

OPTIMIZING EXISTING BUILDING PERFORMANCE: ENERGY AUDITS @ HARVARD UNIVERSITY



Kevin Bright
Green Building Services
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AGENDA



- Harvard's Sustainability Commitment
- Audit Team Organization
- Progress to Date
- Building Results
- Case Study – M&V
- In-House Auditing Benefits and Qualifications
- Tools To Get Started

SUSTAINABILITY COMMITMENTS

1. Reduce GHG Emissions 30% by 2016, including growth.
2. Comprehensive Green Building Standards.
3. University-wide Sustainability Principles.

GREEN BUILDING SERVICES

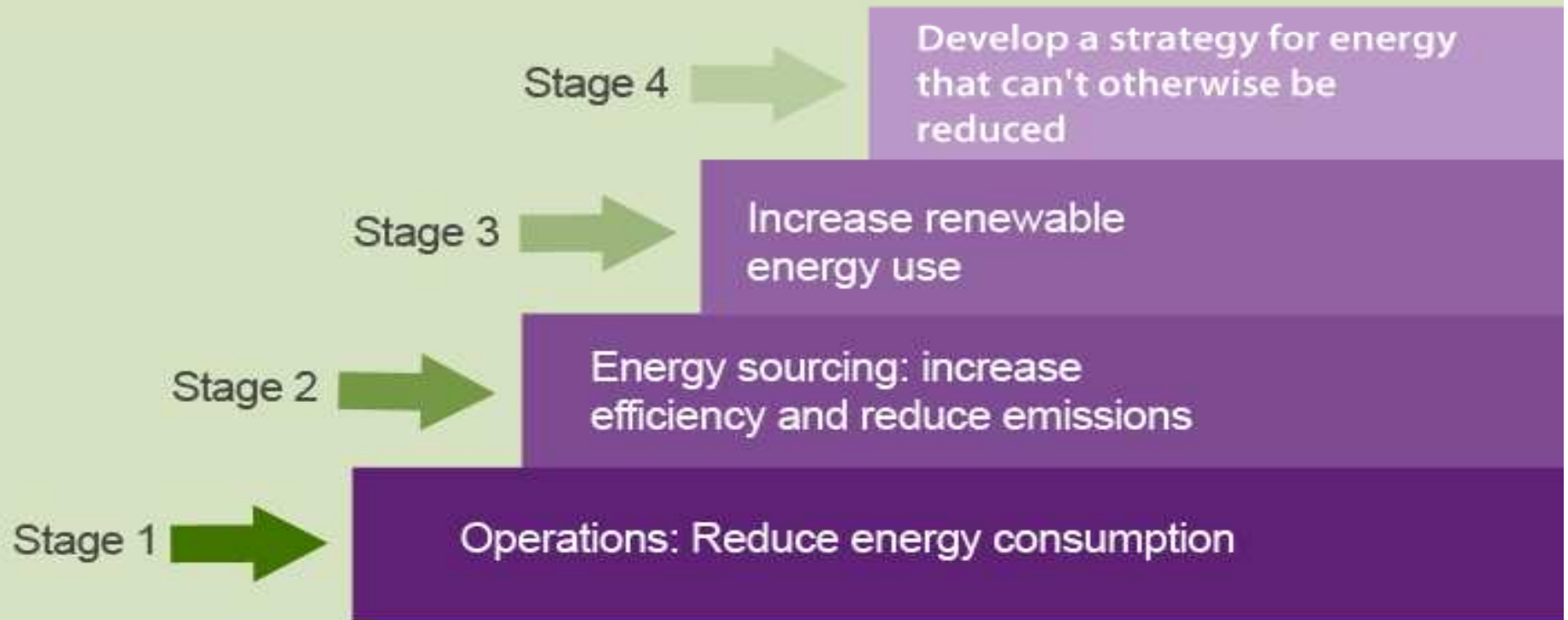
- Lead Harvard in achieving all its sustainability goals.
- Leverage the collective knowledge of partners across Harvard.



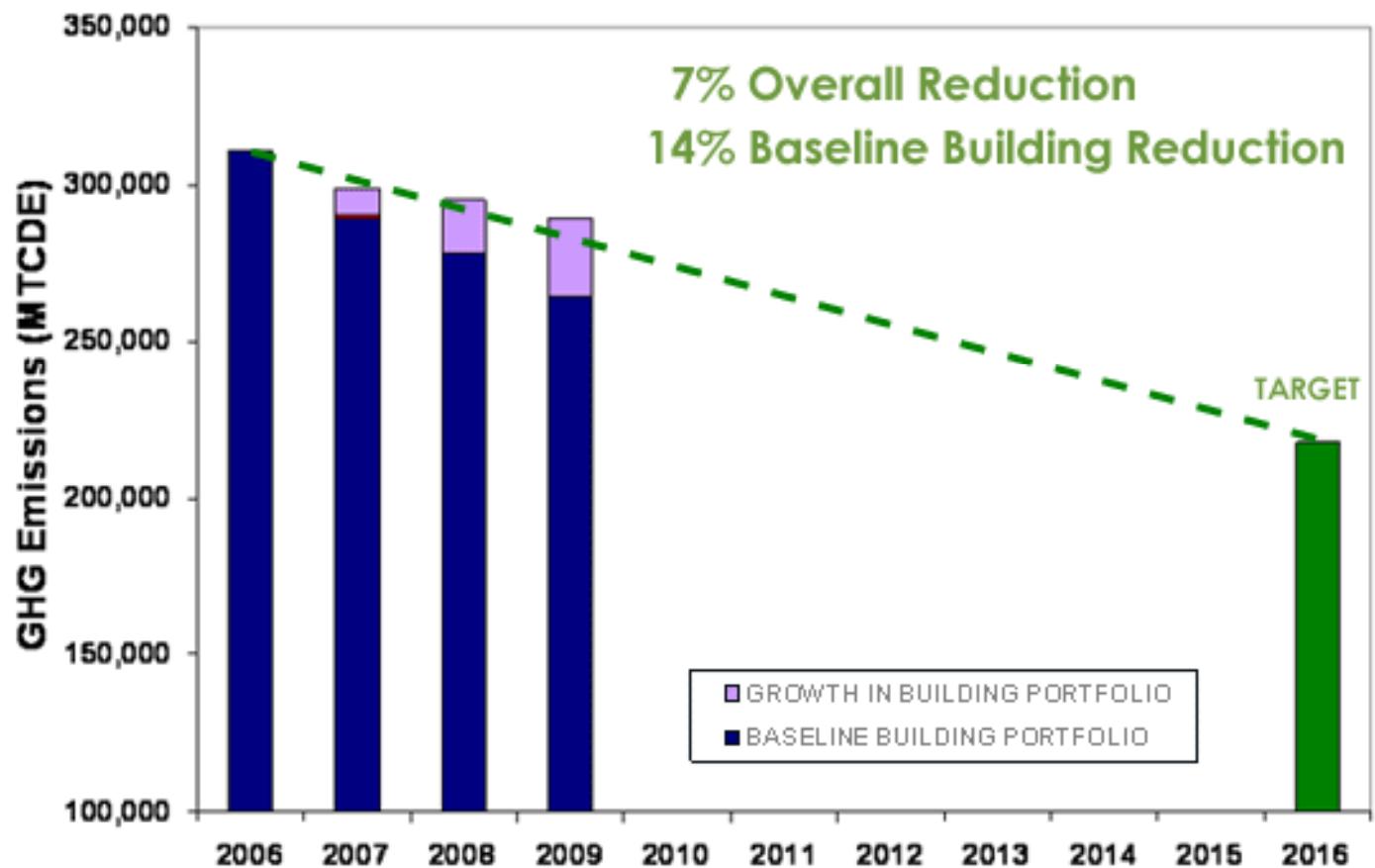
GHG REDUCTION GOAL

- Includes Growth
- Base Year 2006
- Institution-wide

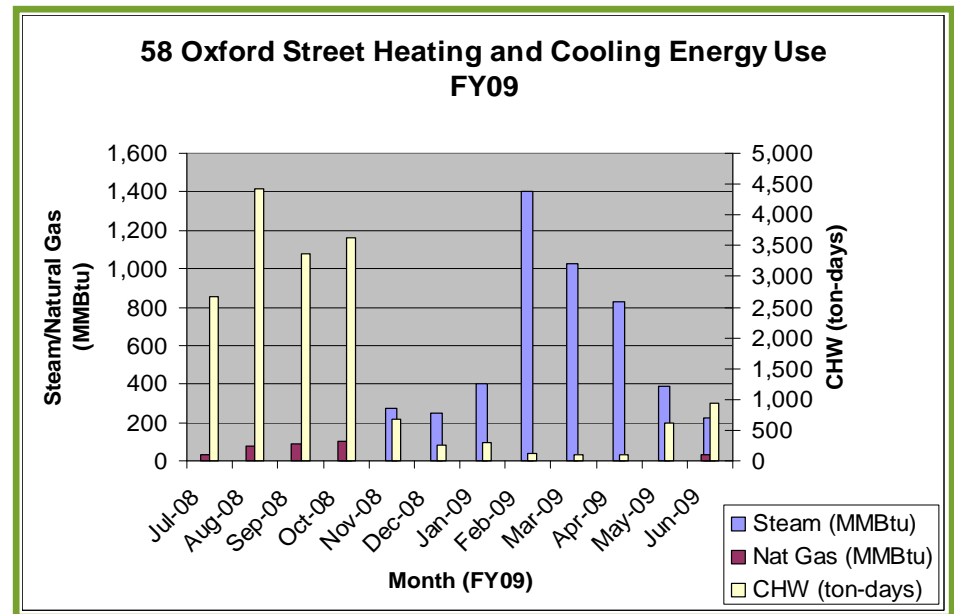
**30%
Reduction
by 2016**



HARVARD GREENHOUSE GAS EMISSIONS FY06-FY09

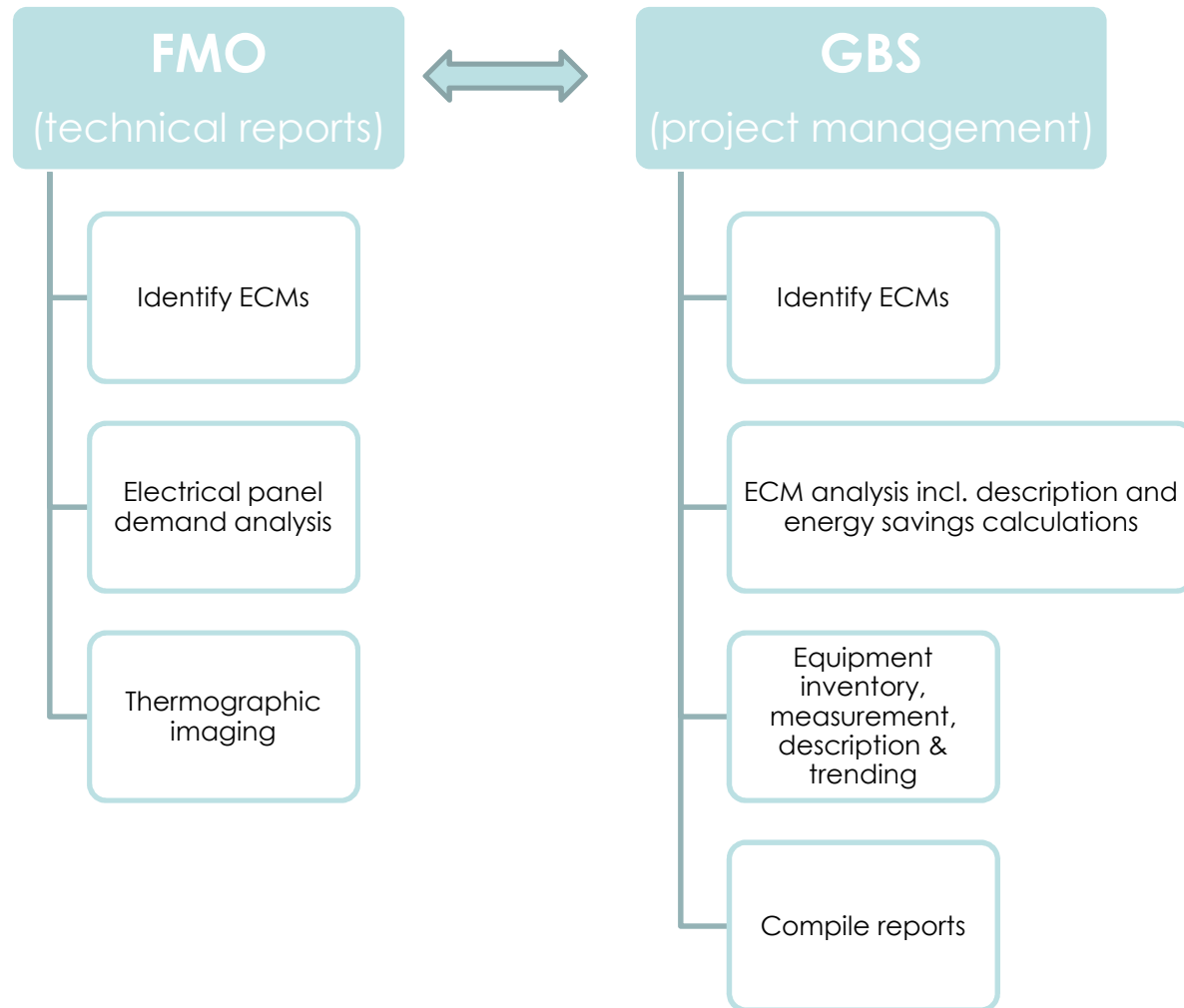


CAMPUS-WIDE ENERGY AUDIT COMMITMENT



ASHRAE Level II audits of all 26 million square feet of campus buildings ranging in space type from dormitories to laboratory research.

AUDIT TEAM ORGANIZATION



IN-HOUSE AUDITING BENEFITS

- Knowledge of Harvard Buildings.
- Institutionalize Common ECMs.
- Compare Results and Deliverable to Outside Vendors.
- Not-for-Profit Organization.
- Quality Control process.
 - Clients are colleagues

“I am delighted that we have the potential to achieve a 9 month payback, reduce MTCDE and potentially qualify for a LEED EBOM. Thank you for the great effort. I can see this type of work as being of great value to the University.”

IN-HOUSE AUDITING QUALIFICATIONS



Building knowledge

- MEP and control systems

Technical / Writing capability

- ECM calculations
- Square footage analysis
- Historical energy use analysis
- Technical report writing

Technological Awareness

- Ability to recommend sound solutions
- CEA/CEM Certification
- HVAC Technician

CALCULATION TOOLS

- ECM Calculation Spreadsheet
- Data Collection / Inventory tools
- LCC Calculator

Energy Conservation Measure	Total Cost (\$)	Cambridge Chilled Water (Ton-Days)	Cambridge Electricity (kWh)	Cambridge Steam (MMBtu)	Cambridge Water (Ccf)	Annual Energy Reduction (KBTU)	Annual GHG Reduction (MTCDE)	Annual Savings (\$)	20 Yr NPV	20 Yr Cost / 20 Yr MTCDE	NPV / Total GHG Red.	SIR	Simple Payback (years)	IRR
Reballast and/or relamp existing linear fluorescent fixtures	\$16,755	0	18,160	0	0	61,980.08	6.7	\$3,003.66	\$25,747.92	\$94.07	\$190.94	3.03	4.68	24.21%
Replace 32-watt U lamps with 30-watt alternatives	\$942	0	615	0	0	2,099.00	0.2	\$101.72	-\$319.78	\$355.03	-\$70.02	0.80	9.26	3.49%
Install occupancy sensors in restrooms, offices, conference rooms and kitchens	\$1,780	0	2,934	0	0	10,013.74	1.1	\$485.28	\$5,019.98	\$54.60	\$230.41	5.22	2.45	45.46%
Replace toilet flushometers with efficient alternative	\$1,000	0	0	0	13	20,993.34	1.1	\$553.17	\$6,256.75	\$38.42	\$280.19	8.29	1.81	60.90%
Replace urinal flushometer with efficient alternative	\$615	0	0	0	13	39,584.91	2.1	\$888.70	\$10,920.20	\$12.53	\$259.35	21.70	0.69	154.42%
Replace sink aerators with efficient alternative	\$400	0	3,422	0	37	605,821.70	32.9	\$11,703.16	\$150,659.13	\$0.52	\$229.17	440.03	0.03	3072.84%
Rebalance HVAC system and resequence controls for AHU	\$65,000	631	529,305	2,272	0	1,806,519.15	363.9	\$161,843.14	\$2,011,344.59	\$8.34	\$276.33	34.14	0.40	262.27%
Reschedule toilet exhaust fan	\$1,000	33	2,859	224	0	229,485.00	29.1	\$11,441.13	\$146,084.30	\$1.61	\$251.16	157.46	0.09	1198.57%
Vary air volume of fume hoods on use	\$105,000	88	161,796	508	0	552,210.71	97.2	\$42,833.28	\$443,398.79	\$54.03	\$228.18	5.22	2.45	45.48%
Repair function of heat transfer loop coil in main AHU	\$8,000	341	0	1,142	0	273,797.95	98.8	\$42,474.74	\$536,631.16	\$4.05	\$271.49	68.08	0.19	556.65%
Reset temperature setpoint for steam consumption	\$500	0	0	17	0	0.00	1.2	\$495.36	\$5,885.58	\$19.57	\$246.78	13.61	1.01	106.36%
Install VFDs for HHW pumps	\$15,700	0	31,691	0	0	494,990.21	32.3	\$12,165.89	\$146,042.56	\$16.17	\$225.79	14.96	0.95	113.71%
Install air-side economizer for Liebert unit	\$16,000	777	1,000	0	0	249,001.77	18.2	\$12,389.31	\$143,178.50	\$41.05	\$393.40	10.58	1.29	83.41%
Reduce outside air flow to dehumidification unit	\$2,000	0	26,017	0	0	531,090.36	33.2	\$12,220.29	\$155,449.47	\$2.81	\$234.23	84.24	0.16	642.68%
Install VFD to operate 75 HP air compressor	\$18,750	0	98,024	0	0	334,557.28	36.4	\$16,213.24	\$199,550.85	\$10.86	\$274.15	26.24	0.56	187.42%
Cycle operation of nitrogen generator based on usage	\$10,000	0	225,864	0	0	779,754.09	84.3	\$37,516.89	\$470,732.10	\$5.54	\$279.09	51.42	0.27	393.43%
Install low or HP motors for pH neutralization tank mixers and cycle operation	\$5,000	0	12,344	0	0	42,610.14	4.6	\$2,050.27	\$20,155.95	\$65.96	\$218.68	4.32	2.44	45.49%
Install storm windows to improve integrity of envelope	\$30,000	0	0	125	0	103,760.20	14.5	\$5,582.50	\$47,727.66	\$82.95	\$164.74	2.99	5.37	22.18%

green.harvard.edu/theresource

Measuring Tools

- Balometer
- Drill
- Ammeter
- Light Meter
- HOBO measuring devices
- Power Analyzer
- Thermographic Camera



ASHRAE LEVEL II AUDIT SCOPE

- Review building systems: design, operation, and maintenance.
- Inventory major energy-using equipment.
- Examine historical and current energy use, including an analysis of end-use components.
- List low or no-cost recommendations with associated costs and savings.
- Compare building performance to others in similar climate with comparable composition.

INTERNAL ENERGY AUDITING METRICS

Number of Buildings audited	30
Area Audited	1,026,419 sq. ft.
Energy Conservations Measures (ECMs) Identified	410
Annual Savings	\$976,219
Combined Simple Payback	3.41 years
Metric Tons of Carbon Dioxide Equivalent (MTCDE) Reduction	2,411 MTCDE
Potential GHG reduction compared to FY06	34.8%



Andover Hall

- Facility comprised of Classrooms, Offices & Chapel on (5) floors with a basement.
- 37,985 SF total
- Building Systems
 - Heating: District Steam System
 - HVAC: (2) AHUs
 - Electrical: 800 amp, 3 phase
 - Chilled water: Dedicated System
- Occupancy Rates
 - Average 280 people per day
- EUI: 77 kBtu per SF



Andover Hall

- 17 ECMs Identified
- Net Cost: \$30,000
- GHG Reduction: 86 MTCDE
- GHG Reduction: 33%
- Annual Savings: \$26,000
- Simple Payback: 1.13 years
- Net Present Value: \$378,500
- EUI Target: 43 kBtu / SF
- Notable ECM – DCV for 14,000 cfm OA unit (0.5 yr payback, \$15,000 savings/yr)



Engineering Science Laboratory

- Laboratory intensive research facility for faculty and students on (4) floors with a basement
- 38,217 SF total
- Building Systems
 - Heating: Campus Steam
 - HVAC: (1) AHU
 - Chilled Water: Campus Network
- Occupancy Rates
 - 180 people per day
- EUI: 511 kBtu / SF



Engineering Science Laboratory

- 18 ECRs Identified
- Net Cost: \$265,500
- GHG Reduction: 840
- % GHG Reduction: 56%
- Annual Savings: \$333,000
- Simple Payback: 0.85 years
- Net Present Value: \$4.5 Mil.
- EUI Target: 312.2 kBtu / SF
- Conversion of CV fume hoods to VAV hoods (4 yr payback, \$22,000 savings/yr)



Quincy House New Residence Hall

- Residence Hall with offices and library on 7 floors with a basement and a penthouse.
- 155,395 SF total
- Building Systems
 - Heating: Campus Steam
 - HVAC: Supply/exhaust fans
 - Chilled Water: Campus Network
 - Electrical: 1,200 amp, 3 phase
- Occupancy Rates
 - 375 people per day
- EUI: 77 kBtu per SF



Quincy House New Residence Hall

- 32 ECRs Identified
- Net Cost: \$665,882
- GHG Reduction: 424
- % GHG Reduction: 56%
- Annual Savings: \$211,000
- Simple Payback: 3.1 years
- Net Present Value: \$4.1 Mil.
- EUI Target: 41 kBtu / SF
- Notable ECM – replacement of 3 gpm with 1.6 gpm alternative (0.15 yr payback, \$30,000 savings/yr)



Schlesinger Library

- Library research facility for faculty and students on (4) floors with a basement
- 26,000 SF total
- Building Systems
 - Heating: Campus Steam
 - HVAC: (2) AHUs, (4) FCUs
 - Chilled Water: Chiller plant
 - Electrical: 1,200 amp, 3 phase
- Occupancy Rates
 - 50 per day
- EUI: 162 kBtu per SF

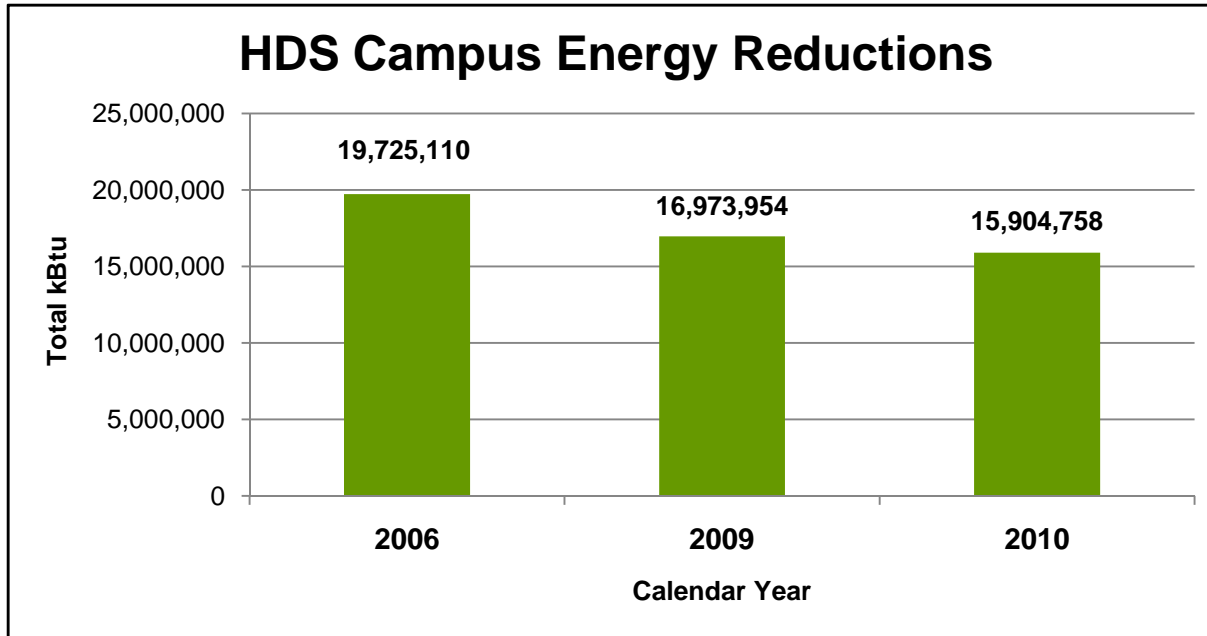


Schlesinger Library

- 13 ECRs Identified
- Net Cost: \$61,000
- GHG Reduction: 105
- % GHG Reduction: 37%
- Annual Savings: \$43,000
- Simple Payback: 1.43 years
- Net Present Value: \$489,000
- EUI Target: 111 kBtu / SF
- Notable ECM – Resequence control of humidification and dehumidification units (0.4 yr payback, \$5,500 savings/yr)



CASE STUDY OF HDS – M&V



Performance to Date:

- 70% of ECMs implemented
- 35% implemented within past year
- Estimated annual reduction of implemented ECMs = 13%
- Measured Reduction to date = 6%
- *Reductions from FY06 also include savings from Occupant Engagement campaigns

HDS Campus Energy Performance (2006-2010)

Building Space Type	Square Footage	EUI - 12.06	EUI - 12.09	EUI - 12.10	% Reduction 12.06-12.09	% Reduction 12.09-12.10
Office	26,815	152	115	89	14%	6%
Classroom	37,985	129	147	131		
Library	58,248	111	104	84		
Office	30,470	54	64	45		
Residence	22,110	78	61	60		
Residence	11,810	58	58	66		
Office	1,695	151	140	114		

FOR MORE INFORMATION

Kevin Bright, Assistant Program Manager
Green Building Services
Harvard Office for Sustainability

Kevin_bright@harvard.edu | 617-495-3875

green.harvard.edu

green.harvard.edu/theresource

uos.harvard.edu/fmo/building_maintenance/index.shtml