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ABSTRACT

Case studies are reported from 19 diverse institutions that, in spite of design limitations, implemented initial conservation programs that saved 15 to 25 percent of the energy previously used. Reporting institutions continued to reduce energy consumption through the development of an energy management program. Focus in this report is on cost avoidance rather than cost savings, since conservation efforts are not likely to be rewarded by a real reduction in current fuel expenditures. The institutions reporting are: University of Iowa; Kent State University; University of Mississippi; University of Missouri; North Carolina State University; Ohio State University; South Dakota State System; University of Texas at Austin; University of Washington; Bradley University; Clarkson College of Technology; Cornell University; Lafayette College; Massachusetts Institute of Technology; Princeton University; Yale University; St. Louis Junior College District; St. Petersburg Junior College; and Carleton University in Ottawa. (LBH)

Energy Conservation on Campus

Volume II

Case Studies

Federal Energy Administration

Office of Energy Conservation and Environment

State Energy Conservation Programs

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Energy Conservation Now

FOREWORD

The Federal Government has developed a variety of programs through the Federal Energy Administration to foster large energy savings in the areas of building construction, maintenance, and operation. This publication has been prepared for institutions of higher education by the Energy Task Force through Federal Energy Administration Contract No. 00-04-50247-00 with the Association of Physical Plant Administrators of Universities and Colleges. Its purpose is to assist colleges and universities and other non-profit institutions to mount and sustain effective energy management programs.

A clearly recognized feature of such an undertaking is the need for a cooperative campus effort involving the president, chief financial officer, and director of physical plant. With this need in mind the Energy Task Force, representing the American Council on Education (ACE), National Association of College and University Business Officers (NACUBO), and Association of Physical Plant Administrators of Universities and Colleges (APPA), developed these guidelines to assist institutions of higher education in establishing or upgrading energy conservation programs. The case studies found in this publication are brief summaries of ongoing energy management programs and may be used to assist institutions of higher learning in the development of an energy management program.

Guidelines to assist institutions to establish their energy conservation programs are found in the first volume, drawing upon these case studies and numerous other technical resources.

The Federal Energy Administration also recognizes valuable contributions of many of the member institutions that provided comprehensive and authoritative energy conservation information that was extremely helpful to all participants.

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INTRODUCTION

Since 1973 energy costs on campuses have doubled, and, on some tripled. Prior to that time cost emphasis was primarily directed toward materials and labor rather than oil, gas, and electricity.

The high cost of energy and the curtailment of primary preferred fuel has upset many long-standing maintenance and operation policies, forcing institutions to look quickly for ways to reduce energy usage. During this search administrators found that many college buildings consume large quantities of energy by virtue of their design. Alteration of many of these facilities would be difficult and costly, thus initial low cost alternatives were taken permitting time for study in order to devise long range methods to lower the amount of energy consumed.

This publication is comprised of a selection of case studies from a diversity of institutions who in spite of design limitations implemented initial conservation programs which saved 15% to 25% of the energy previously used. At some institutions the percentages have been higher. Reporting institutions continued to reduce energy consumption through the development of an energy management program, as discussed in Volume I of this publication.

It should be noted that the term *cost avoidance* is used rather than *cost savings,* reflecting the unfortunate fact that prevailing energy costs have risen so rapidly and astronomically that conservation efforts are not likely to be rewarded by a reduction in current fuel expenditures. Enrollment figures used are taken from the 1974-75 Education Directory published by the Office of Education, Department of Health, Education and Welfare.

University of Iowa

Location: Iowa City, Iowa
FTE: 20,709
Avg. Temp: Oct - Mar 33°F
Apr - Sep 63°F

Approach: Publicity Programs & Plant Modifications
Status: Report, September 26, 1975

OVERALL PROGRAM GOAL

Implemented and publicized campus-wide conservation program. Made specific improvements in the physical plant. Established publicity program.

PUBLICITY AND CONSCIOUSNESS RAISING

1. Designed and distributed posters to keep awareness high. Also used radio, TV, wall stickers, newsletters, etc., to maintain level of interest.
2. Conducted seminars and conferences concerning energy conservation, fuel allocation, etc.
3. Continually promoted faculty research related to energy. Took advantage of federal funding.

CONSERVATION PROGRAM STEPS

1. Reduced interior lighting, eliminated decorative and Christmas lighting.
2. Custodians worked in and illuminated just one section of a building at a time.
3. Large central coffee makers used in place of small, scattered units.
4. Set thermostats at 68°F during heating season except 55°F when unoccupied during weekends. Set at 78°F during cooling season.
5. Drew blinds when outside temprature below 20°F.
6. All libraries closed at midnight.
7. Put timers on motors and equipment where feasible.
8. Discouraged use of elevators.

RESULTS

Steam: Consumption reduced by 11.1%
Electricity: Consumption reduced by 6.6% in FY 74-75

PHYSICAL PLANT MODIFICATIONS

1. Relamped recreation court areas.
2. Installed timers on two 75 HP motors in Dental Building.
3. Cleaned and maintained absorbers cooling towers and replaced air-handler filters.
4. Repaired and insulated steam and condensate lines.
5. Supplemented 100 HP air compressor with 3 HP compressor for nighttime use.
6. Rewired Health Sciences Building to provide smaller units of lighting control.

RESULTS

Power consumption: Reduced by 40%

Kent State University

Location: Kent, Ohio
FTE: 18,559
Avg. Temp: Oct - Mar 37.1°F
Apr - Sep 63.2°F

Approach: Proposal for a Central Control System
Status: Proposal, March 19, 1974

PROPOSED MODE OF OPERATION USING A CENTRAL CONTROL SYSTEM

Air systems will operate continuously during building occupancy for both heating and cooling cycles. At night and during unoccupied periods these air systems will be operated on an on-off basis to maintain reduced building temperatures.

During heating season morning warm-up of the building, all outside air make-up and building exhaust air is shut off. An enthalpy controller controls the amount of outside air used during the cooling season to provide optimum natural cooling. Mechanical refrigeration is controlled on an outside air temperature and occupancy time basis.

When outside air temperature is below 65°, building radiation operates continuously during building occupancy. When building is not occupied and outside air temperature is above 40° the building radiation is off; when outside temperature falls to between 20° and 40° building radiation operates on a predetermined time cycle; and when outside temperature falls below 20° building radiation operates continuously.

CONTROL UNIT SELECTION

Many companies which manufacture environmental temperature controls or computers were reviewed based on the following criteria:

1. Local service representation and familiarity with existing system.
2. U.L. Approved.
3. Since the field systems are about 98% controls, the company's service and maintenance personnel should be "control oriented."

ENERGY CONSERVATION MEASURES

Energy saved by turning off during unoccupied cycle **$84,651.**
Fuel saved by reduction of outside air to 0% in unoccupied heating cycle **$24,655.**
Energy saved by stopping chilled water pumps, cooling tower pumps and fans, mechanical refrigeration during unoccupied cooling cycle **$15,634.**
Fuel saved by turning off absorption cooling systems during unoccupied cooling cycle **$32,870.**

RESULTING ANNUAL COST AVOIDANCE: $157,810

University of Mississippi

Location: University, Mississippi
FTE: 8,598
Avg. Temp: Oct - Mar 50°F
Apr - Sep 76°F

Approach: Contingency Plan
Status: Proposal, Nov. 10, 1973

PROPOSED METHOD OF IMPLEMENTATION

Semi-voluntary reduction of heat usage, designed as Phase 1. Mandatory reductions for worsening conditions designated as Phases 2 - 3 - 4. Shutdown designated as Phase 5.

PHASE ONE

1. Set thermostats at 68°F.
2. Inspect door closers, valves, radiators.
3. Eliminate heat, except standby, to nine buildings.
4. Consolidate dorm residents to close one or more dorms.
5. Cut off steam heat at 12.30 A.M.

PHASE TWO

1. Reduce heat 10-15°F in all buildings by Physical Plant mechanics.
2. Close additional buildings including field house, coliseum, athletic office, grill and snack bar.
3. Maintain enough heat to prevent freezing.

PHASE THREE

1. Close eleven more buildings.
2. Maintain enough heat to prevent freezing.

PHASE FOUR

1. Send students home.
2. Close fraternities, sororities, and nine more buildings.
3. Maintain enough heat to prevent freezing.

PHASE FIVE.

1. Drain water systems.
2. Eliminate all heat.
3. Anticipate extensive damage from freezing as all piping will not drain completely.

University of Missouri

Location: Columbia, Missouri
FTE: 25,022
Avg. Temp: Oct - Mar 47.6°F
Apr - Sep 66.5°F

Approach: Seasonal Conservation Program
Status: Report April 3, 1975

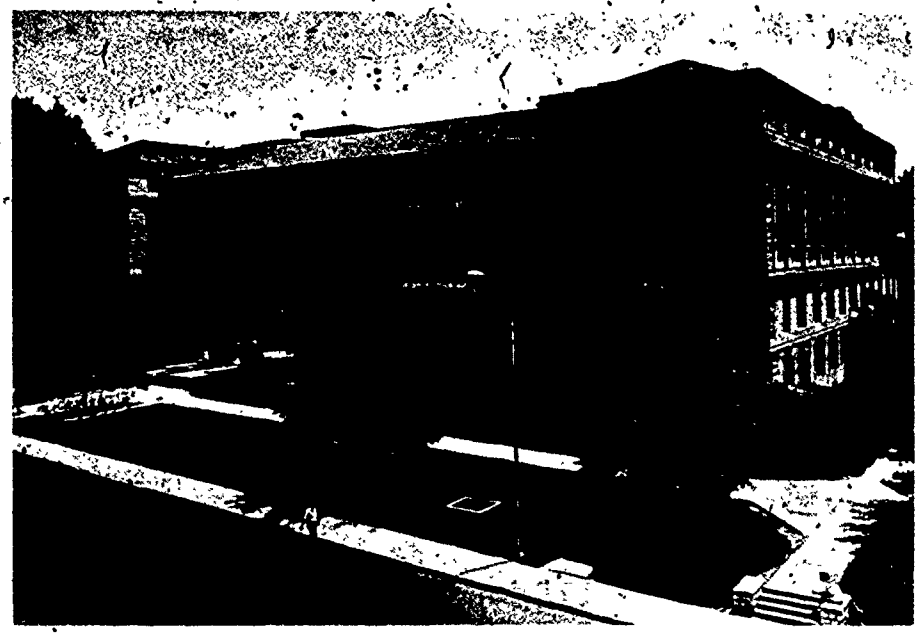
METHODS

1. Raise air conditioning to 77°F
2. Reduce heat setting to 69°F.
3. Reduce domestic hot water to 115°F.
4. Reduce intensity of exterior lighting.
5. Lower heat to 60°F and raise air conditioning to 90°F when a building is not in use for 10 hours or longer.
6. Turn off window air conditioners at night and when the space is to be unoccupied for three hours or longer.
7. Adjust heat with controls, not by opening window.

RESULTS

IN TWO HEATING SEASONS avoided spending $288,000 for steam and $415,000 for electric power.

IN ONE COOLING SEASON avoided spending $170,000 for steam and $152,500 for electric power.



Ellis Library, University of Missouri

North Carolina State University

Location: Raleigh, N.C.
FTE:: 14,257
Average Temp: Oct - Mar 47.1°F
Apr - Sep 69.8°F

Approach: Leased Computer Control System
Status: Report November 24, 1975

IDEA

In addition to time clocks being used to program heating and cooling periods, a computerized control system has been leased for a trial and demostration period. It controls demand and programs the on-off periods for supply air handlers in eleven buildings.

RESULT

After 28 days of operation 205,580 KWH have been saved. At present energy cost, this is an average dollar savings of about $151 per day from 10 of the subject buildings. Possible cost avoidance of $42,280.

ADDITIONAL PHYSICAL PLANT MODIFICATION:

1. Connected lighting load was reduced by 1928 KW against a campus total of 7100 KW.
2. Reduction in campus hot water temperature to 120°F from 140°F has not created any hardships.
3. Room thermostats set at 68°F heating and at 78°F for cooling.
4. Continuous inspection of water lines, steam distribution lines, and valving are made to detect and repair insulation breakdown and steam leaks.

RESULTS

Physical plant modifications have provided reductions of:

Heat: 19.4% in lbs. of steam generated per degree day.

Electricity: 2.93% or 2,431,613 KWH.

Fuel Oil: (Oil plus gas converted to oil equivalent) 37,267 gallons No. 6 oil.

A BRIGHT IDEA

Energy Conservation Scoreboard is now in its fourth year of usage. This idea contributes greatly to increasing the campus awareness of energy use.

Ohio State University

Location: Columbus, Ohio
FTE: 47,268
Avg. Temp: Oct - Mar 40.1°F
Apr - Sep 65.6°F

Approach: Total conservation program
Status: Results July 1, 1975

STUDY METHOD

1. Actual operation of building is determined by:
   a. Ducts traversed to establish actual air distribution.
   b. Motor amperage readings taken to establish actual electrical distribution.
   c. Rooms surveyed to establish actual usage and equipment loads.
   d. Space and ducted air temperatures monitored under varying outside conditions to establish actual operational characteristics of the system.

2. Total predicted energy usage calculated by known usage components and adjusted by system coefficient to coincide with actual metered usage.

3. Effect of proposed energy conservation techniques calculated by examining their effect on each of the components.

CONSERVATION TECHNIQUES – HVAC EQUIPMENT

1. Programmed start/stop of HVAC equipment
   a. Turn on and off in accord with occupancy. Sequence motors into operation to prevent increasing electrical demand.
   b. High velocity systems may operate with return fans running and supply and exhaust off since tests indicate the return fans force about 40% of the air through the system. Tight shutoff of outdoor air and relief dampers is mandatory.
   c. Low pressure systems may be cycled on 100% return air with a night setback thermostat during the heating season.

2. Minimize reheat of AIR SUPPLY
   a. Winter - Set mixed air at 63°F to maintain interior temperatures at 76°F. Mixed air setting of 55°F would require large amounts of energy for excessive reheating to 63°F to maintain 76°F interior temperature.
   b. Summer - Raise supply air temperature when it has 55°F or less dew point. This will permit raising the chilled water supply temperature thereby increasing chiller capacity and perhaps reducing the number of chillers in use.

3. Delamping
   a. Remove fluorescent bulbs and ballast fuses reducing air requirements to spaces and reheating of the air due to false cooling caused by bulb heat. Humidity must be carefully monitored.

4. Variable volume of AIR SUPPLY
   a. Varying the amount of air supplied in accordance with the cooling load rather than mixing hot and cold air or reheating at the space.

b. Reduce fan motor loads at central air handling units with static pressure sensors and modulated inlet vanes.

5. Employ enthalpy economizer cycle which allows the system to use either return air or outside air – whichever contains a lesser amount of heat during the cooling cycle.

6. Chiller Plant Operations
   a. Operate condensor water system at lower temperatures.
   b. Sequence chillers operation.
   c. Operate only necessary chilled water pumps and cooling tower fans.
   d. Elevate chilled water temperatures when humidity conditions permit.

7. Boiler Plant
   a. Operate boilers at lower pressure and temperatures.
   b. Consider elimination of hot standby boilers since, in many cases, a boiler failure will not cause serious hardship.
   c. Operate only the heating water pumps necessary.
   d. Establish a uniform firing rate instead of modulated between high and low firing rates.
   e. Employ heat exchangers to recover heat from the boiler flue gases.

CONSERVATION PROGRAM RESULTS

1. REMOVAL OF BULBS AVOIDED $112,000 YEARLY
   Removed 50,000 excess lamps in interior fixtures as well as certain exterior lighting. (Est. cost $25,000)

2. CONSOLIDATION OF CLASSES AVOIDED $31,000 YEARLY
   Summer classes were consolidated from five buildings to two with complete or partial shutdown of unused facilities.

3. TIME CLOCKS AVOIDED $250,000 YEARLY
   Installed time clocks to shutdown night and weekend ventilation and air conditioning on buildings totalling 4,000,000 square feet. (Est. Cost $15,000)

4. HOT WATER HEAT REDUCTION AVOIDED $30,000 YEARLY
   Reduced temperatures of hot water heat supply. This was effective as well as reducing complaints from older overheated buildings.

5. OSU EN CON PROGRAM OF BUILDING STUDY AND MODIFICATION AVOIDED EXPENSES.
   Modifications completed on six major buildings on which detailed energy studies were made and reports submitted. Pay-backs averaged one year or less. Total modification cost $206,344.

6. PAY BACK OF 2-3 YEARS PREDICTED
   Central Campus Energy Control Center installation underway for four buildings with additional 15 buildings to be added within next year.

7. Miscellaneous utility management, scheduling of mixed air temperatures, and improved

plant efficiencies plus the voluntary efforts account for additional cost avoidance.

8. Estimated cost of total En Con Program Engineering and Administration –$190,000.

Approach: Building Survey—Allied Medical Facility
Status: January 1, 1976

STUDY METHOD

Conducted three stage study:

1. Reviewed contract documents and conducted tests of existing system.
2. Analyzed data and established energy saving hypotheses.
3. Analyzed hypotheses by hand without the use of computers.

FOUR POTENTIAL ACTIONS FOR SAVING

REMOVE BULBS for an Annual Cost Avoidance of $1,581 (one time cost: $1,000)

1. Remove 22% of fluorescent bulbs to reduce energy cost 2%. Greater savings offset by increased reheat costs and humidity increase unless air volume is reduced.

REDUCED AIR VOLUME for an Annual Cost Avoidance of $13,340 (one time cost $8,000).

2. Reduce air volume to spaces where lighting was removed and provide variable volume to spaces where load variations are anticipated, and to interior spaces by blankoff of warm air connection.

UNOCCUPIED SHUTDOWN for an Annual Cost Avoidance of $21,640 (One Time Cost of $14,000)

3. Initiate unoccupied shutdown of air handling systems. Involves motors with a total capacity of 193 HP for 14 hours per day plus 23,000 CFM of air not heated or cooled.

REDUCE & VARY AIR VOLUME for an Annual Cost Avoidance of $4,470 (One Time cost of $7,000)

4. Reduce air volume and employ variable flow rate in TV studio by installing two-speed fan motor. Supply air unit operates at low speed except periods when TV studio demands full cooling.

RESULTS

Monitored energy savings prove total energy reductions of over 50% have been achieved on this building. System operation and environment show substantial improvement such as improved control and fewer draft complaints. Actual payout is approximately 9 months.

South Dakota State System

Locations: Noted Below
FTE: 17,078
Avg. Temp: Oct--Mar 29.4°F
Apr - Sep 63.6°F

Approach: A Measure for Comparing Energy Conservation Efforts
Status: Report February 5, 1975

SYSTEM CONCEPT AND EVALUATION METHOD (All Locations)

A heating system Energy Efficiency Value (expressed in BTUs per gross heated square foot per yearly heated degree day) was calculated for each institution for the last three fiscal years. This value corrects for heating efficiency of fuels, extremes of weather and changes in area heated. Comparison of annual figures shows the effect of energy conservation efforts and the relative efficiency of heating systems from one institution to another. By acting on those systems which have poor or worsening energy efficiency values potentially hundreds of thousands of dollars may be saved.

SOUTH DAKOTA STATE AT BROOKINGS FTE: 6,869

Conservation programs saved money in the coal fired systems of some 80 buildings. Further savings of over $100,000 per year should come from central control, combustion efficiency, automatic coal weighing, flue gas monitors and increasing coal costs.

Energy Efficiency Value is 24 BTU/Sq Ft/Degree Day

Used 7.3% less energy
Cost Avoidance: $24,400

UNIVERSITY OF SOUTH DAKOTA AT VERMILLION FTE: 6,586

Savings due to Central Control, insulating steam pipe joints, utilizing continuous blowdown, linking mechanical ventilation of building to central control, utilizing tunnel heat for boiler room combustion air, installation of entropy meters.

Energy Efficiency Value is 24 BTU/Sq Ft/Degree Day

Used 13% less energy
Cost Avoidance: $52,000

DAKOTA STATE COLLEGE AT MADISON FTE: 972

Measures taken included building shutdowns to 55°F, plastic coverings on windward windows.

Energy Efficiency Value is 14.6 BTU/Sq Ft/Degree Day

Used 28.4% less energy
Cost Avoidance: $34,200

SOUTH DAKOTA SCHOOL OF MINES AND TECHNOLOGY FTE: 1,469

Utilized central controls in innovative manner and implemented effective campus wide conservation program.

Energy Efficiency Value is 24.3 BTU/Sq Ft/Degree Day

Used 15% less energy
Cost Avoidance: $23,793

UNIVERSITY OF SOUTH DAKOTA AT SPRINGFIELD FTE: 1,182

Turned heat down in unoccupied buildings, placed plastic coverings over windows, caulked frames, made bi-monthly checks on valves and traps.

Energy Efficiency Value is 14.5 BTU/Sq Ft/Degree Day

Cost Avoidance: $21,800.

Agricultural Hall at Brookings

University of Texas at Austin

Location: Austin, Texas
FTE: 48,098
Avg. Temp: Oct - Mar 57.3°F
Apr - Sep 78.9°F

Approach: Purchased vs. Generated Power Costs
Status: Report, June 4, 1975

FUNDAMENTAL METHODS

1. Aesthetic outside lighting turned off.
2. Campus, parking lot, and street lighting levels reduced.
3. Classroom and office lighting reduced to between 60 and 80 foot candles; corridors to 30 footcandles.
4. Air conditioning shut down selectively on weekends and holidays.
5. Library hours reduced.
6. Presidential Reminder Memos issued regularly.
7. Presidential Committee on Energy Conservation established. Consists of four faculty, one staff, three students

RESULTS

Use of electricity reduced about 25% over previous period

Cost Avoidance: Estimated at $634,000 in 74-75.

POWER COSTS - PURCHASES VS. GENERATED

Year	UNIT COST Power Purchased from City **	Power Generated by University
71-72	$0.01934	$0.00536
72-73	.02021	.00598
73-74	.04568	.00918
74-75*	.05254	.01800

*Through April 1975
**Note: This unit cost includes cost of "Standby Charges"

University of Washington

Location: Seattle, Washington
FTE: 34,524
Avg. Temp: Oct - Mar 45.8°F
Apr - Sep 60.1°F

Approach: Regenerating Campus Interest
Status: Report October 30, 1974

CONSERVATION AWARENESS REINFORCED

Considerable slippage occurring in energy conservation awareness programs instituted prior year. New letter to "all hands" from President and advertisement in campus paper to reach nearly all of the 50,000 daily campus users.

REVISED PROGRAM FORMAT

1. Reset heating to 68°F and cooling to 80°F.
2. Reset hot water for bathrooms to 110°F and kitchens to 140°F.
3. Reduce lighting levels in classrooms and offices to 70 footcandles and corridors to 20 footcandles.
4. Heating systems shut down from the end of spring quarter to the beginning of fall quarter.
5. Night classes grouped to minimize number of buildings required at night.
6. Encourage users to shut off lights when space is vacant for more than 15 minutes and to delay equipment startups (sterilizers, copy machines, etc.) by better batching.
7. Establishment of an energy management team to intensively reanalyze and retrofit building systems.
8. Reprogramming central supervisory control system (recently hired full-time programmer) to optimize building system operations, including absolute minimum operating time and massive shutdowns on weekends and holidays.
9. Reverted two of four boilers in Central Power Plant to coal burning. One older boiler to be replaced with 250,000 pound per hour three-fuel unit for additional coal burning capacity.
10. *Increasing efforts toward "energy ethic" awareness to gain support of campus inhabitants (comfort and convenience appear to prevail; complacency results).*

RESULTS

In FY-75 fuel consumption was reduced 13.6% over base year FY-73; to a level equal to FY-70 despite a 25% increase in gross square footage.

Cost of Solution: $ 200,000
Cost Avoidance: $1,000,000

Bradley University

Location: Peoria, Illinois
FTE: 5,236
Avg. temp: Oct-Mar 67-69°F
Apr-Sep 74-76°F

Approach: Successful Personnel Magement
Status: Report April 17, 1975

MANAGEMENT APPROACH

Initiated fuel conservation program in 1973 and electricity conservation program in 1975. By taking longer period of time to make changes they found that existing labor force could complete the tasks without outside help.

METHOD

Set heat thermostats at 68°F and cooling at 78°F. Over three year period installed time clocks in all air handling units set to shut off outside air when building is unoccupied. Maintenance to all absorbers. Shutdown absorbers for four weeks in fall of 1973 and six weeks in spring of 1974.

Delamping to 60-70 foot candles in classrooms and offices and 15-20 foot candles in hallways. This will put back into stock sufficient bulbs to increase stock by 35%.

RESULTS

With program two-thirds complete demand has been reduced by 60,000 Watts per 48-hour week.

FUEL CONSERVATION

Oil Cost Avoidance: $28,834
Gas Cost Avoidance: $33,087

ELECTRICITY CONSERVATION

Cost Avoidance: $4,500

Clarkson College of Technology

Location: Potsdam, New York
FTE: 2485
Average Temp: Oct - Mar 29.3°F
Apr - Sep 59.2°F

Approach: Utility Management
Status: Report Oct. 1975

LEVELS OF CONSUMPTION

FUEL/ENERGY	1969-70	1975-76	Possible
Gas	54,000,000 Cu.Ft.	47,000,000 Cu.Ft.	29,000,000 Cu.Ft.
Oil	415,000 Gal.	300,000 Gal.	220,000 Gal.
Electricity	21,500,000 KWH	15,500,000 KWH	13,500,000 KWH
Water	55,000,000 Gal.	49,000,000 Gal.	42,000,000 Gal.

CONSERVATION EFFORT TO DATE

ELECTRICITY

1. Restrict Ventilating air
2. Program fans, pumps, etc. off during non use times
3. De-lamp 180,000 watts
4. New hi-pressure sodium for Arena & new metal arc lighting in Gym
5. Replace incandescent lighting with fluorescent
6. Reduce temperature wherever possible
7. Restrict outside lighting
8. Use of heat sink (70,000 Gal. H_2O) as cold sink to cool building
9. Use automatic demand controllers

Cost Avoidance: $180,000
One Time Cost: $16,000

FUEL OIL & GAS

1. Restrict vent air
2. Use of run-around recovery system
3. Lower temp. in unoccupied areas
4. Reduce to 55°F all areas during vacations
5. Reduce hot water to 120°F
6. Heat hockey arena only during games
7. New insulation on steam and condensate lines
8. Reduce steam pressure from 125 to 70 PSI
9. Install roofing insulation--35,000 square feet

Cost Avoidance: $57,500
One Time Cost: $36,000

WATER

1. Install flow control showers

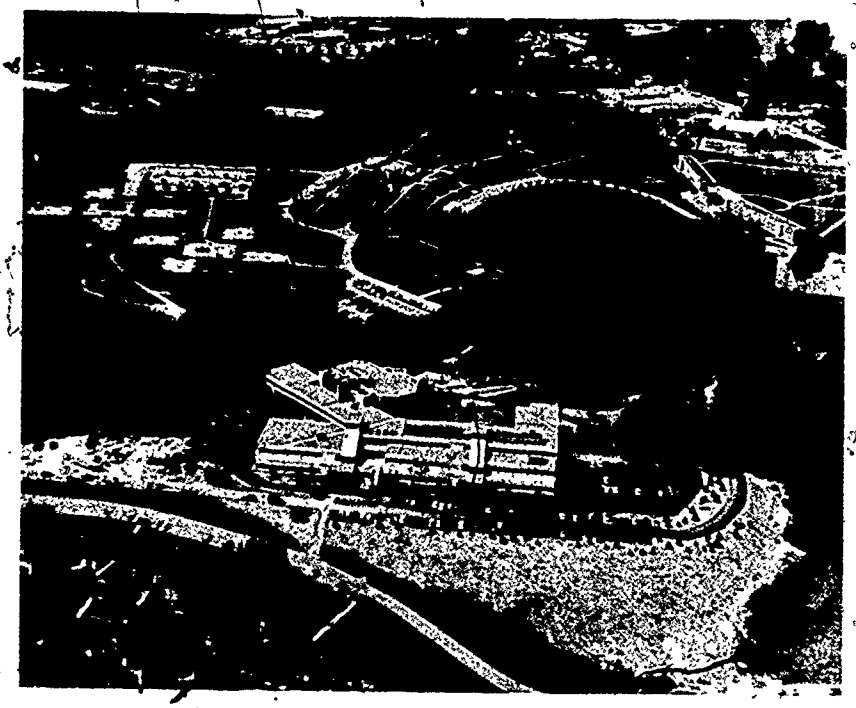
2. Install controls on water cooled equipment
3. Thinner ice pad in hockey rink
4. Use of chillers on some water cooled equipment—closed system

Cost Avoidance: $10,800
One Time Cost: $6,000

FUTURE PROGRAM

1. Continue building insulation
2. Install storm & insulating sash
3. Overall demand & load control
4. Convert some electric heating to gas-oil
5. Additional lighting changes
6. Possible use of river water for rink
7. Further control of water using machinery
8. Continue installation of flow controls on showers
9. Possible use of solar collectors
10. Have developed for approval a complete system for conservation of all types of resources consumed by institution, known as "Project Secure" – Save Energy – Conserve and Use Resources Effectively.

Possible Additional Cost Avoidance: $157,800
One Time Cost: $846,000



Science Center and Dormitories

Cornell University

Location: Ithaca, N.Y.
FTE: 16,500
Avg. Temp: Oct -- Mar 32.7°F
Apr - Sep 60.5°F

Approach: Utility Monitoring and Control/Infrared Survey
Status: February 1976

UTILITY MONITORING

Energy consumption is monitored on a building by building basis. The approximately 200 buildings on campus are equipped with about 1200 metering devices.

DATA ANALYSIS

Billing, consumption, and cost reports are done by computer. Data can be extracted in any format desired. The success of energy reduction programs is quickly determined and problem areas are easily identified.

QUOTAS – PAYBACK PENALTY

Close monitoring enables energy consumption quotas to be set for individual departments and units. Those exceeding their quotas are required to pay the difference out of their own operating budget. This program will soon be implemented on an experimental basis.

VOLUNTARY CONSERVATION PROGRAM

This program has been underway for two years. It is basically a public relations program directed at energy users reminding them to turn off lights not being used, shut doors and windows, close blinds not in the sun, etc.

Cost avoidance: $1,100,000 in two years

HEATING CURTAILMENT

Heat in buildings is not turned on until there are at least two days of average temperature below 62°F. Heat must then be requested by departmental heads. Heat was kept off in all but 17 buildings until October 6, 1975.

Cost Avoidance: $165,000

INFRARED SURVEY

The 25 miles of campus steam lines were checked for leaks and poor insulation by using an aerial infrared survey technique.

Cost: $11,800
Cost Avoidance: $11,800 recouped plus $10,000 saved in first year

POWER MANAGEMENT

An IBM System 7 has been installed and interfaced with the campus Honeywell Monitoring and Control Panel System. This system was installed to manage electric power loads but Cornell has found its largest savings has been steam.

Lafayette College

Location: Easton, Pennsylvania
FTE: 2,237
Avg. Temp: Oct - Mar 38.3°F
Apr - Sep 64.4°F

Approach: Organization, Management, and Implementation
Status: Report, February 14, 1975

PROGRAM:

1. Program controlled by Conservation Committee. Policies established. Committee reviewed all requests for exceptions.
2. Concentrated Public Relations Program. Spot announcements on radio, ads in newspaper.
3. Heating scheduled for all buildings: 50° unoccupied; 68° when occupied.
4. Consolidated activities to minimize facilities to be heated, e.g., night classes, athletic practice sessions.
5. Extended holiday at Christmas.
6. Thermostats locked, systems controlled by clocks whenever possible.
7. Hot water temperature reduced. Usage restricted through shower flow limiters.
8. Frequent monitoring by conscientious technicians. Charting of trends.
9. Minimized fresh air makeup, heat loss through exhausts, fireplaces (boarded up), weatherstripping.
10. Summer cooling target 78°, 50% relative humidity for occupied spaces only.
11. Reduced lighting to 50 ft. candles max., lower in corridors. Removed bulbs.
12. Rehabilitation of distribution systems to reduce leakage, reduce penalties for low power factor.
13. Central, manually operated system for control of heat to major buildings (on-off modes). Heat to buildings cycled on and off according to outside temperatures and usage.
14. Reheat eliminated and/or reduced in cooling systems.
15. Infra-red thermographic survey conducted to locate obvious leaks and insulation problems of underground steam distribution system.
16. Eliminate use of standby boiler when outside temperatures relatively warm – i.e., when failure of primary boiler would not be consequential.

RESULTS

Electricity

Usage Reduced by 25% – $55,000

Fuel Oil

Usage Reduced by 24% – $65,000

Massachusetts Institute of Technology

Location: Cambridge, Massachusetts
FTE: 7,834
Avg. Temp: Oct - Mar 37°F
Apr - Sep 64°F

Approach: Program Leader: Environmental Engineer
Status: Report, April 1975

METHOD OF OPERATION

Grant received from the Union Pacific Foundation to add a new staff member devoted full-time to energy conservation. This Environmental Engineer initiated a systematic study of the sources and uses of energy to provide a basis for the optimum use of energy in the long range as well as the short range.

ENERGY COSTS

From 1970 to January 1975, the price of No. 6 Fuel Oil rose from $1.87 Bbl. to $13.97 Bbl. and electricity rose from 1.2 cents KWH to 2.7 cents KWH. The MIT energy budget rose from $1.8 Million to $5.1 Million during this same period.

STUDY OBSERVATIONS

1. 75% of the consumption of energy on campus is influenced by the actions of the members of the Department of Physical Plant.
2. 60 - 70% of MIT energy consumption is due to HVAC.
3. 14% of total energy consumption is due to lighting.
4. Buildings erected during the 1960s are characterized by high use of energy. Older buildings account for a relatively smaller amount of energy consumption. One group of older buildings consumes energy at a rate of 10.5 KWH per square foot per year as compared to a rate of 35 KWH for a comparable group of new buildings. Heat energy consumption in the older buildings is 110 lbs of steam per square foot per year compared with 204 lbs in the new buildings.

CONSERVATION TECHNIQUES IMPLEMENTED

1. General campus-wide conservation program introduced.
2. Modifications and improvements made to central plant and distribution network.
3. Year around temperature policy adopted to keep temperatures within range of 68° to 80° during occupied hours.
4. Building systems operated on schedules tailored to occupancy patterns through use of computer, time clocks and manual control.
5. Reheat coils turned off and cooling coil discharge temperatures raised in single duct systems for summer use.
6. Hot deck turned off and temperature of cold deck raised for dual duct systems summer.
7. Outside air quantities reduced whenever advantageous.
8. Winter mixed air controller adjustment of single duct supply air and dual duct cold deck raised from 53° to 64 - 70°, permitting use of less outside air.

RESULTS

Reduction in 1974 amounted to 20% in electricity resulting in a $694,000 cost avoidance and to a 25% reduction in steam consumption resulting in a $444,000 cost avoidance.

Cost Avoidance: $1,138,000 (equal to 22-23% of total energy budget)

Massachusetts Institute of Technology

Princeton University

Location: Princeton, New Jersey
FTE: 5,735
Average Temp. Oct – Mar 40.8°F
Apr – Sept 66.8°F

Approach: Total Program – Insulation is Important
Status: Report December 30, 1975

STUDY PROGRAM OBJECTIVES

1. Complete analysis and documentation of energy consumption characteristics of 11 major buildings on Main Campus.
2. Feasibility study of a Central Supervisory Control System.
3. A survey of energy saving capability of storm windows and window shades when used to balance and/or reduce building system loads.
4. Development of energy savings program through the use of higher efficiency, reduced lighting levels and localized lighting of office areas.

FACILITIES OPERATING PROCEDURE CHANGES

1. Residential facilities to be set at 68°F in winter with six-hour night setback to 60°F.
2. Academic buildings, with the exception of special research areas maintained at 65°F with setback to 60° from 5:00 P.M. to 7:00 A.M. at night and on weekends and holidays.
3. Administrative buildings maintained at 65°F with setback to 55°F at night and on weekends and holidays.
4. Increase minimum summer air conditioning temperature level to 77°F.
5. Delamping of non-critical areas.
6. Schedule holidays to provide for long weekend shutdowns.

CENTRAL UTILITY SYSTEMS CHANGES

1. Installation of a heat exchanger to replace steam driven chillers during the winter season when the outside temperature is equal or less than 55°F.
2. Addition of secondary chilled water pumps to major building systems to improve system efficiency and reduce energy consumption.
3. Use of night setback temperature controls.
4. Systems adjustment to reduce or eliminate the need for reheat in areas where humidity control is not critical.

GENERAL CONSERVATION EFFORTS

1. Attic insulation of 11 dormitories and 250 married student and faculty housing units.
2. Minimize individual buildings heat loss through the use of temporary walls over large overhead doors and other major sources of air leakage.
3. Installation of separate hot water heaters in selected apartment houses and dormitories to permit the shutdown of the main boiler units during the non-heating season.
4. Replacement of old furnace burners with high efficiency units in facilities not on the central utility system.
5. Reduction of hot water temperatures.

6. Use of water restrictors in all dormitory shower fixtures.
7. Use of automatic water temperature controls to match the boiler water temperature to demand based on outdoor temperature for apartment boiler units.
8. Installation of non-electric steam radiator controls in individual apartment units to adjust to tenant need and balance the total complex load.

RESULTS OF PROGRAM AND FUTURE CONSERVATION PLANS

1. Design and installation of central supervisory control system. Type and size of system to be determined.
2. Include energy conservation as a prime consideration in future new construction and major renovation programs.

Fuel Consumption reduced by 25%
Electrical Consumption reduced by 13% through FY75.

Nassau Hall

Yale University

Location: New Haven, Connecticut
FTE: 8,583
Avg. Temp: Oct - Mar 37.3°F
Apr - Sept 63.8°F

Approach: Holiday period shutdown, and Computerized Central Control
Status: Report, September 1975.

METHOD OF ENERGY CONSERVATION PROGRAM IMPLEMENTATION

Conservation program initiated 1970. University Operations Conservation Committee convened 1971, proposed thermal cost reduction program. Presidential directive issued 1973 reinforcing ongoing program, stating additional conservation steps and directing Christmas shutdown. Faculty Energy Conservation Committee appointed November 1973 to review procedures and elicit support of the institutional community. Monitor appointed in each area or building to keep track of energy use, reminding occupants of the need to conserve energy.

CONSERVATION POLICY DECISIONS AND TECHNIQUES

1. Temperatures to be reduced University wide to 65-68° range.
2. Air conditioning used only when interior space temperatures exceed 80°: no new comfort air conditioning installed.
3. Review of all forthcoming building designs to minimize energy consuming features.
4. 1970, review of each of the 200 major buildings on the Yale campus with respect to their energy consumption and cost trends. Review points out that science and medical buildings are most energy intensive and thus primary targets for initial conservation measures.
5. Aerial infrared photographic survey of campus to identify heat loss.
6. Thorough review and recalibration where necessary of all existing controls.
7. Reduction in illumination levels (except for security) and lamp wattages.
8. Night and weekend building shutdowns and consolidation of activities into fewer buildings.
9. Reduced hot water temperature.
10. Reduced building heat leakage using blinds, drapes, solar tint, etc.
11. Strictly adhered to standard maintenance procedures such as regular, systematic inspection of steam traps, valve functions and air filtration.
12. Conversion from incandescent to fluorescent fixtures in many areas.
13. Installed time clocks on lighting, exhaust, and air handling systems.
14. Rezoned many heating systems for more efficiency.
15. Installed variable speed drives on motors.
16. Reduced, where possible, fresh air make up.
17. Equipped 3 main boiler plants to operate on either steam or electricity dependent upon availability and expense of energy services.
18. Converted all chiller plants to operate on either steam or electricity dependent upon availability and expense of energy services.
19. Monitoring devices, alarms, and 24 hour recorders installed in all main boiler plants to measure stack emissions and combustion efficiency.
20. Systematic reporting of conservation progress to the University community via calendar announcements, graphs, etc.

HOLIDAY SHUT DOWN

Normal operations suspended from December 22, 1973 to January 1, 1974 and dormitories closed December 22 until January 13. Temperature reduced in all buildings to 50°F and hot water service suspended.

RESULTS OF SHUT DOWN

Fuel oil consumption reduced 18.6%
Electrical consumption reduced 18.0%

SAVINGS	$92,300
COST	15,000
NET SAVINGS	$77,000

COMPUTERIZED CENTRAL CONTROL FACILITY

1. 1970 feasibility study undertaken on a central computerized control system.
2. In 1974, after a four year successful conservation effort, the first phase of the computerized control system installed. System will eventually monitor and control critical mechanical systems in all major buildings and power plants, log and record management information, remotely respond to specific building needs and quickly diagnose and initiate remedial action for the control of malfunctions.
3. Installation of entire system to be phased over ten years to insure that a sound conservation program can be maintained manually prior to the installation of automatic controls.

Yale University

St. Louis Junior College District

Location: St. Louis, St. Louis County, Missouri
(District Office)
Florissant Valley Community College
Forest Park Community College
Meramec Community College
FTE: 6166
Avg. Temp: Oct - Mar 39°F
Apr - Sept 70°F

Approach: Multi-Campus Program
Status: Report, March 13, 1975

STATUS OF EXISTING FACILITY

1. A detailed analysis of utility consumption for each college was made in 1973.

2. District-wide facilities total 1.7 million gross square feet with 1.6 million being air conditioned and temperature controlled year-round. All colleges have central supervisory control systems on the heating, ventilating and air conditioning equipment. In 1972, 373.9 billion BTU's were consumed in electricity and natural gas.

3. Actions taken in 1974 included:

   a. Elimination of third shift (10:00 p.m. to 6:00 a.m.) for custodial work to permit complete shutdown of all large fans with consequential reductions in air conditioning and/or heating loads.

   b. Higher mixed air temperatures — raised from 55°F to 65°F.

   c. Thermostats at 68°F winter and 78°F summer.

   d. Reduced air supply velocity.

   e. Outside community users of space were told that no air conditioning would be provided for weekend functions. This permitted shutdown from 6:00 p.m. Friday to 6:00 a.m. Monday.

   f. Internal scheduling of use of space was tightened up so that use of space during off peak periods would be concentrated in a building area. This allowed elimination of air conditioning in entire buildings or in sections of large buildings.

   g. Incandescent fixtures were replaced with fluorescent fixtures wherever possible.

   h. Lighting levels were reduced wherever possible.

   i. The control system on exterior lighting received increased maintenance and was 100% utilized on all exterior lighting.

4. Results of Program

a. Project reduced total consumption from 373.9 billion BTU in 1972 to 228.6 billion BTU's in 1974 – a 39% reduction.

b. In 1972, 222,000 BTU's per square foot were used. This was reduced in 1974 to 135,000 BTU's per square foot per year.

c. Although utility rates were increased 18% from 1972 to 1974 costs were reduced from $50 per FTE student in 1972 to $41 per FTE student in 1974.

Cost Avoidance: $181,000

St. Petersburg Junior College

Location: Pinellas County, Florida
FTE: 1,670
Avg. Temp: Oct - Mar 65.7°F
Apr - Sep 79.6°F

Approach: Basic Program Pays Off – A Small School Approach
Status: Report, May 2, 1975

FUNDAMENTAL STEPS

1. Set cooling at 78°F.
2. Shutdown all HVAC nights and weekends.
3. Eliminated daytime corridor lighting where natural light is available.
4. No illumination over 80 foot candles for normal use.
5. Shutdown all decorative lighting, fountains, etc.
6. Prohibited use of all electric portable heaters, fans and hot plates.
7. Shutdown all power to refrigerated drinking fountains December through February.
8. Shut off all oil or gas fired hot water heaters used for showers and heating pools when the 24-hour average outside temperature is in excess of 75°F.
9. Closed libraries on Saturdays and eliminated all activities on campus except testing.
10. Inspected and tightened electrical connections, set dampers properly, calibrated thermostats, tightened fanbelts, cleaned and lubricated fans, cleaned and serviced heating and cooling coils, checked burner combustion efficiency.

EXCELLENT RESULTS

Electrical Consumption:

A reduction of 2,690,159 kwh: a 27.8% reduction in 1974 over 1973 levels

Fuel Oil:

Saved 2,828 gallons: a dollar savings of $1,148

Carleton University

Location: Ottawa, Canada
FTE: 7,668
Avg. Temp: Oct - Mar 25.8° F
Apr - Sep 59.3°F

Approach: Future Programs
Status: Report, May 15, 1975

PROGRAM NOW IN FORCE

1. Fan operation reduced from 24 hour operation to 8 to 12 hours per day.
2. Removed 10,000 four foot fluorescent lamps.
3. Reduced domestic hot water heat.
4. Built vestibules, weatherstripped doors.
5. Shaded windows outside and inside.
6. Mechanical chiller operation season reduced from four months to three months.
7. Supply air quantities reduced by reduction of fan speeds, tying exhaust fans to door switches.
8. Connected all chemistry department fume hoods to a central panel under the control of a senior technician.
9. Reduced differential between warm and cool air in double duct systems.

PROGRAMS BEING ADOPTED FOR THE FUTURE

1. Change single duct terminal reheat from constant volume, constant temperature to a large zone *primary variable volume system* controlled by solar loading.
2. Change dual duct, single fan, *constant volume systems* to dual fan, variable volume.
3. Install *heat recovery systems* where once-through air systems exist.
4. Install *secondary systems* to satisfy needs of small area users in large buildings.
5. Install *perimeter hot water systems* to permit shutdown of large air systems out of regular working hours during the heating season.
6. Heat recovery by *heat pump* or *heat exchanger.*

Cost Avoidance

To Date:	$218,000
Future:	$250,000

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