities Allocations

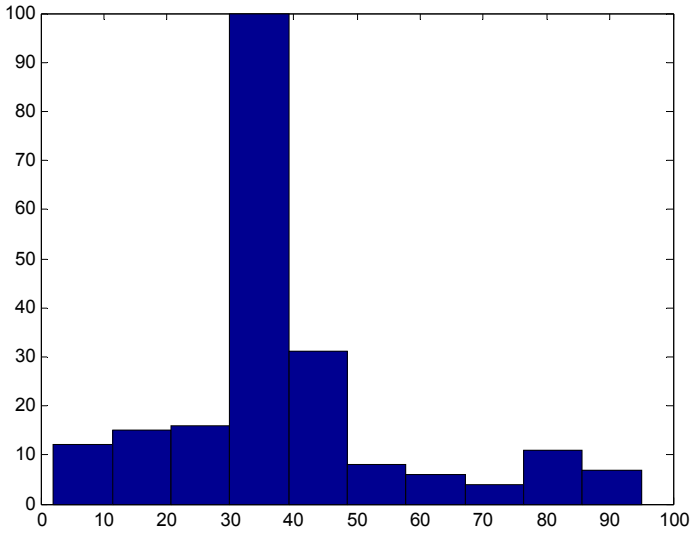
	FY2008	FY2009	FY2009	FY2009
	EXP & ENCB	BUDGET	OUTLOOK	Variance
CAMPUS OP	499,732	610,175		
EH&S	1,535,379	1,537,311		
FPMO/B&G	15,113,936	16,253,378		
SPECIAL R&M	1,943,971	1,810,000		
UTILITIES	23,608,663	28,008,663	31,600,000	(3,591,337)
TOTAL	42,701,681	48,219,527	31,600,000	(3,591,337)

The Mānoa Utility District

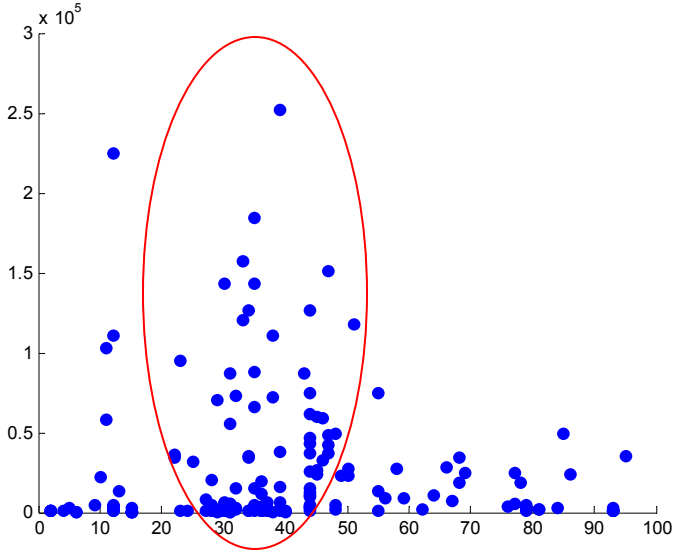


Driving Factors

- Age of buildings (Mean Age 33 years)
- Insufficient Maintenance and Renewal Investment
  - High Utilization factors
- Cost of Energy 0.1725 to 0.267 kWh (55%) increase



Distribution of Buildings by Age

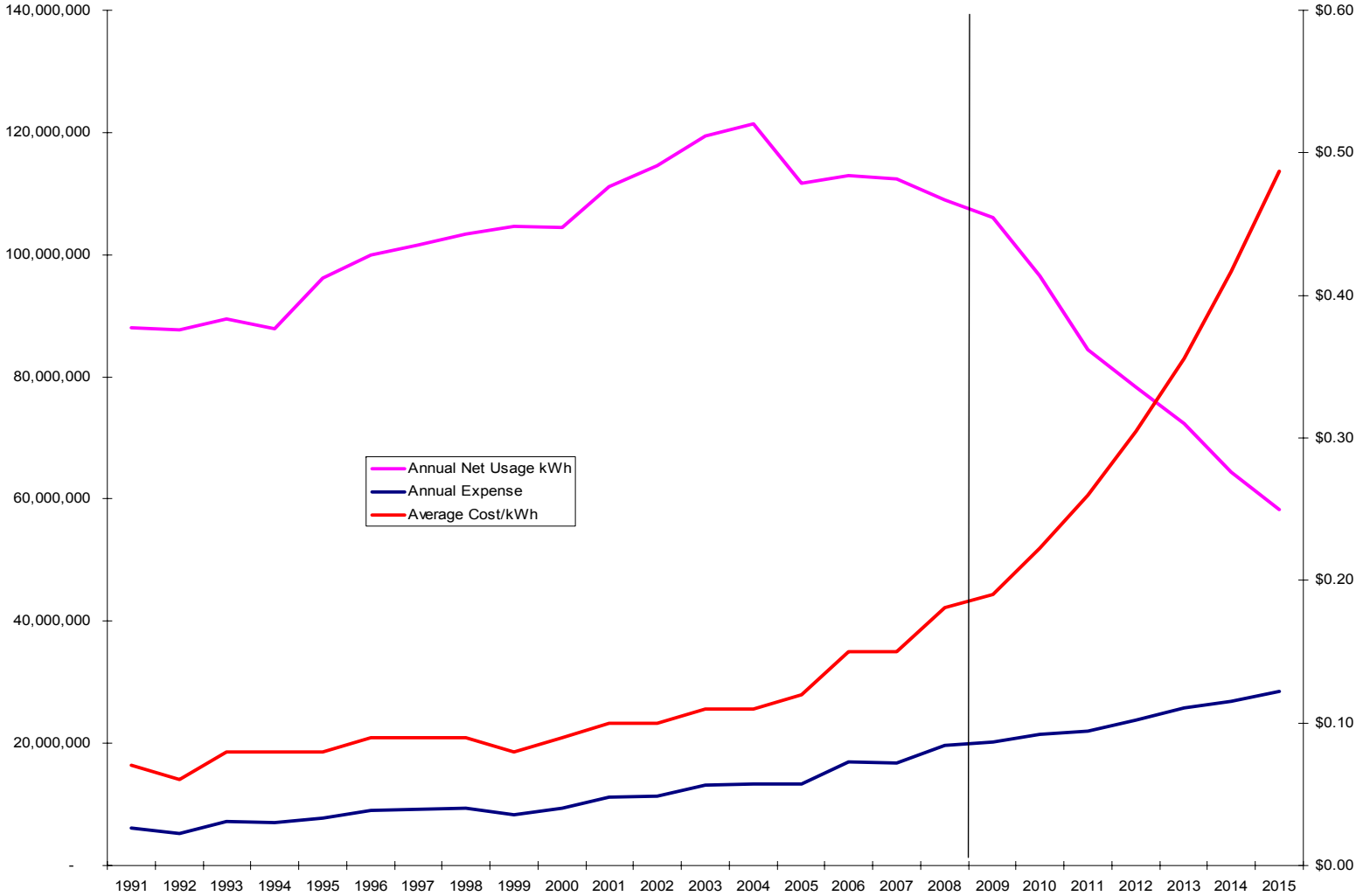


Scatter plot of Buildings Age by GSF

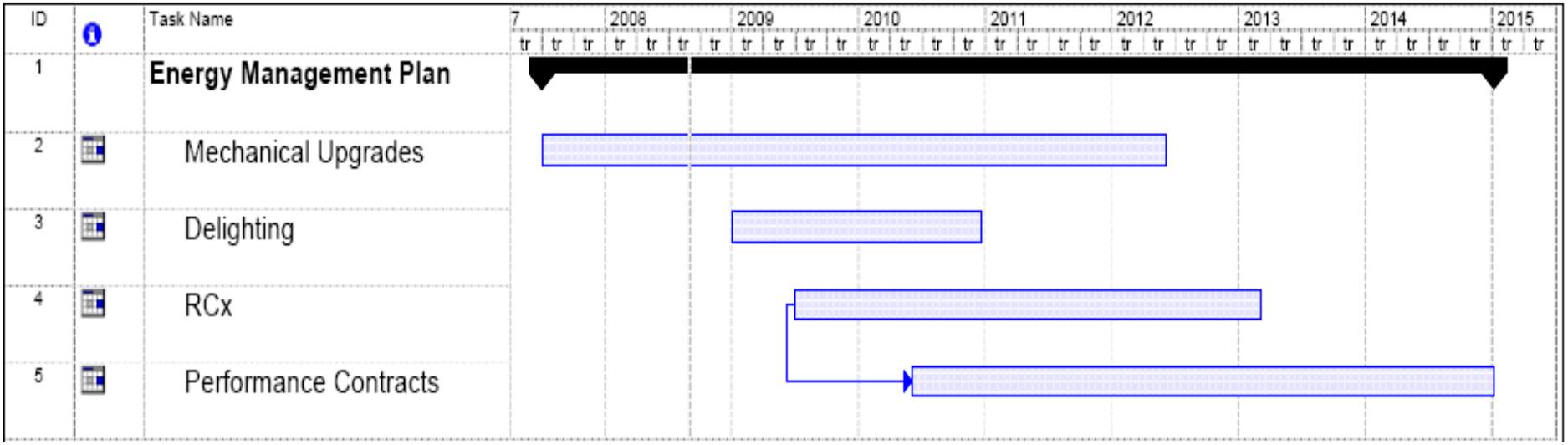
Building Energy Use

Year	Building Name	Type	GSF	Energy use kWhr/yr	Cost/GSF
	Coconut Island/Pauley Lab	lab/class/office	15,000	1,749,280	21.57
1964	Paradise Palm	food/facility/office	9,439	816,000	15.99
1975	Bilger Addition (2)	lab/class	55,575	4,745,966	15.80
1967	St. John Lab	lab/class/office	101,300	7,130,000	13.02
1972	Holmes Hall	lab/class/office	93,016	5,558,000	11.05
1915	Engineering Quad	storage	3,646	213,280	10.82
1972	Wantanabe Hall	lab/class/office	52,609	3,075,840	10.82
1967	Biomedical Science Building	office/lab	120,678	6,870,000	10.53
1962	Auxilliary Services Building	food/facility/office	12,652	699,840	10.23
1982	Law School Library	library	31,500	1,551,440	9.11
1974	Campus Center	food/facility/office	133,342	6,130,000	8.50
1976	IfA Manoa A, B, & C	office/lab	46,340	1,998,000	7.98
1959	Keller Hall	class/office	49,193	2,070,360	7.79
1958	Klum Gym	class/office	22,884	950,000	7.68
1938	Crawford Hall	class/office	24,663	1,000,000	7.50
1996	POST	lab/class/office	228,000	9,192,000	7.46
1976	Speech Pathology Bldg-171E	class/office	7,615	301,970	7.34

Energy Usage and Expense Trends (1Q 2008)



Energy Reduction Schedule



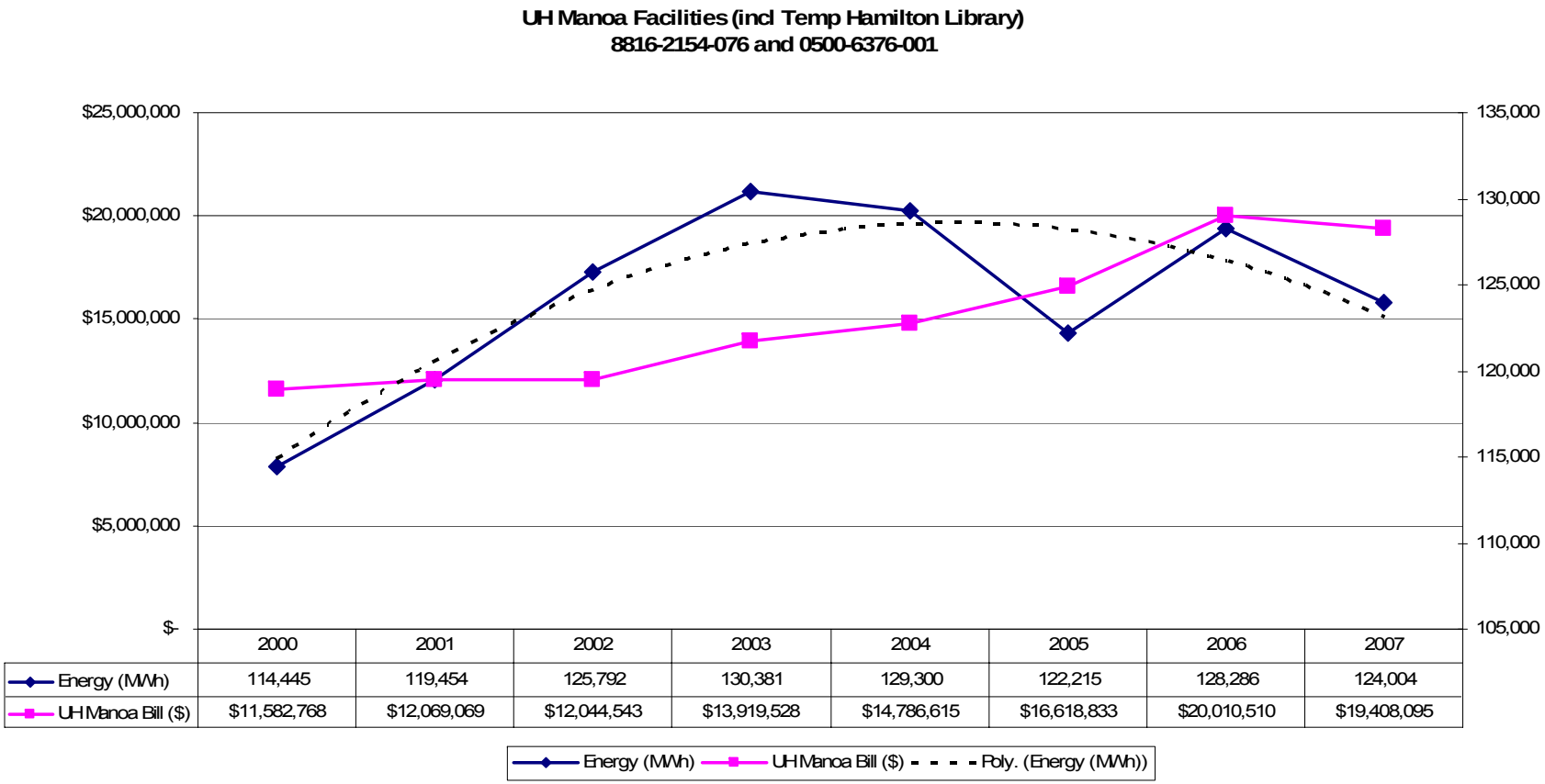
Energy Usage Reduction Plan

Baseline Electrical Usage	2006	2007	2008	2009	2010	2011	2012	2013	2014
Baseline Annual kWh	121,350,873	121,350,873	121,350,873	121,350,873	121,350,873	121,350,873	121,350,873	121,350,873	121,350,873
Engergy Program Savings kWh									
Mechanical Systems kWh	8,500,000	9,000,000	12,400,000	13,000,000	15,000,000	17,000,000	19,000,000	21,000,000	23,000,000
Conservation kWh				2,000,000	6,000,000	8,000,000	8,000,000	8,000,000	8,000,000
Perfornace Contracting kWh					2,000,000	8,000,000	12,000,000	16,000,000	20,000,000
RCx kWh				200,000	800,000	2,000,000	2,000,000	2,000,000	2,000,000
PV Systems kWh					1,000,000	2,000,000	2,000,000	2,000,000	4,000,000
Tota Program Savings kWh	8,500,000	9,000,000	12,400,000	15,200,000	24,800,000	37,000,000	43,000,000	49,000,000	57,000,000
Net Requirement kWh	**112,850,873**	**112,350,873**	**108,950,873**	**106,150,873**	**96,550,873**	**84,350,873**	**78,350,873**	**72,350,873**	**64,350,873**
Percent Reduction Targets									
Mechanical Upgrades		7.4%	10.2%	10.7%	12.4%	14.0%	15.7%	17.3%	19.0%
Conservation		0.0%	0.0%	1.6%	4.9%	6.6%	6.6%	6.6%	6.6%
Perfornace Contracting		0.0%	0.0%	0.0%	1.6%	6.6%	9.9%	13.2%	16.5%
RCx		0.0%	0.0%	0.2%	0.7%	1.6%	1.6%	1.6%	1.6%
PV Systems		0.0%	0.0%	0.0%	0.8%	1.6%	1.6%	1.6%	3.3%
Total Reduction	7.0%	7.4%	10.2%	12.5%	20.4%	30.5%	35.4%	40.4%	47.0%

UHM Energy Drivers

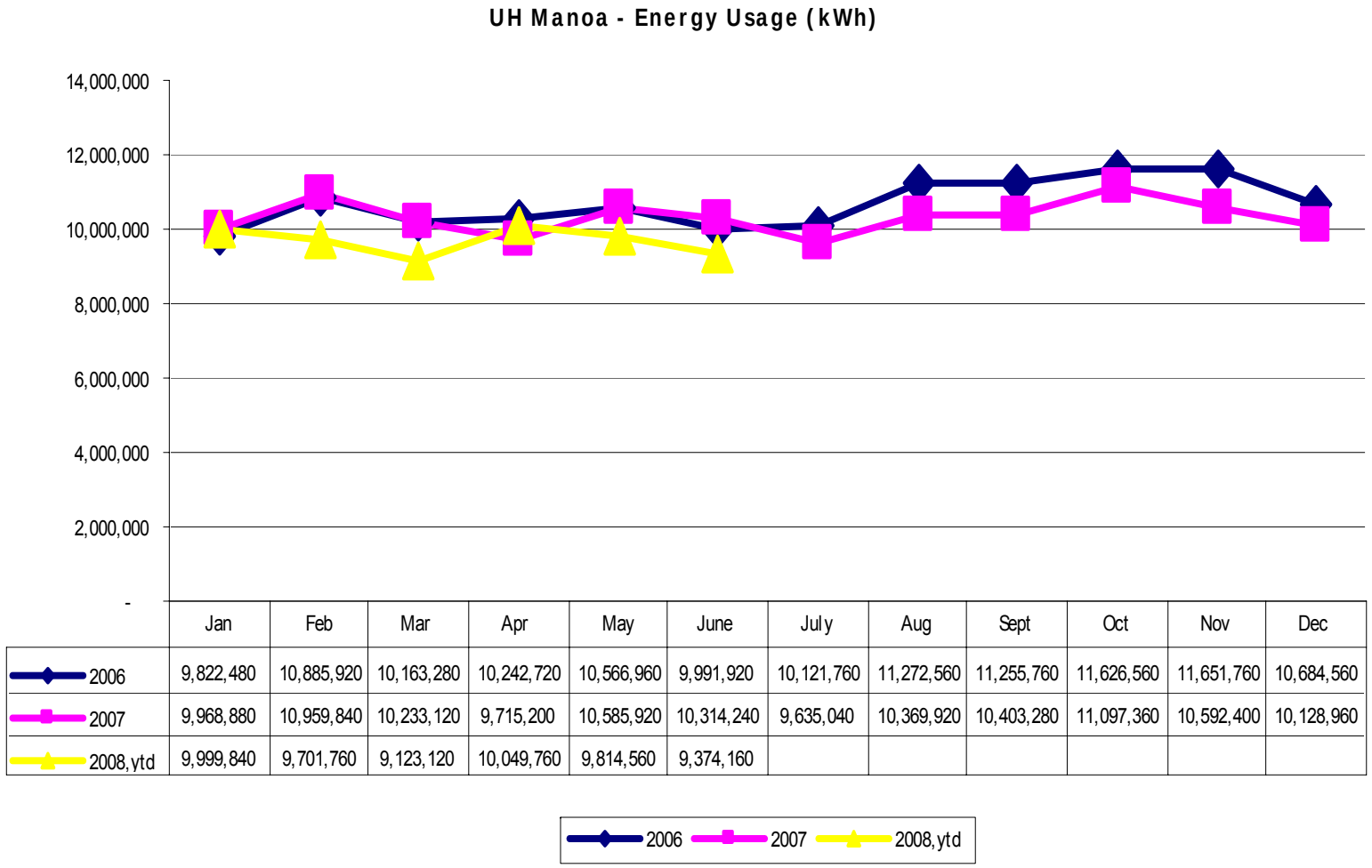
- Total Campus GSF of 5,500,000 ft^2 (excludes TSF GSF)
- Projected FY2009 Electricity Expense of $19,431,265
  - Electricity consumes 43% of the Facilities O&M Budget
- Expense per kWh has increased 17% from 0.158/kWh in 2006 to 0.185/kWh in 2008
- Net Electricity usage is down 3.34% in 2007 from prior year period 2006 due to R&M upgrades saving $792,170 annually at current rates.

Energy (MWh) and UH Manoa Energy Costs



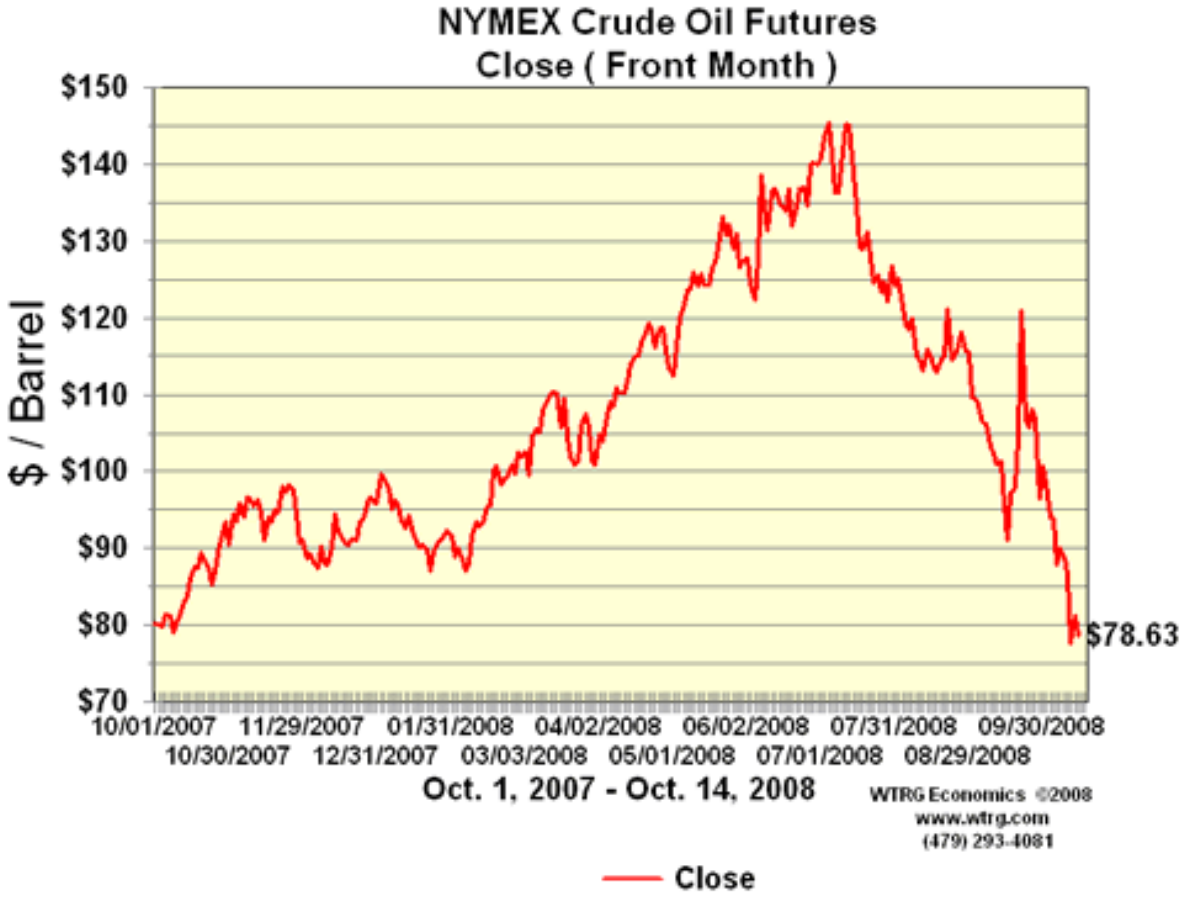
	2000	2001	2002	2003	2004	2005	2006	2007
Energy (MWh)	114,445	119,454	125,792	130,381	129,300	122,215	128,286	124,004
UH Manoa Bill ($)	$11,582,768	$12,069,069	$12,044,543	$13,919,528	$14,786,615	$16,618,833	$20,010,510	$19,408,095

Usage Year-Year

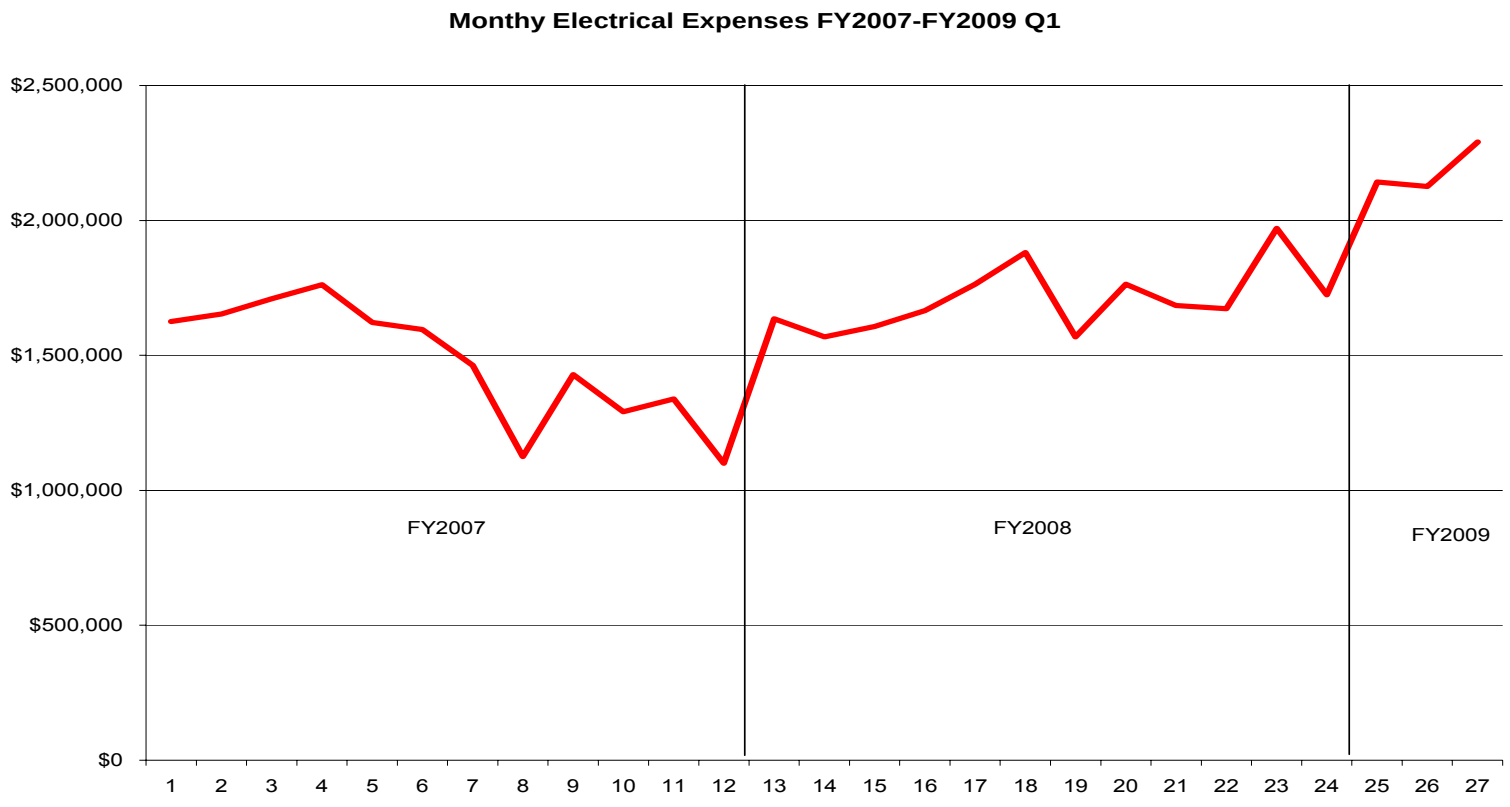


	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
2006	9,822,480	10,885,920	10,163,280	10,242,720	10,566,960	9,991,920	10,121,760	11,272,560	11,255,760	11,626,560	11,651,760	10,684,560
2007	9,968,880	10,959,840	10,233,120	9,715,200	10,585,920	10,314,240	9,635,040	10,369,920	10,403,280	11,097,360	10,592,400	10,128,960
2008,ytd	9,999,840	9,701,760	9,123,120	10,049,760	9,814,560	9,374,160						

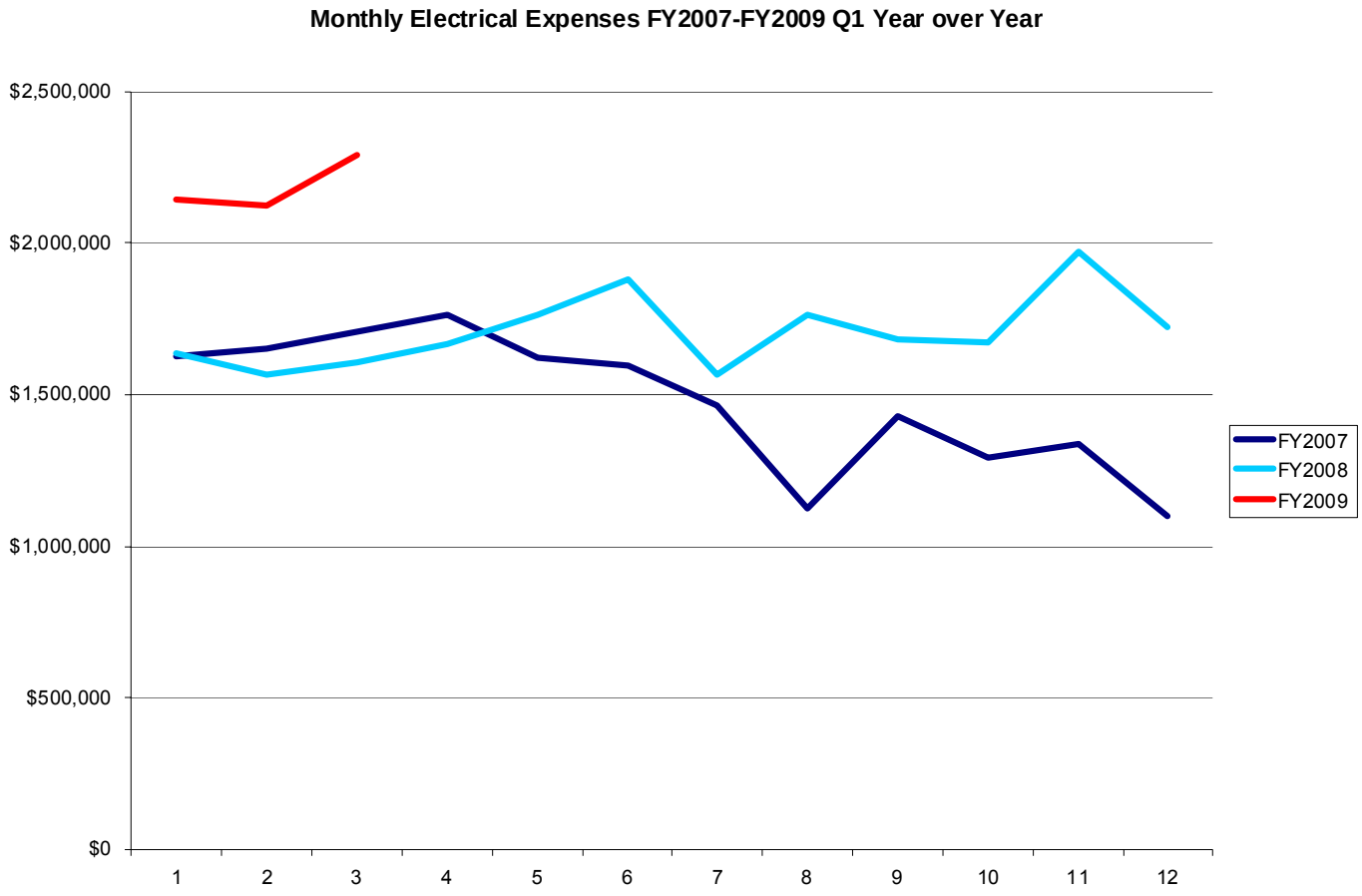
Energy Price Forecasts



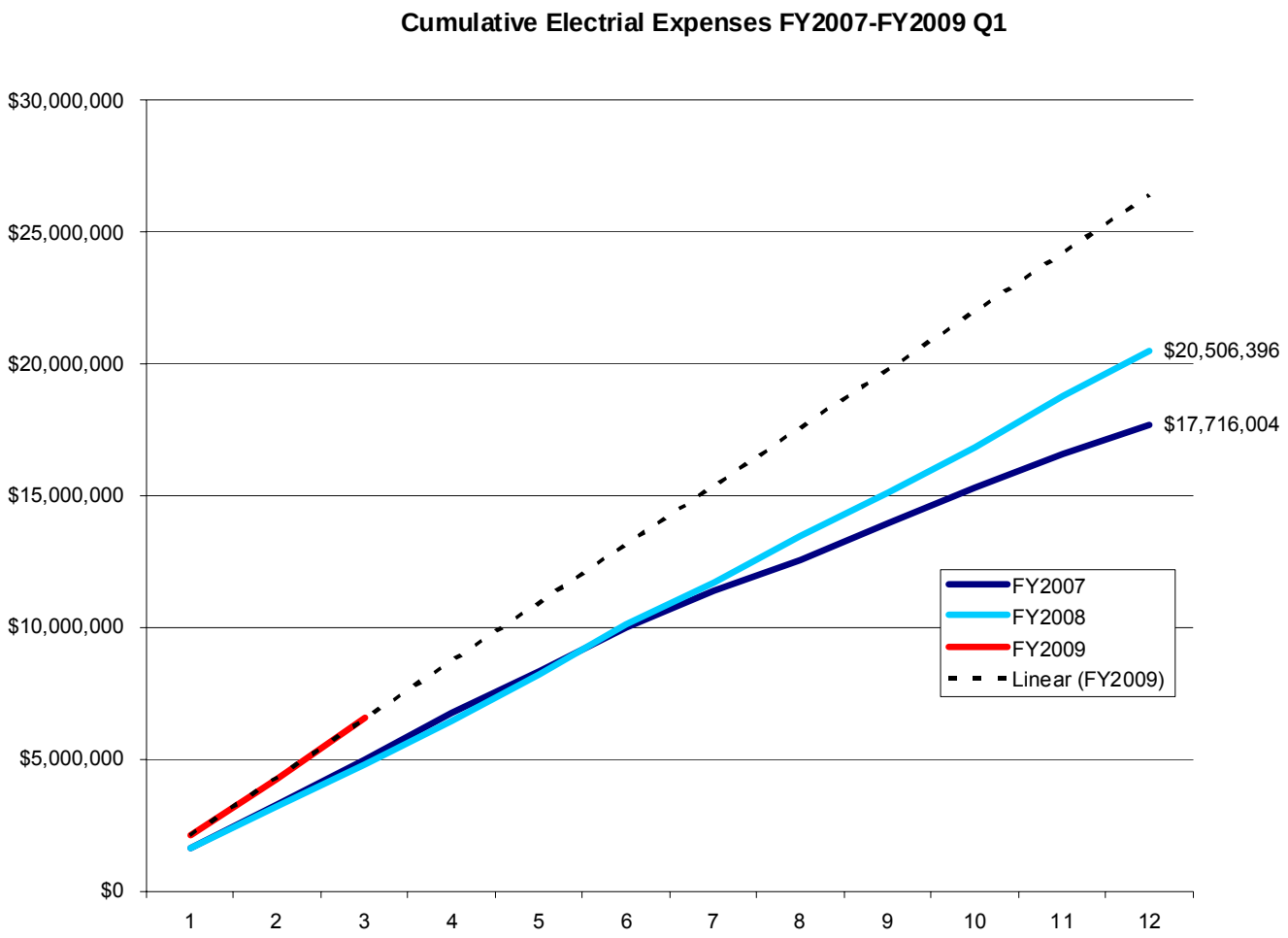
Monthly Electrical Expenses



Monthly Electrical Expenses



Cumulative Expenses



Institutional Expense Comparisons

	UHM 2007	APPA PCAPPA*	APPA RU/VH*	APPA OVERALL*
FCI Index	10.5%	6.0%	11.2%	8.1%
Costs GSF^{-1}				
Operations	$5.46	$7.32	$3.20	$3.74
	54%	78%	61%	68%
Utilities	**$4.68**	$2.09	$2.01	$1.78
	46%	22%	39%	32%
TOTAL Costs GSF^{-1}	$10.14	$9.41	$5.21	$5.52

*APPA Building & Space Report 2003-2004

6,200 kWh Year^{-1} Student^{-1}

2000-2007 Past Projects

Chilled Water Loop A: Upgraded existing chilled water loop system to allow Holmes Hall to serve as the "anchor" chiller plant providing chilled water to Sakamaki Hall, Watanabe Hall, Art Building and University Health Services. Upgraded Energy Management Control System (EMCS) to operate the Loop System at optimum efficiency. During the cooler months of the year, the anchor chilled water plant (Holmes Hall) is capable of providing adequate chilled water to all buildings connected to the Loop and automatically shutting down the respective chilled water plants in each building. During the warmer months, the EMCS will turn on additional building chilled water plants systematically upon demand.

Quadrangle Chilled Water Loop: Extended the existing chilled water system originally feeding Hawaii and Crawford Halls to include George Hall, School of Architecture and in the future Gartley and Dean Halls. The Quadrangle Loop has a capacity of 600 tons of cooling. Installed VFD tertiary pumps at George Hall and School of Architecture.

Kuykendall Hall-Replace Chilled Water Plant Equipment: Replaced the entire chilled water plant with high efficient chillers, VFD pumps and a DDC system for optimum chilled water plant operation. The chilled water system was converted from constant flow to variable flow. The DDC system was also connected to the existing air handling units to allow scheduling of the building.

St. John Building-Replace Air Handling Equipment: Replaced a single built-up constant volume air distribution system with a variable volume system incorporating multiple air handling units. Each air handling unit was equipped with a VFD and serves one entire floor (total of 7 units). Variable air volume (VAV) boxes and thermostats were installed throughout the air distribution system. The new design improved energy efficiency and also provides a reliable system with improved building environmental conditions. Original 240 HP connected motor load reduced to 140 HP connected motor load with VFD's.

Marine Science Building-Replace Chilled Water Plant Equipment: Replaced existing chillers with new high efficiency chillers. Increased the capacity of the chilled water plant from 300 tons to 400 tons without increasing the electrical consumption of the building. Installed new DDC system to allow optimum system operation. Modified the existing chilled water piping to allow additional reliability and redundancy of the chilled water plant.

2000-2007 Past Projects (Continued)

Art Building-Replace Chilled Water Plant Equipment: Replaced existing chillers with new efficient chillers. Improved chiller efficiency by at least 15 %. Modified the air handling control valves from 3-way constant volume flow to two way modulating flow and installed a variable flow secondary chilled water pumping system. Reduced the chilled water demand in the building in half.

Bilger Hall-A/C Improvements: Combined two independent chilled water systems into one. Install new primary/secondary chilled water pumping system. The consolidated central chilled water system created additional chilled water capacity and diversity which allowed cooling to the large lecture rooms on the ground floor. These lecture rooms were originally cooled by inefficient unitary systems.

Keller Hall-Replace Rooftop Air Conditioning System: Replaced original built up reciprocating air cooled chiller and two (2) packaged air cooled chillers with two (2) new air cooled screw chillers. System designed to maintain cooling for the System Computing Center at all times. Chilled water piping is designed to dedicate one chiller for the Computing Center and allow back up cooling from the other chiller in the event of a failure to the dedicated chiller. Provisions for a third chiller were also incorporated into the design to allow 100% chiller redundancy for the Computing Center.

2000-2007 Past Projects (Continued)

University Health Services-Replace Air Conditioning System: Replaced constant volume a/c system with new variable volume a/c system. Consolidated multiple fan coil units into larger centralized air handling units. Installed new VFD air handling units, VAV boxes and thermostats in the air distribution system. Improved indoor air quality of occupied space.

Moore Hall-Replace Air Handling Equipment: Replaced existing constant volume fan coil units with new fan coil units and variable frequency drives (VFD). Installed new VAV boxes and thermostats in the air distribution system.

Music Complex (Old Wing)-Replace Air Conditioning System: Extended the chilled water system to the Old Wing Buildings. Replaced the inefficient unitary systems with a new VAV chilled water system. The capacity of the existing chilled water plant did not change.

EMCS Upgrades to Johnson Controls Metasys System: Upgraded the existing Johnson Controls Systems (21 buildings) to current technology while utilizing the existing system components. Former stand-alone or dial-up systems were upgraded to connection through the UH-ITS system. Upgraded system is BACNet compliant at the System Level.

Bilger Addition-Replace Air Handling Equipment: Replaced existing dual duct constant volume built up system with a new energy efficient constant volume system. Installed a heat pump to provide reheat water for humidity control. Improved indoor air quality of the building without increasing electrical capacity.

TOTAL Annual energy savings = 4,282,000 kWh
TOTAL Annual cost savings = $792,170 at $0.185/kWh

Current Projects FY2008

Holmes Hall-Replace Chiller and Associated Pumps: Replace existing chillers with new energy efficient chillers. Holmes Hall is the "anchor" chilled water plant for Loop "A". This project will increase the capacity of the chilled water plant and improve the EMCS to allow optimum and efficient system operation.

Hamilton Library -5th Floor Rare Books Room-Upgrade Air Conditioning System: Existing system consist of a 16-ton Unitary A/C system with 55 KW of electrical reheat. Current system cannot maintain required conditions and operates at 100% all the time. The upgraded system will consists of two 7.5 ton dehumidifiers with remote condensers. The new design will require only one of the dehumidifiers to operate 90% of the time to meet the required environmental conditions. Upgrades to the Vault envelope is also being done in this project.

Speech Pathology (Bldg 171F)-Replace Air Conditioning System: Replace existing 30 central air cooled chilled water plant and related air handlers with 20 tons of multi-zone variable refrigerant flow direct expansion split systems. New a/c system designed to better match the needs of the facility and improve the indoor environmental conditions. Also includes Replacement of all light fixtures with higher efficiency fixtures.

Sakamaki Hall- Replace Air Distribution System: Replace existing constant volume chilled water system with a new variable volume chilled water system. Consolidate multiple fan coil units into larger centralized air handling units. Phase work to minimize disruption to the building occupants.

Moore Hall: Replace Central Chilled Water Plant. Install new variable flow chillers, variable volume cooling towers, variable volume pumping systems and install a new DDC system to allow optimum operation of the chilled water plant.

Current Projects FY2008 (Continued)

Watanabe Hall-Replace Air Distribution System: Replace existing constant volume a/c system with a new variable volume a/c system. Replace constant volume air handling units with new VFD air handling units. Install new VAV boxes and thermostats in air distribution system. Remove existing electric reheat coils and install new hot water reheat coils as needed.

Bilger Hall/Bilger Addition-General A/C Upgrades: Extend Loop B chilled water piping to Bilger Hall. Modify chilled water piping and controls to allow optimum operation of chilled water system.

Music Complex- A/C Improvements: Create chilled water loop system for the entire Music Complex. Upgrade chilled water plant and install primary/secondary chilled water pumping system. Extend chilled water piping to Orvis Auditorium and adjacent practice building. Remove existing constant volume unitary a/c system and install new VAV chilled water system. Connect new chilled water loop piping to the existing chilled water piping to the Old and New Wings.

Estimated Annual energy savings = 1,100,000 kWh
Estimated Annual cost savings = $203,500 at $0.185/kWh

Completed Energy Scheduling Initiatives

- Hawaii Hall/Crawford Hall: Estimated 525,000 KWH savings per year.
- Law School Administration/Classroom Building: Estimated 400,000 KWH savings per year.
- Moore Hall: Estimated 275,000 KWH savings per year.
- School of Architecture: Estimated 350,000 KWH savings per year.
- Kennedy Theater: Estimated 200,000 KWH savings per year.
- Kuykendall Hall: Estimated 200,000 KWH savings per year.

Estimated Annual energy savings = 1,900,000 kWh
Estimated Annual cost savings = $350,000 at $0.185/kWh

Pending Energy Scheduling Initiatives

- Queen Liliuoakalani Building (Student Services): Potential 750,000 KWH savings per year.
- Webster Hall: Potential 375,000 KWH savings per year.
- Saunders Hall: Potential 700,000 KWH savings per year.
- Business Administration Building: Potential 575,000 KWH savings per year.
- Sakamaki Hall: Potential 500,000 KWH savings per year.

Potential Annual energy savings = 2,900,000 kWh
Potential Annual cost savings = $536,500 at $0.185/kWh

UHM Mechanical Effort Impacts

	Reductions Acutal and Estimated kWh	Annual Cost Avoidance
Past Projects	4,282,000	$792,170
Current Projects	1,100,000	$203,500
Completed Scheduling	1,900,000	$351,500
Recommended	2,900,000	$536,500
TOTAL	10,182,000	$1,883,670

Future Energy R&M Projects

- ***Holmes Hall Air Distribution System Replacement***
- ***POST Building Mechanical Upgrades***
- ***Hamilton Library Phase III Air Conditioning Upgrades***
- ***St. John Building Air Conditioning Upgrades***
- ***Marine Science Building Air Conditioning Upgrades***
- ***Consolidate usages within buildings*** to allow optimum scheduling. Develop classroom buildings, office buildings, lab/research buildings. Consolidate server and computer rooms.
- ***Educate building occupants to become more energy efficient***. Turn off lights when not in use, shut down unitary a/c systems, share lunch rooms (refrigerators, microwaves, coffee makers, etc.)
- ***Improve space planning***. Need to properly assign occupants and evaluate each space on size and infrastructure. Minimize extreme changes to usages. For example, should not change an office to a lab or the reverse.

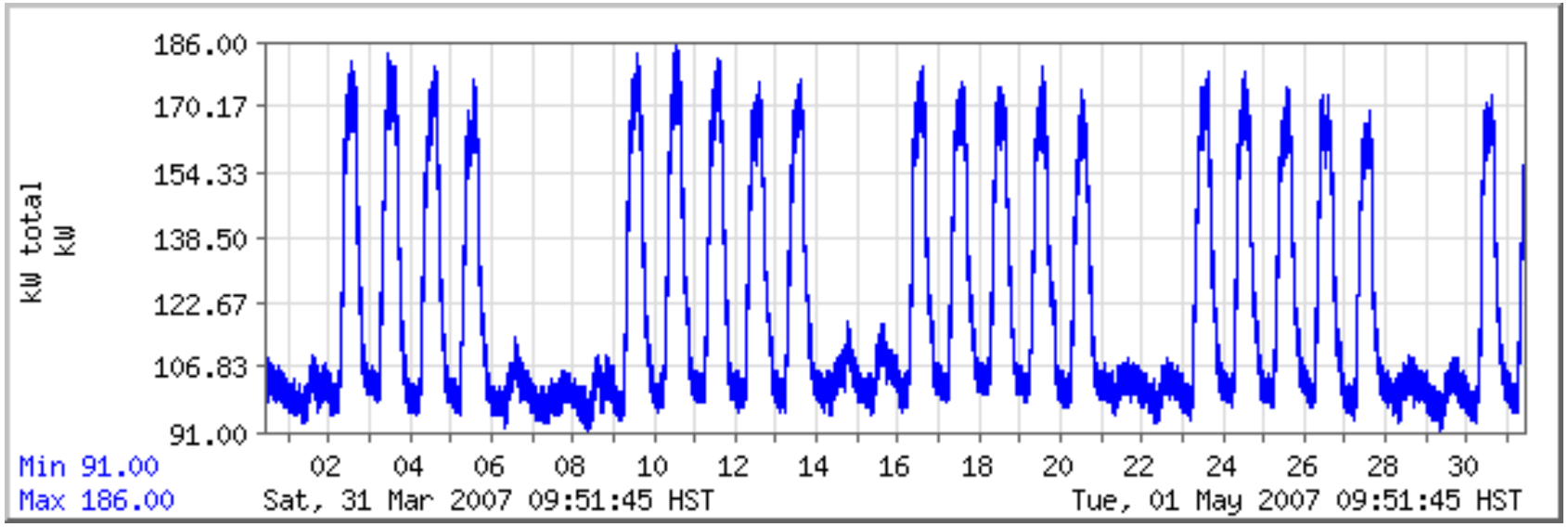
Energy Project Issues

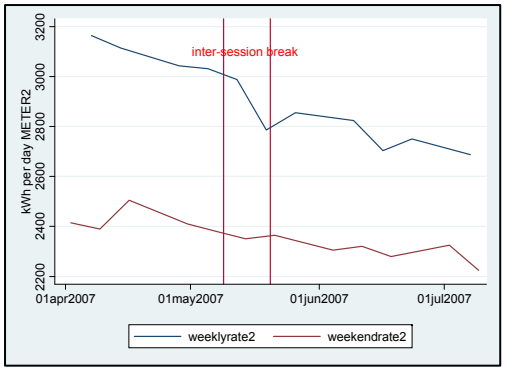
- Energy Project are a proven way to reduce energy costs *however:*
- Existing building systems requires excessive renewal work to the building, which exceeds the funding and causes excessive and long term disruption to the building operation.
- Building envelope inadequate for proper temperature and humidity control.
- Limited time to properly evaluate and design an efficient system.

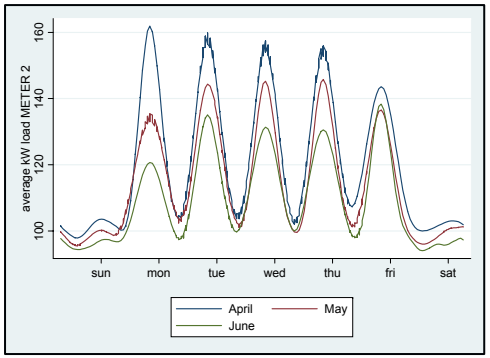
sustainable saunders

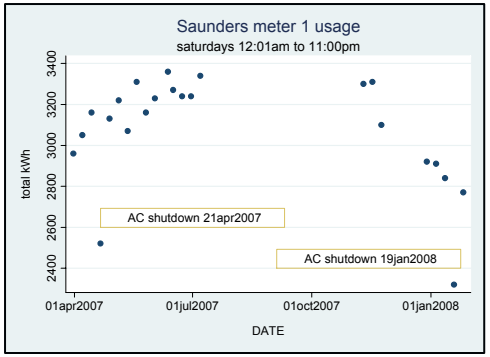
Metering

Data Archive: every 60 seconds since April 2007









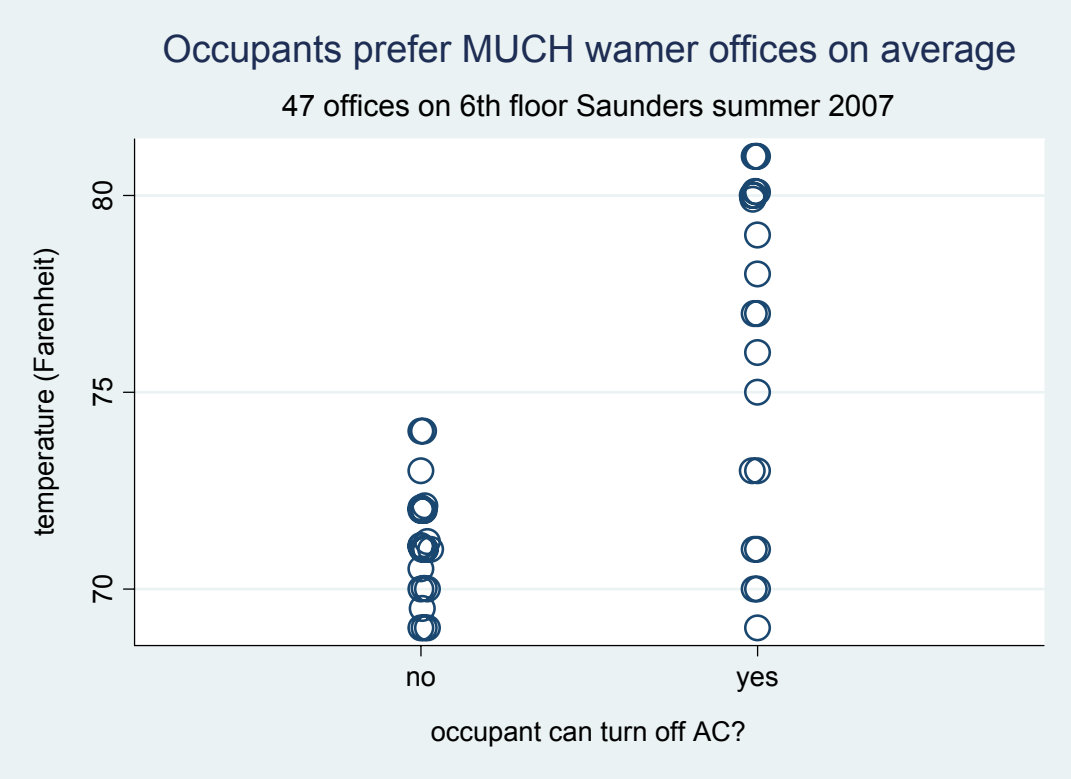
Delamping

Win-Win: remove 53% of the bulbs

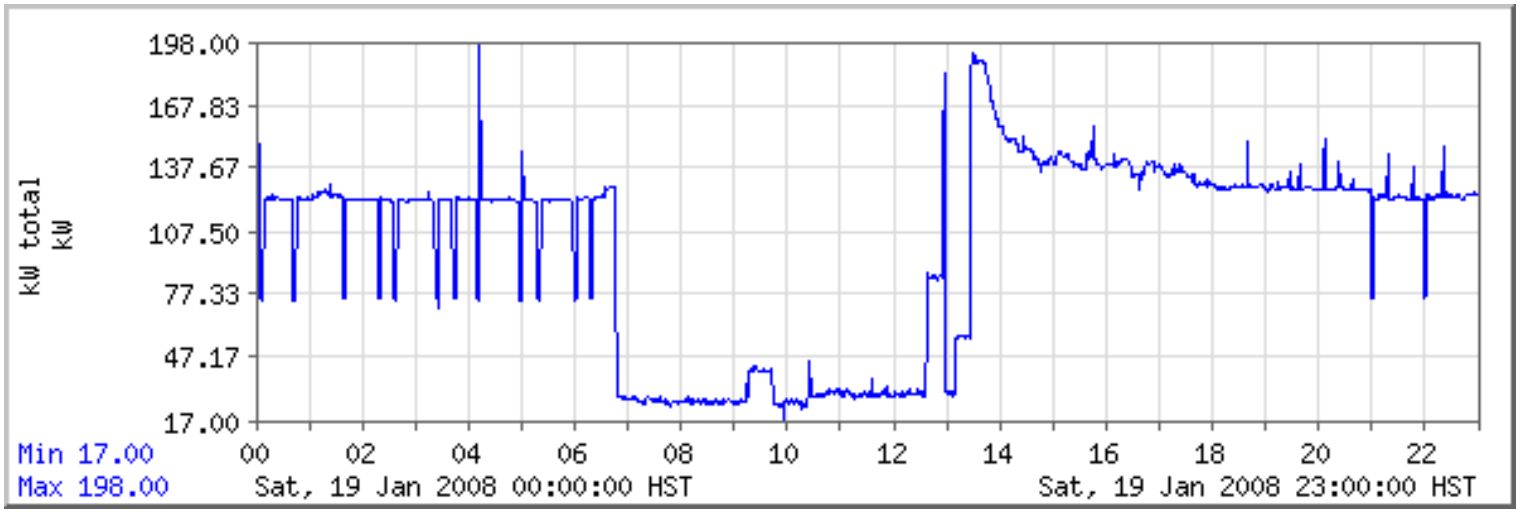
- Better workplace
- Wattage limit compliance
- Illumination recommendation conformance
- HECO rebate: $9,495
- Annual Bulb Replacement Savings: $437
- Energy Savings: 94,190 kWh
  (4.1% of building load)

AC Shutdown Project

- #1 Complaint of Occupants: TOO COLD
- 25% office performance reduction
  for each 5. below optimal



AC Shutdown Project



	cumulative annual savings
For Starters: **off** at 11pm, **on** at 5am	237,341 kWh (10.3%)
Now Imagine: off until 8am	355,157 kWh (15.4%)
Now Imagine: off all weekend	702,720 kWh (30.6%)

Renewable Energy Testbed

- Wind Demonstration
  - Next-Generation Wind Vertical Axis Turbine

- Solar On Saunders
  - Sun Power for Schools Data Monitoring Development
  - Real World Performance Testing and Cost Analyses

UH Goals

- 30% energy reduction by 2012
- 50% energy reduction by 2015
- 25% of energy from renewables by 2020
- Energy and Water Self-sufficient by 2050

Current and Future Initiatives

- Mechanical Upgrades: On-going
- Partnerships
  - HEI, Sea Grant, Social Studies, Engineering, Architecture
- Energy Metering
  - Demand Response (i.e. “Energy Scout”)
- Delighting of Selected Buildings
- Commissioning (Cx) and Retro-commissioning (RCx)
  - Predecessor to PC due to Building Conditions
- Performance Contracting (PC)
- Alternative Energy and Power Purchasing Agreements

UHM Facilities Energy Footprint Reduction

- Current Energy Reduction Programs
  - Mechanical Engineering Upgrades
  - Chill Water Distribution Optimization
  - Building Scheduling (Time-of-day reductions)
  - Maintenance Enforced Conservation
  - 12,200,000 kWh annual reduction in FY2008
- FY2009-FY2015 Projects
  - Mānoa Core Buildings (Large Scale Public-Private Agreement Multi-building energy management projects)
  - Intelligent Metering Project
  - Campus Lighting Upgrades (De-lamping) Project
  - Phase II Building Scheduling (Demand Response)
  - Alternative Energy and Power Purchasing Agreements
  - Energy Reduction objective of 48% kWh $sqft^{-1}$ by 2015

Chevron Human Energy™ Academic Capital Group, Inc. Bank of America Townsend Capital, LLC Johnson Controls

University of Hawai'i Mānoa Facilities Management
Founding Reporter

Example: UHM ***Mānoa Core Buildings*** Project

Building-Integrated Photovoltaic (BIPV) with Re-roofing Projects

KYOCERA

Multiple packaged Re-roofing projects combined with Photovoltaic Systems leverages State and Federal Tax Credits with Building Envelope and Energy Reduction to lower investment costs and usage at the same time.

Proposed Weekend & Holiday AC Shutdowns

Agricultural Engineering	$27,130		Kuykendall Hall	$95,796	
Architecture School	$121,133		Law School	$93,087	
Art Building	$159,840		Miller Hall	$19,044	
Auxilliary Services Building	$62,986		Moore Hall	$155,682	
Building 37	$11,700		Multipurpose Building	$8,010	
Burns Hall	$193,410		Music Building #1 (1093A)	$8,803	
Business Administration	$280,627		Music Building #2 (1093 B)	$1,688	
Center for Korean Studies	$17,539		Music Building #3 (1093C)	$2,939	
Crawford Hall	$90,000		New Music Building	$75,323	
Dance Building	$922		Orvis Auditorium	$11,203	
Dean Hall	$12,586		Sakamaki Hall	$154,742	
Edmonson Building	$94,010		Sinclair Hall	$5,400	
Engineering Quad	$19,195		Snyder Hall	$167,400	
Engineering Quad A+B	$9,598		Social Science (Saunders)	$428,400	
Gartley Hall	$8,582		Spalding Hall	$72,864	
George Hall	$56,970		Speech Pathology Bldg-171E	$27,177	
Gilmore Hall	$146,318		Speech Pathology Bldg-171F	$13,589	
Hawaii Hall	$2,880		Student Services Center	$223,488	
Hawaiian Studies	$45,547		Wantanabe Hall	$276,826	
Hemmenway Hall	$46,800		Webster Hall	$59,670	
Henke Hall	$15,372		Wist Annex 1, University HS 1+2	$9,466	
HPER	$132,300		Wist Hall	$70,963	
IfA Manoa A, B, & C	$179,820		Wist Hall Annex Addition	$63,000	
Kennedy Theater	$40,500				
Klum Gym	$85,500		**TOTAL**	**$3,905,824.86**	

Māhalo