Chapter 5

Six Case Studies

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Six Case Studies

INTRODUCTION AND CASE STUDY METHODOLOGY

As part of its examination of opportunities for increased energy efficiency in the Federal Government, OTA conducted case studies of six diverse facilities.[1] Four are government owned and occupied, the fifth is a privately owned building leased to the Federal Government, and the last is a federally assisted housing authority.

Each case study examin ed two main topics: 1) current energy use and the opportunities for increased efficiency; and 2) the institutional, budgetw, economic, and technical reasons why apparently attractive energy conservation options were not being pursued.

The methodology used in the case studies relied heavily on the experiences of facility managers and any available facility energy analyses that had already been performed. OTA contracted with Enviro-Management & Research, Inc. (EMR), a consulting engineering firm, to conduct the case studies. Each case study included both on-site visits and telephone and mail correspondence. Table 5-1 lists the type of information and data collected.

EMR reviewed and analyzed all information collected on each case study facility. Only commercially proven and very highly cost-effective measures having a payback period of less than 3 years were considered.[2] Also, only more efficient equipment or improved operations and maintenance practices were considered. Approaches which require change in occupant comfort or productivity were not considered. Efficiency measures were divided into three categories: no cost, low cost, and significant cost. No cost measures involve virtually no cost to the facility as they can be implemented by in-house personnel. Low cost measures likewise can be implemented for the most part by in-house personnel, but necessitate some expenditures for materials and equipment required for the retrofit.

CONCLUSIONS: OPPORTUNITIES FOR FURTHER ENERGY AND COST SAVINGS

Three main conclusions are true of all of the case studies. First, there appears to be a large potential for savings. At these six federally owned, leased, or assisted facilities, an average savings of over 25 percent in annual operating cost and energy use appears achievable with proven and highly cost-effective technologies and operating strategies according to facility personnel. OTA's sample was small and not necessarily representative of the opportunities available in the overall Federal Government. However, it should be noted that two of OTA's case study subjects are Federal Energy Efficiency award winners. That is, these facilities and their personnel have made considerable, note-

Table 5-l —Information Collected From Case Study Sites

- General description of existing facilities, systems, and equipment
- Current energy use by type of fuel and major end-uses
- Major trends affecting energy use (e.g., increasing use of personal computers in offices; use of energy-intensive medical equipment such as computerized tomography scanners in hospitals; change in facility's mission; higher occupant density in offices)
- Major operational or equipment changes undertaken since 1980 to increase energy efficiency
- Planned modifications to building systems and equipment
- Experience with implementation of energy efficient technologies
- Energy and cost savings achieved due to implementation of energy conservation measures
- Impediments (institutional, budgetary, economic, and technical) affecting implementation of energy conservation efforts
- Perceived incentives for energy conservation
- Priority given to energy conservation in agency's mission
- Technical and economic criteria used for assessing energy conservation options
- Estimates of time it takes from initial study to final implementation of energy conservation options

SOURCE: EMR, "Case Study of Federal Building Energy Use," contractor report prepared for the Office of Technology Assessment, December 1990.

[1] This chapter is adapted from Enviro-Management & Research, Inc., "Case Study of Federal Building Energy Use," contractor report prepared for the Office of Technology Assessment, December 1990.

[2] Because so many energy efficiency opportunities in the Federal Government are currently untapped, this study focuses only on those which are very highly cost-effective. However, it does not intend to suggest that a very high discount rate is appropriate in analyzing Federal energy efficiency opportunities. See ch. 1, box l-A.

worthy achievements in energy efficiency not generally found throughout the government. Thus, it is reasonable to believe that greater savings are possible than indicated by this limited sample. Again, note that the case study estimates included only extremely cost-effective options in which the capital costs and other costs of implementation are small compared to the savings, with simple paybacks of under 3 years. A less stringent economic test that is more consistent with the cost of capital in the United States would produce higher estimates of potential energy and cost saving.

Second, there remains considerable uncertainty about the true extent of efficiency opportunities at the case studies. None of the facilities had performed a detailed energy audit of all their systems and operations within the past decade. Documentation and inventories for building systems and equipment and related energy conservation options were also often lacking. As a result, detailed, independent analysis of financial and economic characteristics of major options could generally not be performed. Ideally, analysis would include a review of financial, economic, and performance characteristics (e.g., capital costs, operating savings, performance improvements, return on investment (ROI) or payback) for all major options. Instead, the applicability and economic performance of various options were estimated based on the professional judgment of the facility managers and EMR.

Third, there is a variety of constraints to improved energy efficiency at the facilities. Funding or staffing constraints are *common* and important, but low priority, lack of incentives, and other factors are also noted by facility personnel.

CASE STUDY 1: GSA, SUITLAND COMPLEX, SUITLAND, MD

General Services Administration's (GSA) Suitland Complex comprises five major buildings occupied by the National Archives and Records Administration, Naval Intelligence, Census Bureau, and National Oceanic and Atmospheric Administration. The total building area in the Complex is approximately 2 million square feet.

Current Energy Use

The total annual energy expenditures are about $5 million. Several different energy sources are used in the Complex, including electricity, natural gas, and oil. Electricity is the dominant form, accounting for over 90 percent of expenditures. It is used for lighting, comfort conditioning, computer room air-conditioning, and electrical equipment. Natural gas and oil are used for space heating, service water heating, and cooking.

Energy consumption and cost data for the Complex since 1985 are shown in figure 5-1. Electricity consumption has increased by about 26 percent since 1985 due to a variety of factors as discussed below. Natural gas consumption has decreased by more than 50 percent, reflecting the effects of changing weather conditions, energy conservation efforts, and cutback of gas supplies because of participation in a curtailable service program. With regards to the latter, oil consumption, which is very low, has fluctuated because all heating equipment used oil during periods of natural gas curtailment.

Factors Affecting Energy Use

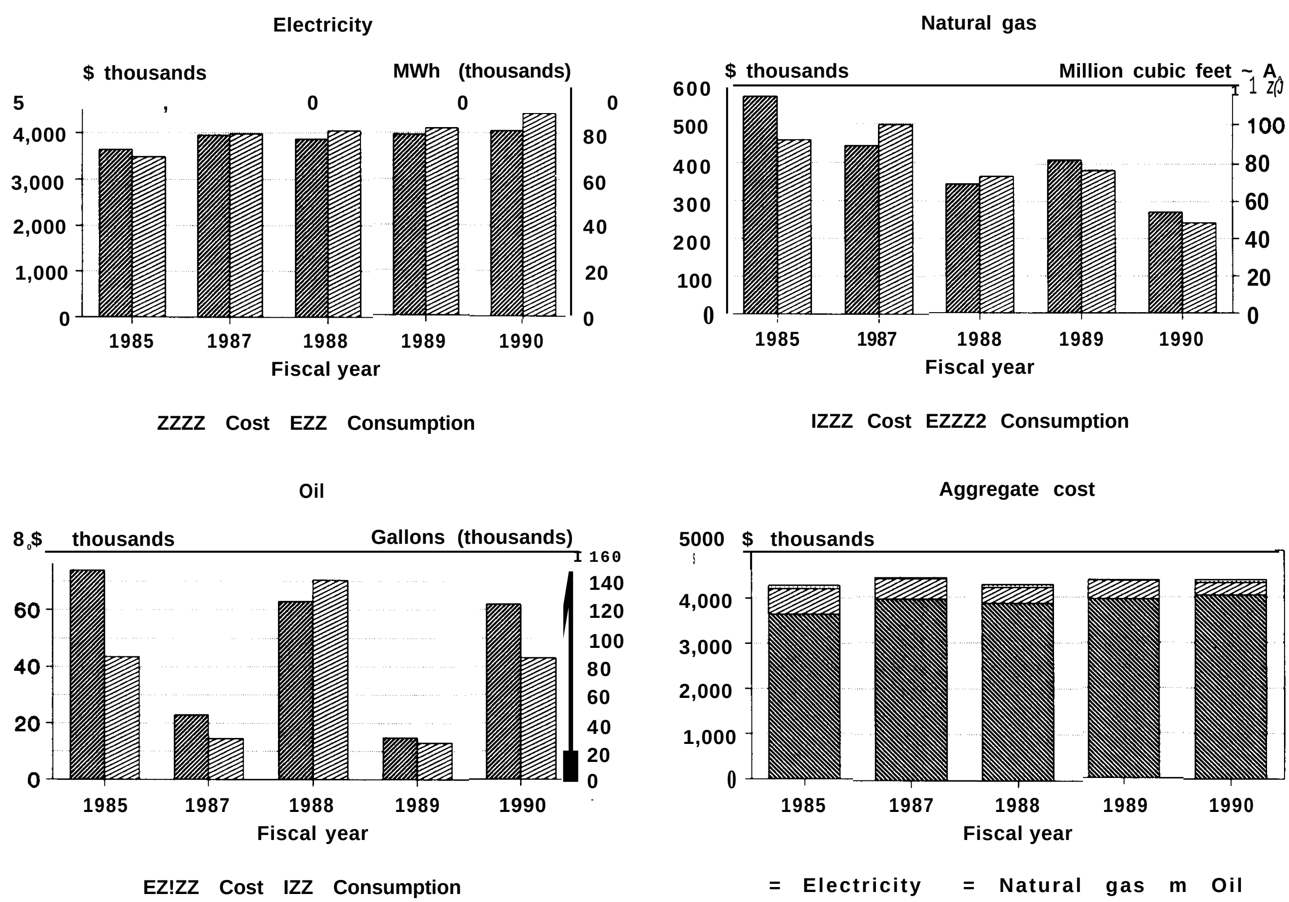
Several changes causing greater energy use are occurring at the Complex:

- More people are working at the Complex. In the past, space allocation was 200 square feet per person. It now is down to 135 square feet per person, and the new goal is 122 square feet per person.
- More computer equipment is being used in computer rooms and offices.
- Office and storage space has been converted to computer rooms.
- Network computers are always left on because of the growing use of electronic mail.
- More building space is being added to the Complex. A 17,000-square-foot addition was built for the NIC 2 Building and a 5,000-square-foot conference center will be completed in 1991. The master plan calls for approximately 1 million square feet of additional space at the Complex.

Energy Conservation Efforts to Date

Many energy efficiency improvements have been implemented at the Complex since 1980 because of personal interest taken by field office personnel. Most of these improvements involved no cost/low

Figure 5-1-Suitland Complex Energy Data



SOURCE: EMR, "Case Study of Federal Building Energy Use," contractor report prepared for OTA, December 1990.

cost options because funding for capital-intensive projects was not readily available. Energy conservation was given low priority, while more attention was focused on other concerns such as asbestos removal, fire safety, health issues, and transformers containing polychlorinated biphenyls (PCBs). Since 1987, however, emphasis on energy conservation has increased substantially due to the new programs initiated by the chief of the energy management section at the National Capital Region (NCR) office and commitment of personnel at the field office. The field office manager is enthusiastic and thorough in finding and trying new energy- and cost-saving measures, and received a Federal Energy Efficiency Award in 1990.

Many measures are actively being considered or currently being implemented (see table 5-2) at the Complex due to joint efforts between the NCR and the field staff. Furthermore, GSA has created a special energy management fund for implementing energy conservation projects. Currently, $30 million has been allocated for fiscal year 1991, one-third of which will be spent on lighting energy conservation retrofits in the NCR.

Energy Conservation Potential

Many cost-effective energy conservation measures have yet to be implemented at the Complex. Thus, a significant potential for further energy conservation still exists. The field office manager estimated that up to 20-percent reduction in energy use can be achieved if the following measures were implemented:

- Replace existing ballasts with higher efficiency electronic ballasts.

Table 5-2—Conservation Measures Implemented to Date at Suitland Complex

Increase efficiency of heating, ventilating, and air-conditioning systems

Maintain systems for efficiency:

Adjusted air dampers for tight closing.
Adjusted fuel-air ratio, fuel temperature at burner tip.
Sealed air leaks into combustion chamber.
Adjusted pumps to control leakage at pump packing glands.
Checked flues and chimney for blockages or improper draft conditions.
Clean filters and heat transfer surfaces.
Clean strainer screens in pumping systems.
Keep maintenance and operating log of all heating equipment.
Maintain correct refrigerant charge to avoid excessive compressor operation.
Recalibrated all controls.
Repair faulty steam traps and valves.
Repair leaks in chilled water, condenser water and conditioned air distribution systems.
Repaired insulation on economizers, condensate receiver tanks, boilers, furnaces, etc.
Use proper water treatment to reduce fouling of heat transfer surfaces in boilers, heat exchangers, etc.

Operate systems efficiently:

Do not permit perimeter and interior systems to buck one another.
Eliminate or reduce use of HVAC systems which require simultaneous heating and cooling.
Operate only necessary heating water pumps.
Operate only the chilled water pump and cooling tower fans as necessary.
Operate return-air fans for heating during unoccupied hours.
Optimize ventilation startup times.
Vary temperature of supply air, heating water and ohilled water, and pressure of steam in accordance with load.
Recover heat from condensate.
Reduce generating and storage temperature levels to the minimum required.
Use outdoor air for economizer cooling.
Use spot cooling of people when they were located far apart.
Use minimum number of chillers and boilers. (More efficient to operate one unit at 90% than two at 45%.)
Use lowest possible radiation temperature in perimeter spaces.
Lower indoor temperature and relative humidity during heating season as practical.
Operate ventilation and exhaust systems only when needed (e.g., at a minimum during unoccupied hours).
Turn off cooling system during unoccupied hours in noncritical areas.
Reduce cooling/heating in over-cooled/-heated spaces.
Locked thermostats to prevent resetting by unauthorized personnel.

Upgraded equipment to allow efficient operation;

Added valves, dampers and controls to set back temperatures during unoccupied periods in noncritical areas.
Added automatic draft damper control to reduce heat loss through breaching when the gas or oil burner in not in operation,
installed automatic ventilation controls.
installed warmup cycle controls on air handling units with outside air intake as applicable.
installed time clocks on self-contained cooling units for automatic shutoff.
installed automatic temperature control valves in radiators controlled by hand valves.
insulated steam lines, above and below ground.
insulated chilled water piping and ductwork carrying conditioned air through unconditioned spaces.
Provided additional thermostats for better control of heating equipment.
Replaced inefficient window air conditioners.
isolated off-line chillers and boilers.
installed boiler stack economizer for preheating feed water.[b]
Recirculated exhaust air using activated charcoal filters in noncritical areas.[b]
Replaced existing boilers which are not at or near the end of their useful life with modular boilers.[b]

improve the building envelope

Added additional insulation to roofs, ceilings and floors over unconditioned areas.
Added reflective films to reduce solar heat gain.
Established rules for all building personnel to keep doors and windows closed when heating or cooling system is operating.
installed weatherstripping around windows and doors.
installed an air curtain at loading dock.
installed automatic door closers on exterior doors.
Rehung misaligned exterior doors.
Replaced broken windows.
Used opaque or translucent insulating materiais to blockoff and thermally seal all unused windows.
Used vestibules and/or revolving doors to reduce infiltration.[b]

Improve lighting efficiency:

Reduce unneeded illumination:

installed photocell or time controls to operate outdoor lighting.
installed occupancy sensors in hallways and other areas.
installed timers to control lights in closets.
Reduced illumination to levels consistent with productivity, safety and security considerations.
Removed unnecessary lamps when those remaining can provide desired illumination.
Relocated luminaires to provide light on task areas.
Use daylighting for illumination in perimeter areas as practical.

Increase efficiency of lamps, ballasts and fixtures:

Used more efficient ballasts.
Use light colors for walls, floors and ceilings to increase reflectance but avoid specular reflections.
Use high-efficiency fixtures.
Clean lamps, luminaires and interior surfaces.
lowered height of lighting fixtures.
Used higher efficiency lamps.[b]

Miscellaneous

Boost hot water temperature locally.
De-energized booster heaters in kitchens at night.
De-energized hot water circuiting pumps when building is unoccupied.
Examined elevator usage; shut down excess capacity.
improved maintenance of motors.
installed and maintained insulation on all hot water pipes, fittings and valves passing through unconditioned spaces.
insulated hot bare pipes and storage tanks.
installed efficient nozzles and faucets.
Located water heater close to point of use.
Turned off infrared food warmers when no food is being warmed.

[a]Unless otherwise noted, all measures are considered by facility personnel to be low cost or no cost.
[b]Significant cost measure as identified by facility personnel.

SOURCE: Adapted from Enviro-Management & Research, "Case Study of Federal Building Energy Use," contractor report prepared for the Office of Technology Assessment, December 1990.

- Replace the existing energy management system with anew system employing direct digital controls. Include optimizing functions on all air handling units and chillers.
- Convert constant air volume systems to variable air volume systems. In conventional buildings employing constant air volume systems, the quantity of air heated or cooled remains the same regardless of the heating or cooling requirements of the area or zone served. The energy waste which results can be almost eliminated by converting to variable air volume systems fitted with adjustable speed fan controls which throttle down conditioned air supply to each area or zone to meet the changing load requirements.
- Replace oversized motors with energy efficient motors. Most motors are oversized for the equipment loads served. The degree of oversizing increases when building loads are reduced through application of various energy conservation opportunities. Motors that are not loaded to at least 60 percent of their potential are inefficient. They should be replaced with energy efficient motors, which are about 8 percent more efficient than the models in use at the facility.
- Use variable speed pumping. The design of chilled water pumps requires that sufficient capacity be installed for ''design' cooling load. However, ''design' load conditions exist only a small percentage of the time, whereas a reduced load and reduced pumping capacity exist most of the time.
- Eliminate all unnecessary exhaust hoods and roof ventilators. The air which is exhausted must be made up by outside air which usually is conditioned. This creates significant energy waste. Correcting the problem can create substantial savings.
- Reduce infiltration and exfiltration through openings in building envelope. Both infiltration and exfiltration place a burden on the heating and cooling systems, much as ventilation does. When conditioned air leaks out, it is made up of indoor air which must be conditioned. When outdoor air leaks in, it must be conditioned, too.
- Install economizer cycle controls. The savings provided by an economizer cycle can range from 10 to 60 percent of current cooling energy costs, depending upon the type of building and heating, ventilating, and air conditioning (HVAC) system involved.
- Balance chilled water and air distribution systems. Balancing assures that only the proper amounts of conditioned water or air are supplied to each zone. This minimizes energy used by the cooling system while simultaneously providing greater comfort.
- Reglaze windows with double or triple glazing. Double- or triple-glazed windows can reduce heat transfer by more than 50 percent, thus significantly lowering heating and cooling load which the HVAC system must meet.
- Reduce thermal losses and eliminate leaks in underground hot water and chilled water lines. Leaks can cause substantial energy waste. The value of such waste can be very large if left uncorrected. The underground hot water distribution system at the Complex is about 25 years old and needs repairing.
- Install automated demand limiting controls. Demand control can result in significant cost reduction by reducing a facility's electrical demand during peak periods. New microprocessor-based systems permit energy reduction as well because these systems can perform many more functions (e.g., optimized start/stop, duty cycling of motors, etc.) than just demand control systems.
- Reduce quantity of service hot water used. Installing-flow reduction devices is one of the most effective techniques for reducing consumption of hot water. These devices include flow restricting orifices which are installed in the line, aerators which reduce flows and mix water with air, and self-closing hot water faucets.

Barriers to Energy Conservation

Several barriers have restricted full implementation of energy conservation measures at the Complex in the past. Some of these still exist. They are as follows:

- Inadequate procurement and clerical staff to implement energy conservation projects even though funding currently is available. This also limits the Complex in taking advantage of local utility incentive and rebate programs.
- Top agency management commitment to energy conservation has not been consistent. As an example, it was not until 1987 that energy

conservation gained greater acceptance and commitment from top agency management. A new chief of energy management was appointed at that time. Once on-board, the chief aggressively promoted energy conservation and initiated a range of new programs.

- Procurement policies limit acquisition of high-quality equipment, products, and services. According to the field office manager, ‘‘The Federal Government’s policy of selecting small businesses and/or the lowest bidder does not necessarily result in quality equipment, products and services. ’
- Economic criteria used by GSA limits implementation of certain technologies which can result in significant energy savings but-have long payback periods (more than 3 years).
- Substantial lag time (3 to 5 years) in acquiring and installing capital intensive equipment and lack of follow-through. For example, it took 3 years to acquire an energy management system and an additional 2 years to install. After completion, the system never worked because it was installed improperly.
- Some new energy conservation technology is too sophisticated for building operators to understand and operate. As an example, the lighting controls for certain outdoor lighting is so sophisticated that most of the mechanics at the Complex are unable to understand or properly operate these devices.
- Lack of funds for personnel training in energy conservation. Although some funds are available, these have been allocated for training in other areas, such as asbestos management and removal.
- Policies that restrict replacing equipment that is still operating but is outdated and inefficient. As an example, the Complex still employs many motors that were installed in the 1950s. Because they still are operating, no funds are available for replacing them with energy efficient motors.

CASE STUDY 2: VA MEDICAL CENTER, WASHINGTON, DC

Built in 1962, the U.S. Department of Veterans Affairs (VA) Medical Center currently comprises 870,000 square feet of hospital, nursing home, research, and other medical care facilities.

Current Energy Use

A variety of energy sources are used at the VA Medical Center with electricity comprising over 90 percent of spending. Electricity is used primarily for space cooling, ventilation, lighting, cooking, and other electrically driven equipment and machinery. Other energy sources are used for the following applications: fuel oil for emergency generators, vehicles, and tractors; natural gas for cooking and laboratory bunsen burners; gasoline for VA-owned vehicles and equipment; and purchased steam for space heating and service water heating. Energy consumption data for the most recent 12 months is shown in table 5-3.

Factors Affecting Energy Use

Many of the building systems used in the Center are relatively inefficient by today’s standards (e.g., lighting systems designed to provide 150 foot-candles in administrative areas, air handling systems designed for 100 percent outside air even in administrative areas, and use of dual duct systems). This is because several of the Center’s buildings were built at a time when energy was relatively cheap and energy conservation standards did not exist.

Although the Center has implemented a range of energy conservation measures, the following new situations have resulted in increased energy consumption for space conditioning, lighting, service water heating, and other support equipment critical to the mission of the Center:

- Personal computers are being used increasingly in administrative areas.
- Energy-intensive medical equipment such as nuclear magnetic resonance scanners is being used increasingly for personal care and diagnostics.
- Occupancy levels are the highest they have ever been.
- Patient care and administrative activities at the Center have substantially increased in recent years.
- Construction of new facilities has added more square footage to the Center. As examples, Building 4 was added in 1973 and a nursing home was built in 1985.
- New mechanical and electrical equipment has been added to the Center in support of new and expanded facilities since 1973.

Table 5-3—U.S. Department of Veterans Affairs Medical Center Energy Consumption, July 1989 to July 1990

Energy source	Energy consumption
Electricity	181,588,000 kWh
Fuel oil	7,933 gallons
Natural gas	2,584,900 cubic feet
Gasoline	8,475 gallons
Purchased steam	88,168,150 pounds

SOURCE: EMR, "Case Study of Federal Building Energy Use," contractor report prepared for the Office of Technology Assessment, December 1990.

Energy Conservation Efforts to Date

The Center has implemented a variety of energy conservation measures since the 1973 oil embargo which dramatically increased the cost of energy. Although the Center has no formal energy management program, it has implemented a range of energy conservation measures to date as part of its continuing maintenance program. The funding for past and ongoing energy conservation efforts has been derived from the nonrecurring maintenance budget. Table 5-4 summarizes the various energy conservation measures that have been implemented to date. Although some of the measures represent one-time efforts (e.g., rehanging misaligned exterior doors and providing additional thermostats for better control of heating equipment), most measures are being implemented on a continuing basis (e.g., shut off exhaust systems when not needed and reset heating water temperature in accordance with load). Most of these are no cost/low cost measures.

Energy Conservation Potential

Although these energy conservation efforts have resulted in some energy savings and reduced cost, the potential for further energy and cost savings remains high. Because the Center has to date implemented mostly no cost/low cost measures, a significant potential for further energy and cost savings still exists. It is estimated by engineering and operating personnel at the facility that up to a 30-percent reduction in energy use can be achieved if the following measures are implemented:

- Reduce illumination in various spaces to levels consistent with American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Standard 90 (e.g., reduce from 150 foot-candles to 75 foot-candles in administrative areas).
- Replace all existing fluorescent lamps with higher efficiency fluorescent lamps.
- Replace existing ballasts with higher efficiency electronic ballasts.
- Replace incandescent lamps with compact fluorescent lamps as appropriate.
- Replace existing mercury vapor lamps with high-pressure sodium lamps for exterior lighting.
- Add controls (timers, motion detectors, dimmer switches, daylighting controls, etc.) as appropriate to turn off lighting during noncritical periods (e.g., 8 p.m. to 5 a.m.) in hallway corridors and unoccupied areas.
- Add controls to turn off all lighting in the parking garage of the nursing home when not needed.
- Replace existing energy management system with new system employing direct digital controls. Include optimizing functions on all air handling units and chillers.
- Convert remaining constant air volume systems to variable air volume systems.
- Use adjustable speed drives for variable fan speed control.
- Replace all motors above 40 hp with energy efficient motors.
- Use variable speed pumping during light loads.
- Use an active solar system for heating in the swimming pool, which currently consumes one-third of total purchased steam in the winter and one-half of total purchased steam in the summer.

Barriers to Energy Conservation

Despite the past energy conservation efforts at the Center, many barriers and constraints still must be overcome in order to achieve further energy and cost savings. These are as follows:

- Relatively low priority is given to energy conservation because energy expenditures constitute a very small percentage of the overall Center budget. Medical care and safety and health-related projects (e.g., asbestos and PCB removal) are given a much higher priority. Because of the nature of the Center's mission, patient care is accorded the highest priority. According to the assistant chief of engineering, "If a doctor needed a new piece of machinery to do a scan, that machinery will be bought before any engineering projects are even con-

Table 5-4-Conservation Measures Implemented to Date at VA Medical Center[a]

Increase efficiency of heating, ventilating, and air-conditioning systems

Maintain systems for efficiency:

Adjusted dampers in mixing boxes and multizone units to reduce leakage.
Adjusted pumps to control leakage at pump packing glands.
Checked refrigeration systems for correct refrigerant charge to avoid excessive compressor operation.
Clean filters, heat transfer surfaces and combustion surfaces.
Use proper water treatment to reduce fouling of transfer surfaces in chillers, boilers and heat exchangers.
Corrected improper automatic control operation.
Keep maintenance and operating log of heating equipment.
Maintain all cooling equipment.
Repaired insulation and leaks on economizers, condensate receiver tanks, boilers, furnaces, etc.
Sealed all air leaks into combustion chamber.
Use low resistance filters, registers and grilles to reduce horsepower required for air movement.

Operate systems efficient/y:

Eliminate or reduce use of HVAC systems which require simultaneous heating and cooling.
Use minimum number of chillers; isolate off-line units.
locked thermostats to prevent resetting by unauthorized personnel.
Lower indoor temperature and relative humidity during heating season.
Operate condenser water system at lower temperature.
Operate only the chilled water pump and cooling tower fans as necessary.
Operate only necessary heating water pumps.
Recover heat from condensate.
Reduce generating and storage temperature levels to the minimum required.
Reduce fan speed and hours of fan and pump operation.
Turn off cooling system and reduce ventilation rates during unoccupied hours in noncritical areas.
Use lowest possible radiation temperature in perimeter spaces.
Use outdoor air for economizer cooling.
Use spot cooling of people when they were located far apart.
Vary temperature of heating water, chilled water and supply air, and pressure of steam in accordance with load.
Close off unused areas and rooms.
Do not cool lobbies, passageways and storage areas to same degree as work areas.
Increase indoor temperature and relative humidity levels during cooling season as practical.
Reduce cooling in over-cooled spaces.

Upgraded equipment to allow efficient operation:

Added heat recovery on all computer room cooling units.
Added heat recovery roils on major exhaust systems.[b]
Added heat recovery coils on major dual duct air handling units.[b]
Added controls to setback temperatures during unoccupied periods in noncritical areas.
Converted constant-volume fan system to variable air volume.
Eliminated unnecessary exhaust hoods and roof ventilators.
Installed economizer cycle.
Installed and maintain insulation on all hot water pipes, fittings and valves passing through unconditioned spaces.
Installed valves and dampers to permit shutoff of heating in unoccupied areas where there is no danger of freezing.
Installed energy management control system.[b]
Insulated all steam lines, above and below ground.
Insulated all duct work carrying conditioned air through unconditioned spaces.
Insulated chilled water piping and ductwork located in unconditioned spaces.
Insulated hot bare pipes and storage tanks.
Provided additional thermostats for better control of heating equipment.
Replaced oversized hoods that removed excessive quantities of air.

Improve the building envelope

Improve building envelope:

Caulked all windows and door frames.
Established rules for all building personnel to keep doors and windows closed when heating system is operating.
Installed weatherstripping around windows and doors.
Installed loading dock door seals.
Installed automatic door closers on all exterior doors.
Reduced solar heat gain.
Reglazed windows with double glazing.
Rehung misaligned exterior doors.
Repaired cracks and openings in exterior surfaces.
Used vestibules and/or revolving doors to reduce infiltration.

Improve lighting efficiency:

Reduce unneeded illumination:

Added photocell or time controls to operate outdoor lighting.
Use light colors for walls, floors and ceilings to increase reflectance but avoid specular reflections.
Reduced illumination to levels consistent with productivity, safety and security considerations.
Removed unnecessary lamps when those remaining can provide desired illumination.
Used daylighting for illumination in perimeter areas as practical.

Increase efficiency of lamps, ballasts and fixtures:

Clean lamps, luminaires and interior surfaces.

Miscellaneous

Adjusted valves for minimal water use.
Boost hot water temperature locally.
Checked sterilizer and refrigeration equipment for proper gasketing and function. Repair or replac as necessary.
Inserted orifices in hot water pipes to reduce flow.
Installed efficient nozzles and faucets.
Installed demand limiting equipment.
Clean refrigeration condenser coils.
Recover steam condensate for service water heating.
Replaced sterilizers to reduce steam demand.
Replaced old steam cookers with new flask cookers.
Replaced selected motors with energy efficient motors.[b]
Turn off electrical appliances and machinery not being used.
Use water properly for grounds.

[a]Unless otherwise noted, all measures are considered by facility personnel to be low cost or no cost.
[b]Significant cost measure as identified by facility personnel.

SOURCE: Adapted from Enviro-Management & Research, "Case Study of Federal Building Energy Use," contractor report prepared for the Office of Technology Assessment, December 1990.

sidered. However, if a circuit breaker in an electrical panel is operating in an unsafe manner, it also will be accorded a high priority for funding. . ."

- Lack of policy and direction on energy conservation from central office to top management at the Center. This is due in part to the low priority accorded to energy conservation by various VA administrators during the past decade, as well as the lack of available agency funding for energy retrofits and capital intensive improvements.
- Top management commitment to energy conservation has not been consistent. Some past hospital administrators have placed a greater emphasis on energy conservation than others.
- Lack of a comprehensive energy management program and an energy coordinator who would be responsible for implementation of such a program.
- Lack of internal incentives to conserve energy, both for staff and Center as a whole. Although the annual DOE Federal Energy Efficiency Awards recognize achievements of selected Federal energy managers, the availability of additional incentives for other agency personnel is nonexistent. Furthermore, if the Center does achieve energy cost savings, these savings cannot be used for future energy conservation projects, but are retained in the general utility fund by the central office.
- Limited availability of funding and the long lag time (3 to 4 years) in obtaining appropriations after the need for the money has been identified. This factor is becoming increasingly important because the Center has implemented many of the no cost/low cost measures, and mostly the significant cost projects remain.
- Not enough qualified staff to undertake energy conservation improvements. For this reason and because of limited availability of funds, the Center cannot benefit from the current utility rebate programs, particularly with respect to lighting.
- Lack of awareness of new energy conservation products and techniques because the Center does not reimburse engineering and operation staff for attending workshops and conferences or even becoming members of associations (American Society of Heating, Refrigerating and Air-Conditioning Engineers, Association of Energy Engineers, etc.) involved in energy-related fields.

CASE STUDY 3: SAN DIEGO DIVISION OF THE U.S. POSTAL SERVICE, CA

The San Diego Division of the U.S. Postal Service administers over 370 postal facilities located in two mail sectional centers (MSCs), one in San Diego and the other in San Bernadine.

Current Energy Use

Energy sources used at the Division include electricity, gasoline, and a small amount of natural gas. Electricity is used primarily for ventilation, space cooling (in inland facilities only), lighting, and by electrically driven mail processing equipment. Lighting systems account for about 40 to 50 percent of the total electricity consumed. Natural gas is used for space heating and water heating. Gasoline is the primary fuel used by the Division's vehicles.

Figure 5-2 summarizes annual building energy use for 1985, 1987, and the most current 12 months. Although energy conservation programs have resulted in reduced energy use, reductions have been offset by increased energy consumption due to several factors as discussed below.

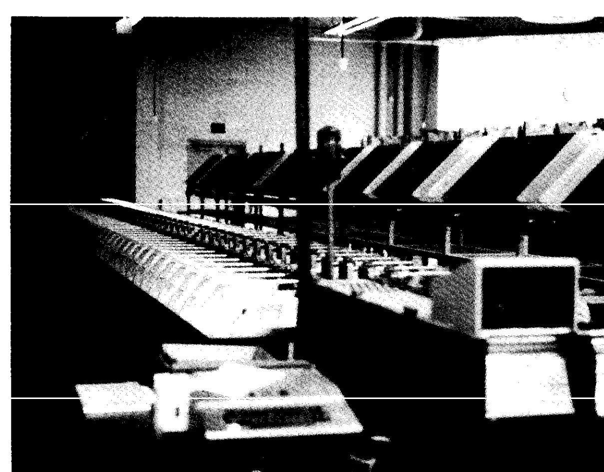
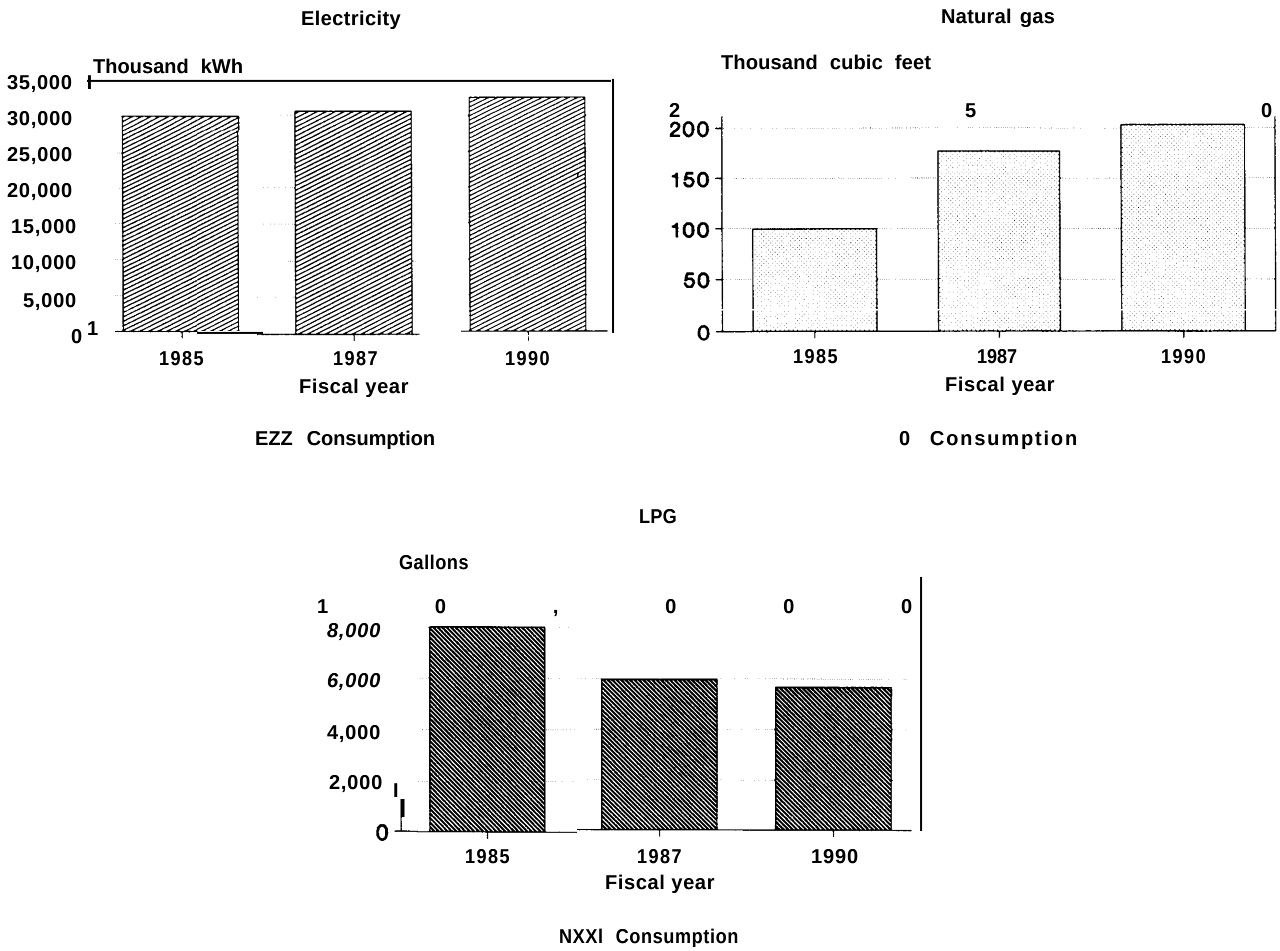


Photo credit: Robin Roy

Automated mail handling equipment improves service and reduces costs, but increases electricity use.

Figure 5-2—Energy Consumption at USPS San Diego Division, Fiscal Years 1985, 1987, and 1990



SOURCE: EMR, "Case Study of Federal Building Energy Use," contractor report prepared for OTA, December 1990,

Factors Affecting Energy Use

Three factors are influencing greater energy use in the Division:

- New automated mail processing equipment (e.g., bar-code sorters, optical character readers, letter sorting machines, and flat sorting machines) is being added fairly rapidly to central facilities as well as large and associate post offices. The goal throughout the U.S. Postal Service is 100 percent bar-coded mail by 1995.
- Increased automation in certain facilities is necessitating the use of air conditioning to control humidity at levels conducive to the operation of the automated mail processing equipment.
- New and expanded facilities are adding more square footage and additional energy using support equipment under the control of the Division.

Energy Conservation Efforts to Date

The Division has had a successful energy conservation program for several years. In fact, it received a national corporate energy award from the Association of Energy Engineers in 1990, and the energy coordinator at the facility was named energy manager of the year. The Division also won a 1990 Federal Energy Efficiency Award.

Energy conservation efforts at the Division date back to 1984 when a postmaster at one of the facilities took personal interest in energy conservation and obtained support from the general manager to initiate energy conservation programs at his facility. These efforts reduced that facility's energy use by 25 percent. Realizing the success of these efforts, the Division has encouraged other facilities to initiate similar energy conservation programs.

The Division general manager/postmaster is committed to energy conservation and management. One innovative action taken by the general manager several years ago involved the creation of a division energy coordinator's position. Once on-board, the new energy coordinator initiated the Federal Government's first shared energy savings (SES) contract to retrofit lighting at the San Diego General Mail Facility. According to the energy coordinator,

> The results to date have been impressive. Energy savings have far exceeded those projected. One reason for these huge savings is that the Division has been incredibly aggressive in the enforcement of this contract.

The primary focus of the energy conservation program to date has been retrofit of lighting systems.

In 1987, the Division negotiated a shared energy savings (SES) contract to retrofit lighting systems at the San Diego General Mail Facility comprising 398,626 total square feet of floor area, a few percent of the Division's total. The retrofit involved replacing 2,292 existing fluorescent lighting fixtures and their associated ballasts, and removing 992 others. It included installation of energy efficient magnetic ballasts, specular reflectors, and new 34-watt lamps. The retrofitted systems are now maintainingg the same light levels with two lamps, instead of four lamps used in older systems with considerably less heat and energy consumption. The SES contract has not only met but has exceeded energy savings expectations of the Division to date.

Even though the SES contract has proven successful in reducing energy use, there are no plans to use SES again at the Division's other facilities because local utilities are providing substantial rebates of 40 percent or more for every dollar invested in retrofitting existing lighting systems with energy efficient lamps and electronic ballasts. Rebates are also available for a variety of other energy efficient equipment retrofits (e.g., high-efficiency space conditioning equipment, high-efficiency motors, daylighting controls). By using Postal Service investment funds and utility rebates rather than SES, the Division has been able to retain all the cost savings in several recently conducted lighting retrofits.

Some of the no cost/low cost energy conservation measures that have been implemented at various facilities to date are shown in table 5-5.

Energy Conservation Potential

Based upon the successful results of the SES project, lighting surveys have been conducted at all Division facilities larger than 3,000 square feet to determine the potential for additional lighting system retrofits. As shown in table 5-6, a significant potential for energy reductions still exists. Division personnel estimate that up to 35 percent reduction in energy use can be achieved if the following measures are implemented. Several of the lighting measures are being implemented in 1991 using Postal Service funds and utility rebates.

Table 5-5—Conservation Measures Implemented at U.S. Postal Service, San Diego Division

No cost/low cost measures:

- Shut down ventilation systems during unoccupied periods in noncritical areas.
- Reduced ventilation rates during unoccupied hours to a minimum in noncritical areas.
- Turned off cooling systems during unoccupied hours in noncritical areas.
- Raised chilled water temperatures in accordance with load.
- Operated only chilled water pumps and cooling tower fans as necessary.
- Reduced illumination to levels consistent with productivity, safety, and security considerations.
- Added switching and timers to turn off lights when not needed.
- Used daylight for illumination in perimeter areas as practical.
- Removed unnecessary lamps when those remaining can provide desired illumination.
- Established an effective lighting usage program.
- Moved desks and other work surfaces to a position and orientation that will use installed luminaries to their greatest advantage.
- Added photocell or time controls to operate outdoor lighting.
- Used light colors for walls, floors, and ceilings to increase reflectance but avoid specular reflections.
- Used more efficient ballasts.
- Relocated luminaries to provide light on task areas.
- Lowered height of lighting fixtures.

SOURCE: EMR, "Case Study of Federal Building Energy Use," contractor report prepared for the Office of Technology Assessment, December 1990.

Table 5-6--Summary of South County Lighting Retrofit Potential

Facility	Total fixtures	Total fixtures to be retrofit	Average rate	Annual kWh saved
1. Alpine	119	108	0.097	25,201
2. Andrew Jackson	193	132	0.086	36,461
3. Bonita	144	134	0.096	26,269
4. Rancho Del Ray	77	62	0.097	21,328
5. Chula Vista Main Office	164	153	0.078	38,346
6. City Heights Station	91	89	0.100	25,336
7. Coronado	121	105	0.093	32,394
8. Downtown Station	629	548	0.096	137,800
9. El Cajon Main Office	607	538	0.078	139,576
10. El Cajon Bostonia	166	154	0.087	63,182
11. Encanto Station	62	61	0.099	17,342
12. Fashion Valley	112	111	0.102	11,609
13. Hillcrest Station	261	218	0.100	57,581
14. Imperial Beach	82	98	0.096	9,201
15. Jamul	62	62	0.097	16,125
16. John Adams	65	67	0.101	18,487
17. Lakeside	106	96	0.098	18,885
18. La Jolla Annex	142	140	0.081	47,787
19. La Jolla Main Office	383	367	0.081	68,923
20. La Mesa Annex	83	69	0.098	17,079
21. Lemon Grove	204	172	0.082	44,857
22. National City	122	96	0.084	39,487
23. Navajo Sia	128	119	0.088	22,324
24. North Park	85	70	0.096	19,181
25. Ocean Beach	113	113	0.099	17,434
26. Pacific Beach	112	107	0.078	35,523
27. Point Loma	98	86	0.099	19,693
28. Santee	180	180	0.099	29,855
29. San Ysidro	185	133	0.086	25,932
30. Serra Mesa	144	135	0.082	36,033
31. Southeastern Station	60	58	0.099	14,181
32. Spring Valley	275	266	0.087	73,841
33. University Station	57	41	0.099	9,062
34. William Taft Station	213	161	0.088	53,306
Total	5,645	5,049	0.092	1,273,822

SOURCE: EMR, "Case Study of Federal Building Energy Use," contractor report prepared for the Office of Technology Assessment, December 1990.

- Retrofit lighting systems at all facilities listed in table 5-6 with higher efficiency lamps, electronic ballasts, and specular reflectors.
- Retrofit lighting systems at the General Mail Facility at San Diego with higher efficiency lamps(32watt or T-8s) and electronic ballasts. This will require renegotiation of the SES contract, but the savings more than justify this action.
- Replace each electric motor as it burns out with an energy efficient motor.
- Replace all incandescent lamps with compact fluorescent lamps.
- Replace disabled and outdated postal system energy management and control systems (EMCS) with direct digital control systems in central and large facilities. When properly applied (to HVAC, service water heating and lighting systems), operated and maintained, direct digital EMCS can significantly reduce energy consumption and cost.
- Implement preventive maintenance programs for HVAC to systems to keep equipment operating efficiently and cost-effectively. According to the Division energy coordinator, "About 90 percent of the HVAC system maintenances performed by outside contractors, and 50 percent of the contractors never show up to perform the maintenance. Enforcement of maintenance contracts has been a major problem because of the lack of staff."

Implementation of most of the lighting-related energy conservation retrofits present annual return on investments greater than 50 percent (see example calculations for one postal facility in table 5-7), with payback period less than 2 years. Two projects have an estimated return on investment of around 300 percent. Other energy conservation measures (e.g.,

Table 5-7-Spring Valley Post Office Lighting Retrofit Analysis

Retrofit savings (kWh)	
Lighting kWh-before	117,543
Lighting kWh-after	43,702
Savings (kWh)	73,841
Percent reduction	63%
Retrofit savings (dollars)	
Savings (kWh)	73,841
Cost/kWh	0.0865
Lighting savings	$6,350.00
A/C savings	$ 952.50
Reduced maintenance	$ 276.00
Total savings/year	$7,578.50
cost	
Retrofit Cost	$18,216+3256 (37additional 2x4)
San Diego Gas & Electric incentive	$11,632
Net cost	$9,840
Investment analysis	
Savings-years	$22,735.50
Annual return on investment	$ 77%
Payback period (years)	1.3

SOURCE: EMR, "Case Study of Federal Building Energy Use," contractor report prepared for the Office of Technology Assessment, December 1990.

energy efficient motors and EMCS) are also expected to result in payback periods less than 3 years, particularly when current utility incentives are accumulated for calculation of net retrofit costs.

Barriers to Energy Conservation

The Division has been a leader in implementing the first Federal SES contract, and many energy management opportunities still exist. However, there are several barriers to further gains:

- Relatively low priority is being given to energy efficiency improvement because utility expenditures compose a very small percentage of the Division's overall budget.
- Lack of incentives for key personnel to pursue energy conservation. U.S. Postal Headquarters has no incentive programs (e.g., cash awards, recognition certificates, etc.) to recognize employees whose suggestions or actions result in energy and cost savings. The Divisions also do not have any such programs.
- Inadequate support staff to implement energy conservation and preventive maintenance programs for facility and building systems and equipment (HVAC, lighting, etc.).

CASE STUDY 4: FORT BELVOIR ARMY BASE, VA

The Fort Belvoir Army Base consists of 3,000 buildings including housing, a hospital, research and development facilities, administrative facilities, a commissary, cafeterias, warehouses, and hangers. The Base includes a total area of approximately 10 million square feet of buildings. It houses about 2,300 families and has a total daytime population of 16,000.

Current Energy Use

The total annual energy expenditures for the Base are about $14 million. Although a variety of energy sources are used at the Base, electricity and natural gas are most commonly used. Electricity is used for lighting and comfort conditioning. It is also used by computers, security devices, and other electrically driven equipment. Natural gas is used for space heating, cooking, and service water heating.

Energy consumption and cost data for the Base for fiscal years 1980-90 is shown in figure 5-3. Note, energy use at the Base has increased somewhat since 1987 because of factors as described below.

Factors Affecting Energy Use

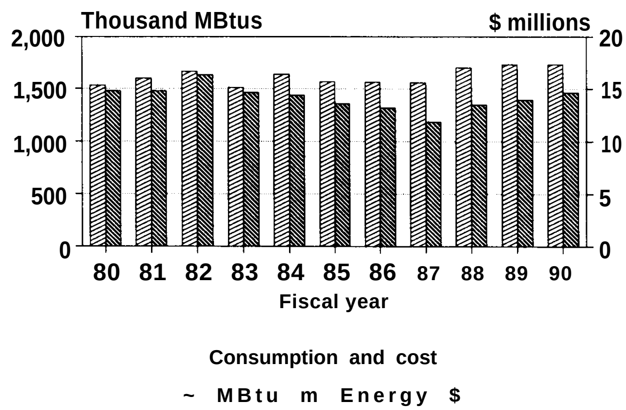
Although the Base has implemented some energy conservation measures, new situations have emerged and resulted in increased energy consumption for comfort conditioning, lighting, and computer equipment. These situations are as follows:

- More building space is being added to the Base. For example, a 230,000-square-foot Army intelligence headquarters recently was built. Additional building space is being planned such as a 3-million-square-foot engineering proving grounds, a 200,000-square-foot industrial park, a 120,000-square-foot commissary, and an 80,000-square-foot warehouse.
- Daytime population at the Base is projected to rise from 16,000 to 30,000 by the year 2000. This includes a large amount of new housing.
- More computer equipment is being used in computer rooms and offices.

Energy Conservation Efforts to Date

The Base has had a formal energy program since 1977 which has implemented many no cost/low cost energy conservation measures. Some significant

Figure 5-3-Fort Belvoir Energy Consumption and Cost, Fiscal Years 1980-90



NOTE: Site accounting used for electricity (1 kWh -3,412 Btus).
SOURCE: EMR, "Case Study of Federal Building Energy Use," contractor report prepared for OTA, December 1990.

cost measures have also been performed, such as the acquisition of an energy management system. Several capital-intensive measures are currently being studied by the U.S. Army Corps of Engineers, Baltimore District, for selected buildings. Table 5-8 lists those measures which have been partially or fully implemented to date.

Energy Conservation Potential

A significant number of no cost/low cost energy conservation measures have been implemented at the Base. However, they have not been the result of any detailed energy audit of the Base or a comprehensive energy management plan. A study of selected capital-intensive energy conservation measures for specific buildings was underway at the time of this site visit.

Most measures have been implemented on a selected basis. Because of inadequate in-house operation and maintenance staff, many low cost measures have yet to be implemented or need to be repeated.

Maintenance of mechanical systems currently is performed by an outside contractor. However, according to management personnel at the Base, ''There is inadequate monitoring of the contractor's performance, and there are not enough incentives for the contractor to do a good job. The contractor basically keeps the systems running, but has no concern for fine-tuning them to conserve energy. '

Management personnel at the Base estimate that an additional 20-percent reduction in energy use can be achieved if the following measures are implemented:

- Replace existing ballasts and lamps with higher efficiency electronic ballasts and T-8 32-watt lamps.
- Replace existing energy management system with new system employing direct digital controls. Include optimizing functions on all air handling units and chillers.
- Convert constant air volume systems to variable air volume systems.
- Use adjustable speed drives for variable fan speed control.
- Replace all motors with energy efficient motors.
- Install economizer cycle controls on all air handling units with outdoor air intakes.
- Trim chilled water pump impellers to match load.
- Balance chilled water and air distribution systems.
- Rehabilitate steam plant and eliminate all steam leaks.
- Calibrate all control systems. A well-planned program of control adjustment and calibration should be an important part of any energy management program. It will save energy and money, while also improving comfort conditions.
- Improve maintenance on all HVAC equipment to keep it at peak efficiency.
- Install automated demand limiting controls.

Barriers to Energy Conservation

Despite the past energy conservation efforts at the Base, many barriers still must be overcome in order to achieve further energy and cost savings. These are as follows:

- Lack of staff to develop recommendations for energy conservation retrofits and supportive documentation. According to the Base management personnel, "We have never experienced problems getting funding providing that we have full supportive documentation. However, our staff is so limited that developing ideas and implementing them is a big problem. "

Table 5-8-Measures Partially or Fully Implemented to Date at Fort Belvoir

Increase efficiency of heating, ventilating, and air-conditioning systems

Maintain systems for efficiency:

Adjusted air dampers for tight closing.
Adjust fuel-air ratings.
Clean combustion surfaces and strainer screens in pumping systems.
Corrected improper automatic control operation.
Maintained cooling equipment.
Repaired insulation on economizers, condensate receiver tanks, boilers, furnaces, etc.
Repaired leaks: chilled water, condenser water, conditioned air, etc.
Sealed all air leaks into combustion chamber.
Used proper water treatment to reduce fouling of heat transfer surfaces in boilers, heat exchangers, etc.

Operate systems efficiently:

Eliminate or reduce use of HVAC systems which require simultaneous heating and cooling.
Increase indoor temperature and relative humidity levels during cooling season as practical.
Keep air movement in and out of radiators and connectors unrestricted.
Locked thermostats to prevent resetting by unauthorized personnel.
Optimize ventilation startup times.
Reduce cooling in over-cooled spaces.
Reduce fan speed.
Reduce ventilation rates during unoccupied hours to a minimum in noncritical areas.
Turn off cooling system during unoccupied hours in noncritical areas.
Turn off or eliminated all portable electric heaters when not needed.
Use the minimum number of boilers.
Use outdoor air for economizer cooling.
Use spot cooling of people when they were located far apart.

Upgraded equipment to allow efficient operation:

Added automatic draft damper control to reduce heat loss through breaching when the gas or oil burner is not in operation.
Added controls to setback temperatures during unoccupied periods in noncritical areas.
Installed economizer cycle.
Installed automatic ventilation controls.
Installed time clocks on self-contained cooling units for automatic shutoff.
Installed valves and dampers to permit shutoff of heating in unoccupied areas where there is no danger of freezing.
Installed warmup cycle controls on air handling units with outside air intake as applicable.
Installed vestibules and/or revolving doors to reduce infiltration.
Converted constant-volume fan system to variable air Volume.[b]
Replaced inefficient window air conditioners.[b]
Isolated off-line boilers.[b]
Installed central supervisory control system.[b]
Installed automatic temperature control valves in radiators controlled by hand valves.[b]
Insulated steam lines, above and below ground.[b]
Insulated chilled water piping and duct work carrying conditioned air through unconditioned spaces.

Improve the building envelope

Added additional insulation to roofs, ceilings and floors over unconditioned areas.[b]
Added additional insulation to walls.[b]
Caulked and weatherstripped windows and door frames.
Installed loading dock door seals.
Lowered indoor temperature and relative humidity.
Reglazed ail glass with double glazing.[b]
Reduced solar heat gain.
Repair cracks and openings in exterior surfaces.
Replace broken windows.
Used opaque or translucent insulating materials to block off and thermally seal unused windows.
Used infra-red television camera to determine where heat losses are occurring from buildings and underground distribution piping.[b]

Improve lighting efficiency

Reduce uneeded illumination:

Added switching and timers to turn off lights when not needed.
Moved desks and other work surfaces to a position and orientation that used installed luminaires to their greatest advantage.
Relocated luminaires to provide light on task areas.
Removed unnecessary lamps when those remaining can provide desired illumination.
Use daylighting for illumination in perimeter areas as practical.
Use light colors for walls, floors and ceilings to increase reflectance but avoid specular reflections.

Increase efficiency of lamps, ballasts and fixtures:

Added photocell or time controls to operate outdoor lighting.
Used higher efficiency lamps and ballasts.
Clean lamps, luminaires and interior surfaces.

Miscellaneous

Boost hot water temperature locally.
Improved maintenance of motors.
Installed and maintained insulation on all hot water pipes, fittings and valves passing through unconditioned spaces.
Installed efficient nozzles and faucets and orifices in hot water pipes to reduce flow.
Recover heat from kitchen waste for water heating.
Replaced gas pilots with electric ignition device.
Use demand limiting equipment (e.g., on electric water heaters) during periods of peak electrical demand.
Turn off electrical appliances and machinery not being used.

[a]Unless otherwise noted, all measures are considered by facility personnel to be low cost or no cost.
[b]Significant cost measure as identified by facility personnel.

SOURCE: Adapted from Enviro-Management & Research, "Case Study of Federal Building Energy Use," contractor report prepared for the Office of Technology Assessment, December 1990.

- Lack of internal incentives to conserve energy, both for operating personnel and the Base as a whole. According to facility personnel, ''In the early 1980s, an incentive program was in place whereby the installation that saved the most energy in one year received a proportion of the energy cost savings, which sometimes amounted to as much a $1.5 million." This program was abandoned in 1985.
- Lack of an energy management plan, direction, and guidance from top management. Because operating staff is so limited and the Base is so large, facility personnel need guidance from top management and professional engineering staff to develop and implement cost-effective energy conservation projects.
- Lack of proper maintenance of HVAC systems and equipment. A properly planned and executed program of equipment maintenance can contribute significantly to reduced waste. Equipment which is correctly and regularly serviced and maintained will last longer and will operate more efficiently, thereby requiring relatively less energy than equipment which is ignored. For example, a scale build-up of l/32-inch on condenser tubes can reduce the efficiency of a chiller by 25 percent, while also cutting down on the effective life of the unit.
- Inadequate contractor incentives based on performance of maintenance on mechanical systems. Under the current contract, the maintenance contractor is provided no incentives such as cash awards for fine-tuning equipment and controls and saving energy. Its main responsibility is just to keep the systems running.
- Shortage of field personnel to inspect equipment and systems and contractor performance. Currently, there is only one quality assurance inspector who performs random inspections and evaluations of contractor performance. More inspectors are needed.

CASE STUDY 5: GSA-LEASED OFFICE BUILDING, WASHINGTON, DC

This privately owned office building is leased by the General Services Administration and occupied by several Federal agencies. Built over two decades ago, the building consists of 88,933 square feet and houses about 750 to 800 daytime employees on weekdays.

Current Energy Use

Several energy sources are used at this GSA-leased building. Electricity is primarily used for space cooling, ventilation, lighting, cooking, and other electrically driven equipment and machinery. Natural gas is used for space and service water heating purposes. Utility bills are paid by the building owner.

According to the building manager, "Overall energy use at the building has slowly increased in recent years, due primarily to increased occupancy and increased use of personal computers. " This trend could not be verified because building energy consumption and cost data were not provided by the building owner.

Factors Affecting Energy Use

Although the building has implemented a range of energy conservation measures, the following new situations have resulted in increased energy consumption:

- Personal computers are being used increasingly in the building.
- Occupancy levels have increased approximately 25 percent in recent years.
- New mechanical and electrical equipment has been added to the building to support increased occupancy levels.

Energy Conservation Efforts to Date

Many no cost/low cost measures have been implemented at this building since 1985. Some of these improvements have involved significant cost options such as lighting fixture retrofit. Several capital-intensive measures are currently being studied. Table 5-9 lists those measures which have been partially or fully implemented to date.

Energy Conservation Potential

Because the building has implemented mostly no cost/low cost measures, a significant potential for further energy conservation still exists. Operating personnel estimate that up to a 20-percent reduction in energy use can be achieved if the following measures are implemented:

- Use more efficient ballasts.
- Reduce quantity of service hot water used.

Table 5-9-Energy Conservation Measures Implemented at GSA Leased Building[a]

Increase efficiency of heating, ventilating, and air-conditioning systems

Maintain systems for efficiency:

Adjusted all pumps to control leakage at pump packing glands.
Adjusted outdoor air dampers for tight closure.
Adjust fuel-air ratio and clean filters and combustion surfaces.
Checked flues and chimney for blockages or improper draft conditions.
Clean strainer screens in pumping stations.
Corrected improper automatic control operation and recalibrated controls.
Keep maintenance and operating log of all heating equipment.
Maintain all cooling equipment.
Repaired insulation on economizers, condensate receiver tanks, boilers, furnaces, etc.
Repaired leaks in water, steam, air, fuel distribution system.
Repaired faulty steam traps, valves, dampers, etc.
Sealed air leaks into combustion chamber.
Use proper water treatment to reduce fouling of heat transfer surfaces in boilers, chillers, heat exchangers.

Operate systems efficient/y:

Do not cool lobbies, passageways and storage areas to same degree as work areas.
Eliminate or reduce use of HVAC systems which require simultaneous heating and cooling.
Increase indoor temperature and relative humidity during cooling season as practical.
Keep air movement in and out of radiators and connectors unrestricted.
lower temperature and humidity as practical in heating season.
lacked thermostats to prevent resetting by unauthorized personnel.
Operate heating water and chilled water pumps and cooling tower fans only as necessary.
Operate condenser water system at lower temperature.
Optimize ventilation startup times.
Rebalanced chilled water and air distribution systems.
Reduce ventilation rates during unoccupied hours as practical.
Reduce heating/cooling in over-heated/-cooled spaces.
Turn off cooling system and portable electric heaters during unoccupied hours in noncritical areas.
Use lowest possible radiation temperature in perimeter spaces.
Use the minimum number of boilers and chillers.
Use outdoor air for economizer cooling.
Vary temperature of supply air, chilled water, and heating water and pressure of steam in accordance with load.

Upgraded equipment to allow efficient operation:

Added controls to set back temperatures during unoccupied periods in noncritical areas.
Connected ventilation fans in toilet rooms to light circuit.
Converted constant-volume fan system to variable air volume.
Installed warmup cycle controls on air handling units with outside air intake as applicable.
Installed economizer cycle.
Installed automatic ventilation controls.
installed valves and dampers to permit shutoff of heating in unoccupied areas where there is no danger of freezing.
Installed automatic temperature control valves in radiators controlled by hand valves.
Installed and maintain insulation on all hot water pipes, fittings and valves passing through unconditioned spaces.
Installed central supervisory control system.
Insulated all duct work carrying conditioned air through unconditioned spaces.
Insulated chilled water piping and ductwork located in unconditioned spaces.
Insulated all steam lines.[b]
Isolated off-line chillers and boilers.[b]
Recovered heat from condenser water system.[b]
Reduced air flow rates to minimally satisfactory levels.[b]
Replaced existing boilers which are not at or near the end of their useful life with modular boilers.[b]
Used low resistance filters, registers and grilles to reduce horsepower required for air movement.[b]

Improve the building envelope

Add additional insulation to roofs, ceilings and floors over unconditioned areas.[b]
Caulked all windows and door frames.
Established rules for building personnel to keep doors and windows closed when possible when heating system is operating.
Installed automatic door closers on all exterior doors.
Repaired cracks and openings in exterior surfaces.
Replace broken windows.

Improve lighting efficiency

Reduce uneeded illumination:

Added photocell or time controls to operate outdoor lighting.
Added manual switches and timers to turn off lights when not needed.
Reduced illumination to levels consistent with productivity, safety and security considerations.
Removed unnecessary lamps when those remaining can provide desired illumination.
Revise cleaning schedule so lights can be turned off earlier.
Use daylighting for illumination in perimeter areas as practical.
Use light colors for walls, floors and ceilings to increase reflectance but avoid specular reflections.

Increase efficiency of lamps, ballasts and fixtures:

Clean lamps, luminaires and interior surfaces.
Used higher efficiency lamps.[b]

Miscellaneous

Avoid using electric water heater during periods of peak electrical demand.
Balanced water flows to minimally satisfactory levels.[b]
Examined elevator usage; shut down excess capacity.
Installed demand limiting equipment.[b]

[a] Unless otherwise noted, all measures are considered by facility personnel to be low cost or no cost.
[b] Significant cost measure as identified by facility personnel.

SOURCE: Adapted from Enviro-Management & Research, "Case Study of Federal Building Energy Use," contractor report prepared for the Office of Technology Assessment, December 1990.

- Reduce service water heating, generating, and storage temperature levels to the minimum required.
- De-energize hot water circulating pumps when the building is unoccupied.
- Install occupancy sensors, timers, and switches to control lighting.
- Optimize HVAC system controls.
- Use booster heaters for food service. Instead of maintaining the central service water heating temperature at a higher level to satisfy the needs of the food service facility, reduce the temperature of the central systems and add a booster heater at the food service area to elevate water temperature locally.
- Convert constant air volume air handling systems to variable air volume systems.

Barriers to Energy Conservation

Building operating personnel perceive no barriers to their energy conservation efforts. According to the building manager, "The building owner is committed to energy conservation and closely examines energy consumption on a regular basis. Adequate staff is available to keep systems and equipment operating effectively. Furthermore, funding for energy conservation retrofits, training and continuing education is available provided that requests are properly supported with technical documentation and analysis of cost/benefits. ' However, energy conservation efforts at the facility are largely dependent upon recognition of opportunities by building management and operating personnel. Because further potential for energy conservation still exists at the facility, future energy conservation efforts will depend upon the implementation schedule established by the building manager.

The building is monitored by GSA leasing inspectors who, for the most part, are not engineers. Thus, they cannot offer suggestions and guidance to building operating and maintenance personnel with regards to energy efficiency improvements. At one time, GSA provided a 30-month training program for leasing inspectors, but it was discontinued several years ago.

According to a GSA manager overseeing leasing operations at this building, ''Most of the knowledgeable operating staff that GSA had at one time has been hired by private industry. This is because the industry pays them higher salaries and provides better benefits. Current building lease inspectors at GSA are GS-9s, a pay level substantially lower than a person performing the same duties in private industry. This has substantially curbed GSA's efforts to properly monitor leased buildings and to provide suggestions for cost-effective energy improvements.'

CASE STUDY 6: RICHMOND REDEVELOPMENT AND HOUSING AUTHORITY, RICHMOND, VA

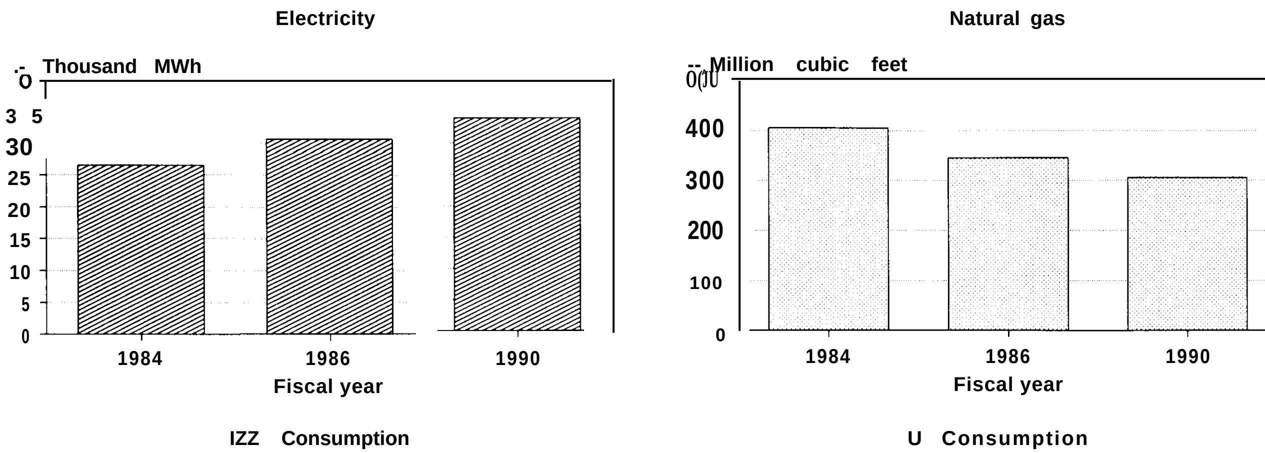
The Richmond Redevelopment and Housing Authority (RRHA) manages 4,500 housing units in 20 different projects. A total of 16,000 residents live in the various projects, many of which were constructed almost half a century ago. All facilities are heated. Only high-rise facilities housing the elderly are provided with air conditioning, using central chilled water systems. Occupants can install their own window air-conditioning units, but they have to pay a monthly usage charge to the Authority.

Current Energy Use

Utility expenses (including water and sewer) constitute 40 percent (approximately $5 million) of the Authority's budget. Several types of energy sources are used at various facilities managed by the Authority. Electricity is used for Lighting and electrical equipment in all projects. It also is used in certain projects for electric space and service water heating. In the majority of the projects (4,100 units or 91 percent), natural gas is used for space and service water heating purposes.

Annual energy consumption for all projects at the Authority for selected years is shown in figure 5-4. Although electricity use has increased by about 28 percent since 1984, gas use has decreased by about 25 percent. Despite implementation of various energy conservation measures, electricity use has increased due primarily to increased use of window air-conditioning units by tenants. On the other hand, gas use has declined because of implementation of certain energy efficiency improvements, as well as close monitoring and control by a central EMCS at various projects.

Figure 5-4-Richmond RHA Annual Energy Consumption for Selected Years



SOURCE: EMR, "Case Study of Federal Building Energy Use," contractor report prepared for OTA, December 1990.

Factors Affecting Energy Use

Although the Authority has implemented a range of energy conservation measures, the following new situations have resulted in increased energy consumption for building systems:

- Use of air-conditioning window units by tenants has increased in multifamily projects.
- Authority lacks control over how the tenant uses energy. The Authority does provide guidance to tenants on how to use energy efficiently. However, it has no control over tenants' energy habits (e.g., tenants leaving windows open while HVAC equipment is running or tampering with thermostat set points).

Energy Conservation Efforts to Date

A few energy conservation measures were implemented at various projects as early as 1982. However, most of the energy conservation measures that have been implemented to date were initiated in 1985 when a new general engineer at the Housing and Urban Development (HUD) Richmond field office was assigned responsibility for RRHA. He took personal interest in energy conservation and sought top management commitment in reducing energy consumption and implementing energy conservation measures. His achievements to date include obtaining funding for new computers for use by the Authority to provide more accurate building energy use data and information, and initiating and obtaining funding for a variety of energy conservation projects at the Authority.

A central EMCS has recently been added to monitor and control heating and selected cooling systems in four family projects. RRHA's experience with its EMCS has been very productive. RRHA developed in-house EMCS expertise with an enthusiastic and highly competent staff, leading to innovative use of their system. In addition to providing considerable energy savings, the EMCS' remote monitoring capabilities have helped reduce maintenance service calls.

Many energy conservation measures have been implemented in some, but not all, projects. Several capital-intensive measures are currently being studied. Table 5-10 lists those measures which have been implemented to date at various projects. Implementation of these measures has yielded savings of approximately half a million dollars annually.

Energy Conservation Potential

A significant potential for further energy conservation still exists. According to the engineers at HUD and the Authority, "We have already reduced energy consumption due to various energy conservation actions that we have taken to date. Our ultimate goal is to reduce energy consumption to 55,000 Btu/ft^2, a reduction of over 50 percent.'

Table 5-10-Energy Conservation Measures Implemented to Date at Richmond Redevelopment Housing Authority

Replaced doors with steel thermally insulated doors.
Installed insulation in walls.
Installed foam insulation in brick and block units.
Replaced old boilers with high-efficiency condensing boilers having digital controls.
Weatherstripped and caulked all windows and doors.
Replaced all plumbing fixtures with water savings devices.
Installed fluorescent lighting and solid-state ballasts where necessary.
Performed annual preventive maintenance on all heating units.
Performed annual preventive maintenance on all plumbing fixtures.
Added thermostatic controls on the radiators to vary circulating water temperature.
Added central energy monitoring system at four projects to control heating and cooling systems.

SOURCE: EMR, "Case Study of Federal Building Energy Use," contractor report prepared for the Office of Technology Assessment, December 1990.

The Authority intends to achieve further energy reductions by continuing to implement energy conservation measures such as the following:

- Adding insulation to walls in high-rise buildings.
- Installing automatic lighting on/off controls. As example, when automatic lighting controls were installed in a high-rise facility, a 78-percent lighting energy savings was experienced in the facility and payback was in less than a year.
- Installing motion detectors connected to electric baseboard heaters. As example, when the person walks into the room, the heater comes on to maintain 72 'F. When a person walks out of the room, the heater controls set back to 68 OF.
- Expanding the central EMCS (which currently controls 4 of the 20 projects) to monitor and control heating and cooling systems at all projects.

Barriers to Energy Conservation

The following are barriers to energy conservation:

- The 3-year rolling base existing under the Performance Funding System has prevented full implementation of many energy conservation measures. This program was set up by HUD and enacted by Congress. Under this program, HUD provides individual authorities with funding for approved energy conservation projects. Both HUD and the Authority equally share in the savings derived from the implementation of energy conservation measures. At the end of 36 months, the Authority does not receive any share of further savings. Furthermore, the Authority must pay a penalty to HUD if it exceeds the newly established energy consumption levels.
- Lack of incentives for authorities to implement energy conservation programs. In many cases, savings cannot be applied to the facility because of allowable expense level requirements. For example, higher efficiency heating systems are more sophisticated and require more maintenance. Although they result in considerable savings, no allowance is provided for expenses associated with additional maintenance.