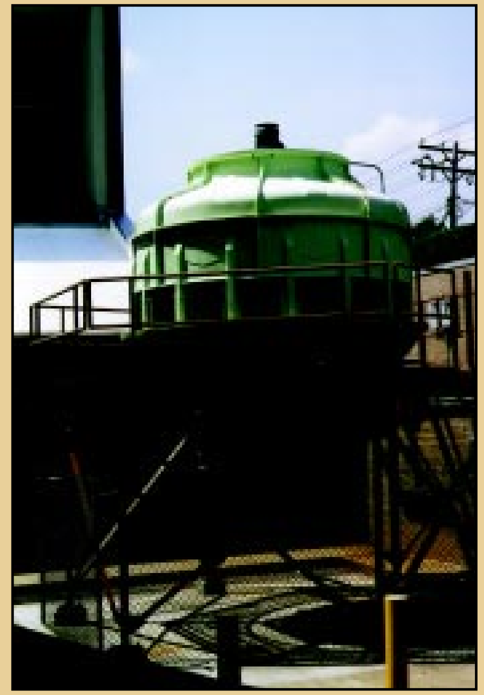


Excellence in Facility Management

Five Federal Case Studies

National Institute of
BUILDING SCIENCES

Excellence in Facility Management

Five Federal Case Studies

National Institute of
BUILDING SCIENCES

Prepared under the auspices of

The Facility Maintenance and Operations Committee (FMOC)

The National Institute of Building Sciences (NIBS) is a non-governmental, non-profit organization, authorized by Congress to encourage a more rational building regulatory environment and to accelerate the introduction of existing and new technology into the building process.

This document was prepared under Department of Defense Contract Number DASW01-96-D-0040, and may not be reprinted or quoted extensively without the permission of DOD and the National Institute of Building Sciences; however, this permission is not required for agencies of the United States Government.

Individual copies or bulk rate orders of this report are available from the National Institute of Building Sciences. For pricing information contact:

The National Institute of Building Sciences
1090 Vermont Avenue, N.W., Suite 700
Washington, D.C. 20005-4904
202/289-7800 FAX 202/289-1092
e-mail nibs@nibs.org

This report can also be ordered using Visa or Master Card by calling NIBS at (202) 289-7800 with the following information: the card account number, the expiration date, the name as it appears on the card, and the dollar amount of the order.

This document may be viewed on the NIBS Construction Criteria Base and the NIBS website *www.nibs.org/fmoc.htm.*

Copyright. 1998 by the National Institute of Building Sciences

All rights reserved. Copying all or portions of this document for resale or redistribution is strictly prohibited. No part of this document may be reproduced by any mechanical, photographic, or electronic process, or in the form of a phonographic or tape recording nor may it be stored in a retrieval system, transmitted, or otherwise copied for public or private use, without written permission from the National Institute of Building Sciences.

NIBS Document Number -5350-1

ACKNOWLEDGMENTS

The National Institute of Building Sciences wishes to express its appreciation to the Office of the Secretary of Defense which supported the development of this document through the Facility Maintenance and Operations Committee and to its chairman, William Brodt, of the National Institutes of Health.

NIBS would like to thank the dedicated professionals who provided background information and assistance in understanding the accomplishments which make these five facilities models of excellence: Edward B. Murtagh, P.E., John G. Carothers, Jr., Marvin C. Hansen, Bob Bausch, Tony Ippolito, John S. Best, Master Chief Kevin Evans, Amita Poole, P.E., David Angier, and Tom Reemelin.

NIBS would also like to give our appreciation to Thomas R. Rutherford, P.E., who served as DoD's technical representative and through his direction and counsel provided the leadership for this project.

Lastly, NIBS wishes to express its appreciation for the excellent professional services provided by its contractor, Parsons Brinckerhoff Energy Services; Ronald V. Descheneaux and Charles R. Cochran, in the development of this document working closely with the NIBS project manager, Alexander Shaw.

TABLE OF CONTENTS

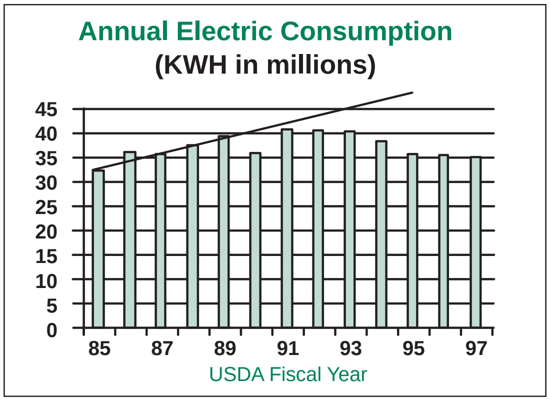
Executive Summary

The five buildings described in this document prove conclusively that life cycle planning pays dividends; dividends in dollars, in energy utilization, in environmental sensitivity, and in occupant comfort and productivity. No matter where the starting point, we found that :

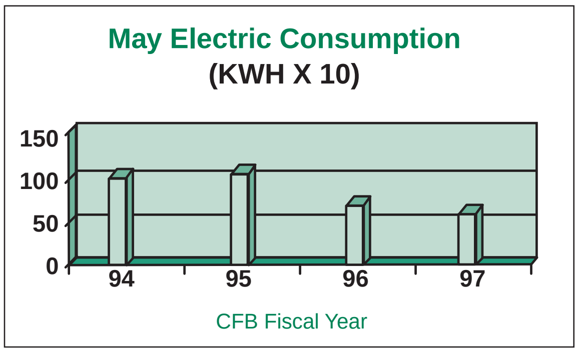
- There are great opportunities for improvement in facilities of all ages and conditions.
- A life-cycle plan allows priority setting and accomplishment of multiple objectives.
- Working smart means learning from the mistakes of others and sharing your successes.
- Dedicated, caring professionals succeed because they believe in constant improvement.

After screening over twenty-five sites, all worthy of consideration for this study, we selected five facilities which covered the broadest possible gamut of size, age, mission, climate region, and complexity. Two of the facilities are brand new, one is over a hundred years old. Two buildings contain approximately 40 thousand square feet, another over two million. One had not been well maintained; two others had old mechanical equipment. Several house typical office functions while the primary mission of another is maintaining uninterrupted operation of antenna and computer equipment. Site locations ranged from the Pacific Northwest, to the Midwest, to Florida, and the East Coast. One building is on the national historic register. Another building is the late seventies architectural embodiment of a once-but-no-longer, state-of-the-art solar system. Another is almost nondescript.

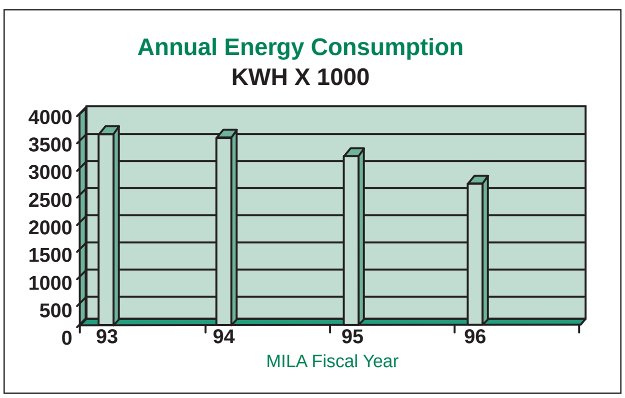
The type of opportunity varied by facility but in all cases the creation of a comprehensive plan enabled the facility management to capitalize on existing opportunity.



Our baseline case study (Headquarters of the U.S. Department of Agriculture) was a situation of long term deferred maintenance, a building in very bad shape. A carefully developed and vigorously implemented plan led to an impressive list of discreet upgrade projects all of which offered favorable payback rates.

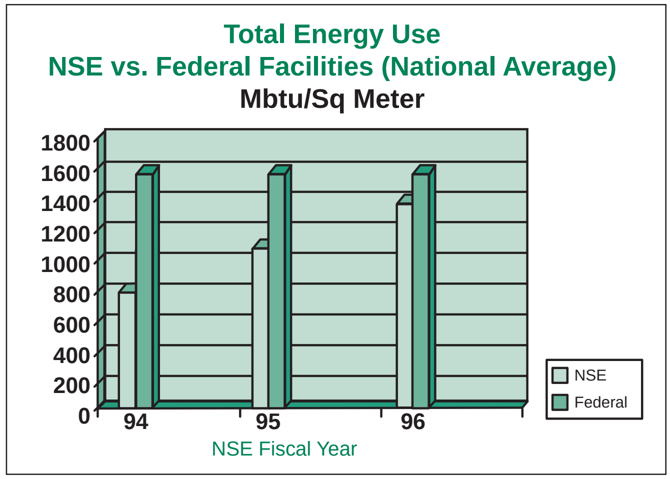


A small office building (Carbondale Federal Building) in Illinois is a case study proving that change is constant and all technology must be reevaluated periodically. Analysis revealed that replacing the exotic technologies which had been designed into the original facility with modern, conventional equipment, would generate significant savings from the first day they were installed.

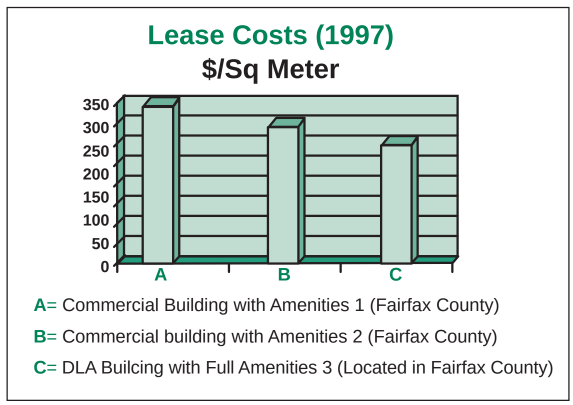


Another small facility (at Kennedy Space Center) with a critical, high-tech space mission, determined that a comprehensive, proactive maintenance program would prevent them from getting into trouble; not only guaranteeing mission accomplishment but also saving money annually over the life cycle of the building.

A new installation (Naval Station Everett) in Washington state is the most complex case study; where an initial commitment to excellence and constant improvement was backed up by planning, audits, evaluation, and the dogged human communication effort required to succeed.



The final case study (Defense Logistics Agency Headquarters) is a brand new building where careful planning, design, and use of the latest equipment and computer management systems have produced a handsome, functional, highly productive facility where rents are 35 per cent below the norm.



The similarities in approach among these five diverse facilities are perhaps most instructive. They demonstrate that a comprehensive long term plan is a very powerful tool. Taking the full life cycle view enables facility managers to understand their most important priorities. A comprehensive plan allows them to design projects that accomplish multiple objectives simultaneously. A plan also helps them to capture the most economically opportune window for implementing needed change.

Lastly, we observed that the continued existence of communication structures necessary to develop and implement long term operations and maintenance plans also improves the overall productivity of the organizations involved.

The specific details of the case studies vary, but together they offer a single message. Today's action is most effective when the decision to take it, is made in the broadest possible context - over the entire life cycle of the building.

INTRODUCTION

This document was conceived and produced to demonstrate the validity of a very simple idea: “Better buildings improve the productivity of the people who work in them.” But in the course of studying the remarkable buildings described here, we found even more than we expected about what constitutes “better” buildings. They are made possible by planning, designing, constructing and operating them with an emphasis on what they will cost over their entire life cycle, including costs for energy, cleaning, maintenance and repair. But when this larger view of life cycle cost is applied, the result is not only less expensive buildings, but better buildings: places where the occupants are productive and focused on their work; places where work gets done as effectively as possible, so that more work is possible; places that use their equipment, systems, and resources economically. We found that of all the necessary materials and procedures for creating better buildings, the most important ingredient is the commitment of the people involved. The five facilities described in this brochure were selected precisely because they are successfully using these principles today. And as you will see, they are producing astounding results.

The buildings in this document are federal facilities, in part because the need for improvements in the federal sector is so pressing, and because improvements there can be effective examples for the private sector. The federal government is responsible for a vast array of facilities throughout the U.S., its possessions and territories. The stewardship of these assets is an awesome responsibility. The Department of Defense alone owns some 400,000 buildings, comprising 222.96 million square meters of space. The current renovation of the Pentagon alone will cost over a billion dollars. The opportunities for improvement are clearly of great significance not only to the people who work in federal facilities, but to the taxpayers as well.

This document was also created in the context of the National Construction Goals, formulated by the Construction and Building Subcommittee of the President’s Science and Technology Council. The subcommittee report calls for 50 percent reductions: in delivery time of buildings; operations, maintenance, and energy costs; waste and pollution; and job related illnesses and accidents. It also calls for 30 percent improvements in productivity and occupant comfort. This last goal is a major focus of this brochure.

A simple calculation of a typical DOD office space reveals the enormous significance of productivity gains. The first cost for a typical office unit of 9.29 square meters (sm) costing $2,153/sm to build is $20,000. The annual operating cost for that office is $21.53/sm, or $200 per occupant. The occupant of the space, on the other hand, costs about $60,000 per year. In the first year the person costs three times more than the building, but extended over a typical forty year building life, the occupant accounts for more than 95 percent of total costs. Another way of stating this conclusion is that productivity improvements in the range of four percent can pay for all building costs. In other words, "Take good care of your people and the building is free!"

But quantifying this very real effect has been difficult, even for the facilities in this document, where the effects are felt every day. Recent research indicates that significant, measurable improvements in productivity are possible. An analysis by the Advanced Building Systems Integration Consortium at Carnegie Mellon University showed expected productivity gains in the range of 5 to 35 percent. The source of these gains came from providing work environments with privacy, the ability to concentrate (no distractions), ergonomic furniture, access to windows, and control of lighting, heat, and cooling. Subsequent to the Carnegie Mellon effort, a literature search by the Army's Construction Engineering Research Laboratory (CERL) found 45 cases in which some, but not all of these improvements had been implemented. Demonstrated productivity gains from the improvements in the 45 cases, did in fact, range from 5 to 35 percent.

The five case studies in this document were selected from candidate facilities around the country nominated by various federal agencies. These facilities were selected to provide models of excellence in energy and life-cycle facility management and to represent the widest possible range of size and facility type, climate, and benefit.

Before selecting each facility, we made certain that we had an on-site contact person who could provide real data and also communicate the intangibles of why some things worked and why others did not. Their names and telephone numbers are listed in the brochure so that readers can verify our descriptions or pursue follow-up questions.

In reading these five case studies you will find many and varied engineering and scientific successes; but the bottom-line of the entire document is the people involved. Our team left each site visit profoundly impressed by the diligence, determination, and professionalism of the people we had just interviewed. These facilities are models of success because the people running them care about their jobs and firmly believe there is always room for continued improvement.

We heard stories of major plumbing problems discovered only because the manager took the initiative to come in on weekends to find out what was really happening in his building. One building engineer spent Friday nights in the facility 35 miles from home, because recurrence of vandalism was expected. A maintenance contractor voluntarily initiated ISO 9000 certification even though the company was already getting very high marks for successful performance. One of our hosts chose to forgo a much anticipated training seminar in order to be certain he was completely prepared for our visit. And finally, there is the story of a BRAC (Base Realignment and Closure) team that refused to fail. After abandoning several prior move strategies and being denied a schedule extension from Congress, they realized that the initial, vertical construction plan seriously delayed the start of occupancy. The team came to the simple conclusion that they should build their new facility horizontally; occupying one end, a section at a time, as construction continued toward the other end.

These five facilities are successful because the people involved borrowed good ideas from colleagues and were smart enough to know when they needed help. We hope that this document serves to share their success and their wisdom with a much larger audience.

III U.S. Department of Agriculture Headquarters: *From Rags to ....*

Beautiful, old, and historically significant, the USDA buildings provide special challenges to facility managers.

- After long-deferred maintenance, this facility was experiencing serious malfunctions.
- USDA implemented a comprehensive Energy Management Program.
- Condition Survey completed, they embarked on a plan to correct deficiencies in HVAC and steam systems.
- Implemented multi-phase historic restoration program.
- Installed water sub-meters.
- Used life-cycle cost analysis to institute water management program.

Maybe it's not quite Riches yet, but today the story of the USDA Headquarters Complex is a definite success story.

As a result of long-deferred maintenance this facility was experiencing serious malfunctions. To further complicate the situation, some simple solutions toward energy reduction were not available because the facility had been designated as an historic site. The age of the buildings and associated mechanical/electrical systems, in combination with years of deferred maintenance, had taken a great toll. Building facades were in poor condition; the steam system was hemorrhaging vast quantities of energy; automatic temperature controls were frequently inoperative; hallway lights stayed on all night. Throughout the facility, oversized HVAC systems and pumps were being used, as failed equipment had been replaced with whatever size was available. Huge quantities of city water were being wasted. Over the years, water-cooled air conditioning units had been tied directly into the city water system. Stuck solenoid valves in cafeteria-kitchen steamers, frozen open by high levels of calcium in DC water, were dumping hot water. As a result, huge quantities of city water were being wasted

Many of the problems discovered at USDA were found by a very vigilant facilities maintenance (FM) staff whose members would walk the floors on nights and weekends. Their discoveries were not evident during the normal course of operation. They found inoperative light sensors, maladjusted time clocks, ventilation systems running constantly, and hot water running down the drain in the cafeteria. Their own initiative and caring attitude caused them to "go the extra mile" for the betterment of their facility.

Energy wasteful tricks were required to keep ancient systems operating. Because faulty controls would continually shut down the chilled water plant during low winter loads, the FM staff had learned to create "false loads" by operating the heating and cooling coils simultaneously in the air handlers. Oversized preheat coils in ventilation air handlers created temperature stratification which caused the control system to continually overcompensate until freeze protection was triggered and the entire ventilation system was shut down. Again, Facility Management staff found the only solution was to completely shut outside-air dampers and draw ventilation air from attic spaces. The unfortunate consequences were 'negative' pressure within the building, terrible inefficiency, extreme infiltration through leaky windows, and numerous occupant complaints because of drafts. On the flip side, leaking steam control valves allowed steam to reach preheat coils in the ventilation air handlers. This resulted in offices being heated regardless of the need. Poor air quality and the inability to regulate local temperature caused tenant satisfaction to drop to an all-time low.

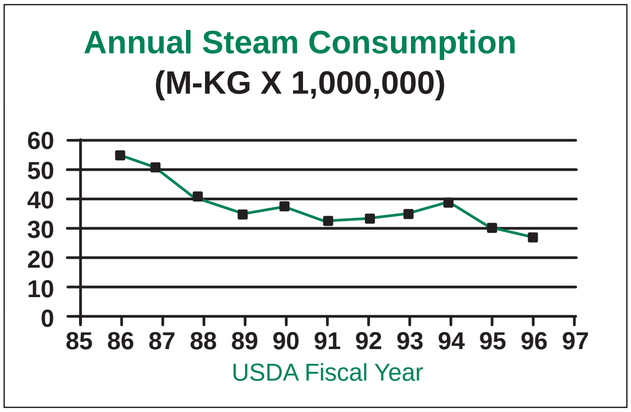
In the face of all these problems and in spite of the limitations imposed by the Historic Register designation, the USDA facility management organization began to develop and implement a comprehensive Energy Management Program that continues proactively today. The program involves a methodical assessment of existing conditions, facility-wide building tune-up, load reduction, equipment replacement, building facade restoration, and indoor air quality programs. It addresses the prudent use of energy but does not neglect the human side of the equation. The improvements made at the

USDA Headquarters Complex have shown that energy efficiency and good indoor air quality are not incompatible. Creature comfort and quality of life issues are incorporated into all major decisions.

A major segment of the Energy Management Plan was the steam heating system. Engineering professionals were hired to perform a baseline survey of the sprawling steam system and to develop a database of all steam traps. Over the years the steam system had deteriorated into a bewildering network of piping; some functional, and some not. Pipe insulation was frequently deteriorated or nonexistent; large sections of piping in remote tunnels had been left bare after asbestos-containing insulation was removed. Leaks were common. Numerous steam traps were either clogged or blowing steam. In one case, the condition survey found a 152 meters long steam main serving two small radiators; the original loads having long since been removed. In other instances it was found that stairwells and storage areas were being heated needlessly. Large steam mains were run during the cooling season only to serve small domestic hot water heaters.

Once the condition survey was completed, a plan of action was implemented to correct deficiencies in the steam and other HVAC systems. Faulty steam traps were replaced. Decommissioned piping was removed. Insulation deficiencies were corrected. Every effort was made to eliminate dumping steam condensate. In three of the USDA buildings,

The South Building- Headquarters for USDA- contains over 185,807 square meters (2,000,000 sq. ft.) of space.



electric hot water heaters were installed and the steam was turned off completely during the cooling season. Not only did this help to keep the buildings cool, but damage caused from operating the steam stations continuously, at low loads, was eliminated. All oversized steam preheat coils in ventilation air handlers were replaced with hot water coils. Air handlers were upgraded with high efficiency filters. Operating staff can once again open outdoor air dampers in the ventilation air handlers in the winter and operate the HVAC system as designed. As a result of these and other improvements, steam usage has gone down; even though the amount of outdoor air being conditioned has increased significantly. This is no small accomplishment. Because of a range of problems with steam metering devices (see sidebar) it is impossible to know exactly, but it is conservatively estimated that yearly cost avoidance ranges between 30 and 35 per cent.

Addressing HVAC temperature controls was another critical step in improving the work environment and lowering utility costs. Temperature controls for the preheat systems in all major air handlers were replaced.

Providing food for over 5,000 employees per day is a necessary operation but it is costly in energy terms.

Most office thermostats were replaced. Direct Digital Controls (DDC) were installed in many HVAC systems; with a two-fold purpose. The DDC systems not only reestablished control of the overall HVAC system, but also serves as a training tool for the operating staff. The South Building is scheduled for phased renovation over the next ten years. As each phase is completed, it will be equipped with a Building Automation System. The new DDC systems are preparing the facility maintenance staff to operate the historic USDA building with current technology rather than the 1960's technology they have been using. DDC has also enabled operating staff to reactivate many economizer systems that had been deactivated over the years. DDC control of HVAC systems is possible via telephone modem from any location.

GSA provides steam and is responsible for metering the quantity delivered to USDA. Problems have arisen with outdated, unreliable, non-functional, and improperly read meters. In the absence of accurate energy consumption data, USDA can not assess their true accomplishments, justify expenditures to superiors, or budget properly. There are also no disincentives for the extremely wasteful practice of "dumping" steam condensate. It might be extremely beneficial to all users of the steam, and to the government in general, to establish such programs.

Another element in improving the overall HVAC system was to upgrade the mechanical rooms that house HVAC equipment. Over time, these spaces have been reconfigured to improve maintainability of the mechanical equipment, old decrepit lighting has been replaced, and the rooms have been cleaned up and painted. The improved work environment has resulted in increased pride in the critical building maintenance organization. Today lights in the utility rooms are turned off and there is much less trash littering the corners.

As indicated above, the exteriors of the historic USDA Headquarters buildings were in very poor condition. Over the decades, the exterior facades had been exposed to rain, ultraviolet light, and both physical and chemical stresses. Envelope maintenance had been deferred. To make matters worse, the building frequently operated under negative pressure which caused serious air infiltration problems. Infiltration through the building envelopes resulted in unwanted drafts and imposed heavy demands on HVAC systems throughout the headquarters complex. In addition to energy impacts, air infiltration was also a source of outdoor pollutants and moisture intrusion. Moisture intrusion damaged building components, reduced insulation values, and created a breeding ground for microbial growth.

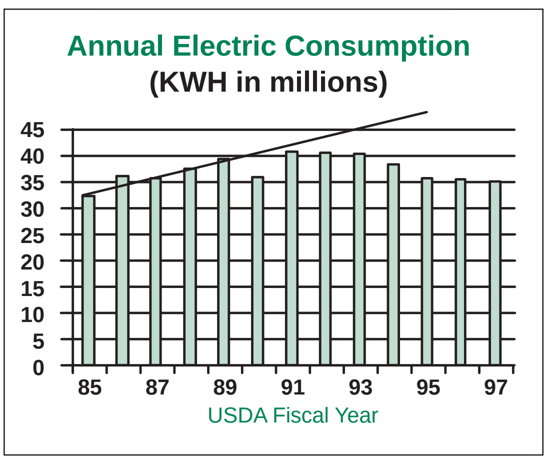
An uncorrected, nagging problem is that in order to prevent condensation from flooding interior areas around the building, induction units operate using chilled water at 15.5 degrees centigrade rather than at the design temperature of 10 degrees. This is a significant operations inefficiency but would require major capital expenditure to correct.

A multi-phase historic restoration program was implemented to address the deteriorated building exterior. The program included restoration of exterior masonry walls, restoration or replacement of exterior wood windows, and roof repairs. Because of the historic designation of the buildings, the facade could not be changed in any significant way, which eliminated the concepts of window shading, awnings and thermal panes. Energy-efficient insulated windows could not be installed in most of the complex. Life-cycle cost studies also showed that interior storm windows were not cost effective. The new replacement windows, however, were tight-fitting and provided with weather stripping. In addition to window restoration projects, most of the flat roofs in the complex were replaced with higher levels of insulation and new membranes. The HVAC problems that were creating negative pressurization were also corrected.

The USDA Facility Management Staff are always on the lookout for projects that both save energy and free mechanics and electricians from routine, reactive maintenance chores.

To ensure continued performance of building envelopes, the Operations and Maintenance Program is currently being upgraded. A schedule of regular professional inspection will document conditions and provide long-term tracking of the maintenance program. Regular inspections will also identify problems when they are still minor and inexpensive to correct.

Because existing fixtures were nearing the end of their useful life, a study was conducted to determine the economics of replacing existing lighting with the combination of energy-efficient T-8 lighting, electronic ballasts, and occupancy sensors. Replacement was found to be very cost effective. In addition to improving lighting quality, cooling heat loads were also reduced. Other energy conservation opportunities were identified by performing after-hours surveys of the complex. Existing time clocks and motion sensors were either repaired or replaced. Oversized mechanical equipment was identified and replaced. LED exit signs (light emitting diode) were installed throughout the complex, which both saved energy and got the electricians out of the business of changing light bulbs all day. The focus of this effort was to take into account true “life- cycle” savings, though projects with quickest pay-back were logically accomplished first.



Results have been most impressive. Between 1985 and 1992, electric usage had increased about 3 per cent annually (one million kilowatt hours per year). The rise was due in large part to the increased use of computers, fax machines, copiers, and other electronic office equipment. In addition, the increased use of systems furniture resulted in higher occupancy rates. By 1992, the electric usage was over 41 million kw hours. At a 3 per cent rate, the expected 1997 usage would have been approximately 46 million kilowatt hours. Instead, thanks to the energy management program implemented in FY 1992, consumption was actually reduced by 24 per cent (to about 35 million kilowatt hours). Instead of rising a million kilowatt hours per year, consumption dropped by that same amount, for a cumulative saving of two million kilowatt hours per year.

Reduction in water usage is another major piece of the USDA success story. Initial condition surveys revealed that Total Dissolved Solids (TDS) in the Washington, DC water were quite high and the cause of major problems. High TDSs were causing solenoid valves to stick open and creating massive scale build up which dramatically reduced the efficiency of heat exchangers. Frozen valves were wasting significant amounts of both hot water and thermal energy from the headquarters' kitchens. To address these problems, sediment filters and water softeners were installed. Sub-meters were also installed. In large facilities such as USDA headquarters complex, it is impossible to manage water usage without sub-metering. Sub-metering revealed that a single malfunctioning water regulator in a water-cooled ice machine would waste as much as 26.5 cubic meters (7,000 gallons) a week. Not only did the older units consume vast amounts of city water, they were also labor intensive to maintain. The water sub-meters also revealed that even properly operating water-cooled ice machines consume significant quantities of water. Recently all old water-cooled ice machines in the kitchens were replaced with air-cooled units. The combined savings from water and maintenance resulted in excellent pay-back. One kitchen averaged 8,130 cubic meters of water per month before the change compared to an average of 5,291 cubic meters after; reflecting a phenomenal reduction of over 35 per cent. Several newer water-cooled units remain, but will only be used during the summer when ice usage is high. Because of their limited use, it was not cost effective to replace the newer units.

USDA operating staff have found a direct correlation between energy/resource "guzzling" equipment and extremely high levels of maintenance required to sustain functionality.

Seeking other ways to conserve water the facility management organization undertook facility surveys and life-cycle cost analyses to develop a Water Management Plan. The surveys found dozens of water-cooled air conditioning units that were tied into the city water system. Most of these units have either been replaced, or decommissioned. When air conditioning units were replaced, lighting retrofits were also performed to ensure that new, smaller systems could be sized properly.

In 1988, water usage in the USDA Headquarters was 605,664 cubic meters (160 million gallons). This year, it is anticipated to be less than one-third as much (189,270 cubic meters). In a facility the size of the USDA, this represents a very significant cost avoidance. What's more, many water conservation opportunities remain. When the

Air-cooled ice machines replaced extremely wasteful water-cooled units.

facility is modernized, water-efficient plumbing fixtures will be installed throughout. The dramatic reductions in water usage at USDA Headquarters suggests that other federal facilities might also find savings by developing and implementing their own Water Management Plans.

Perhaps the single most valuable innovation undertaken by the facility management organization at USDA Headquarters was the installation of an ice storage system to supplement the chillers at the complex. The project was accomplished in coordination with an incentive program offered by the local electric utility company. The system works by freezing water in a huge cavern during the night at off-peak electric rates. The latent cooling capacity stored in the ice is then used to cool chilled water for the air handlers. Ice storage eliminates the need to run the chillers at peak rates during the heating season and significantly reduces chiller use at peak rates during the cooling season. Many of the previously described improvements to the HVAC system were executed simultaneously with the installation and commissioning of the ice storage system. The new thermal storage system included the DDC system for the chilled water plant. DDC allows continuous monitoring of the ice plant and of operational HVAC changes as they are implemented. DDC trend analysis means that problems are now quickly identified and corrected.

It may seem that these improvements required huge sums from the USDA coffers. That was not always the case. Many building tune-up

All USDA mechanical rooms were cleaned and polished as part of the maintenance upgrade. This spotless new chiller for the ice plant reflects the current conditions.

improvements, for example, were no cost or low cost. Implementation projects for the Steam and Water Management Plans were frequently relatively low in cost, with pay-back in months. Monitoring of energy and water systems frequently revealed low cost/no cost improvement opportunities. Careful commissioning of energy projects and coordination of related activities greatly improved cost-effectiveness. The DDC system saves considerable money both through monitoring and analysis of performance and quick identification of system malfunctions.

Improvements requiring major funding are only implemented after thorough life-cycle cost analysis. The longest amortization period for any project was 14 years for the combined ice storage system and DDC control system for the chilled water plant. Savings from this project are significantly greater than anticipated, however, due to a combination of enhancements to the thermal storage system and operational changes in the chilled water system implemented during the commissioning period.

The “package” of improvements recounted in this study had a very positive effect on morale, on efficiency of operation, and on the overall well-being of the inhabitants. USDA has not measured improvements in productivity, but the tangible results may be best expressed in the voices of the customers; or better yet, by their absence. Complaints that rooms were either too hot, or too cold, dropped by a factor of four (from an average of 40 calls per day, to 5-10).

Working “smarter” had a positive effect on the morale of the maintenance staff. There are many examples of this. Steam system upgrades freed mechanics to do worthwhile work, rather than “reactionary” patchwork formerly necessary just to keep the system operating. While they used to spend 160 man-hours per year correcting repetitive problems at the steam station in the Auditors Building; this number dropped to almost 40 man-hours per year after the upgrade program. Similarly, replacing incandescent lights in the dining area with fluorescents, saved 40 man-hours per year because of the longer replacement cycle. The strategically placed meters made it possible (certainly far easier) to analyze the complex of water problems in the cafeteria kitchens. Filtering the condensing water system in the cooling towers, saved 30-40 man-hours per month and reduced down-time from taking the towers off-line for cleaning.

A happy side benefit from all these improvements is that highly skilled mechanics are less often required to perform reactionary, “non-sensical” work such as changing light bulbs, plugging steam traps, adjusting thermostats, or responding to the never-ending hot/cold calls.

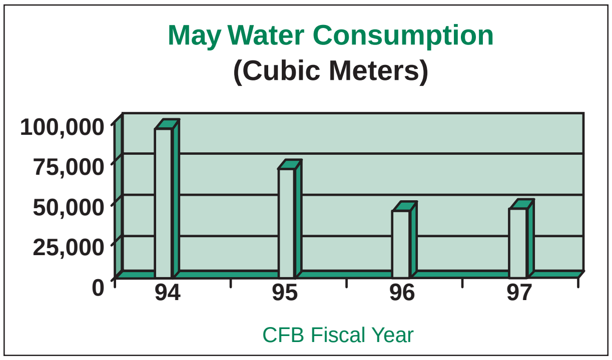
As the saying goes, “Success breeds success!” After budget managers see cost savings and tangible results, they are far more willing to spend money for additional improvements in the future. It is a synergistic process.

The facility maintenance organization at USDA is quick to point out that they are far from finished with this “rags to riches” story. But they have accomplished a great deal. And they have done so from working very smart. They surveyed existing conditions, they set priorities, they developed a plan of action, they monitored and metered, they did life-cycle costing, they piggy-backed projects and commissioned them as funding became available. But most of all, once the parameters were determined, they forged ahead. Knowing that waiting would only delay the savings and cost more in the long run, they quickly began to implement their plan.

IV Carbondale Federal Building:
Many Small Improvements Add Up to Large Savings!

Solar arrays dictated the design of the south elevation of the Federal Office Building in Carbondale, Illinois

- Originally expected to save thousands of dollars, solar systems designed in the 1970's didn't always pay off.
- Exposed solar collectors were easy targets for vandals, with resultant loss of 40,000 liters of water and treatment chemicals.
- Equipment changes eventually brought a 45 per cent reduction in energy costs.
- Maintenance staff proved that a pro-active approach is the single most important improvement. Customer satisfaction forms were 95 per cent to 100 per cent positive.



The Federal Building at Carbondale, Illinois is an award-winner- certainly no surprise to those associated with the maintenance staff of this remarkable operation. The Department of Energy and the Federal Interagency Energy Policy Committee selected the site to receive the 1997 Federal Energy and Water Management Award. This award recognizes the contribution made toward the efficient use of energy in the Federal sector during Fiscal Year 1996.

Three major factors contributed to the success of the Carbondale energy efficiency program:

- Abandonment of an inefficient and vulnerable solar array system.
- Installation of two centrifugal chillers replacing a single absorption chiller.
- Replacement of a single electric boiler with ten gas-fired packaged-boilers.

Equipment changes alone brought about a 45 per cent reduction in energy costs. Carbondale is not simply a story of energy efficiency, however - it tells a much bigger story of people caring for customers, minding their well-being and being there when needed. This story warrants further explanation.

One is struck by the unusual shape of the building, built in 1978. The original design incorporating a high-tech active solar energy system, was part of a federal solar demonstration program. There are four levels; three above grade and one below. The structure incorporates three building modules connected by a skylit central corridor - a multi-level ramp joining the north and south entrances. Ramps are used (in lieu of elevators or escalators) to provide wheelchair access to all areas of the building. The south face of each building module is sloped to incorporate an array of evacuated-tube, concentrating solar collectors; a total of 743.2 square meters of water-filled glass tubing. Clerestory windows and skylights are provided on the north face of each module. The clerestory strips light the upper loft level while the skylights provide daylight to the larger floors below.

The original solar energy system was designed to heat and cool the building. High temperature water from concentrating collectors provided heat in winter and was used to regenerate a lithium-bromide absorption chiller in summer. Two 43,532 liter storage tanks were located in the basement mechanical room. Upon demand hot water from the tanks was circulated through water coils to heat the building.

In the cooling mode, the solar system supplied hot water to a 60 ton absorption chiller which used lithium bromide as absorber and water as refrigerant. 180 (82.2c) degree water was required to process the lithium bromide solution. The system produced 45 (7.2C) degree chilled water which was circulated to coils in the facility's air handlers. A 360 KW electric boiler provided backup on cloudy days, or when the solar system was down.

At Carbondale, as is the case in most facilities, theory and reality are not always the same. The cooling cycle of the solar system worked reasonably well for the design temperature of 78 degrees Fahrenheit (25.6 degrees Centigrade) which was the federal standard in 1978. The design capacity of the system was exceeded in 1993 when the federal temperature standard was changed to 72 degrees Fahrenheit (22.2 degrees Centigrade), in order to improve customer satisfaction, as per Executive Order 12861 "Setting Customer Service Standards". At this point the absorption chiller called for more hot water than the solar system could deliver. During such problem periods the backup electric boiler was used to provide hot water required for cooling and heating. During low demand periods this was analogous to heating a bath tub in order to get a pot of coffee.

The fragile nature of the solar system left it quite vulnerable to recurrent damage inflicted by vandals. Vandalism normally occurred on weekends, when "partying" college students returned to their cars in the Carbondale building parking lot. The students found it amusing to throw empty beer bottles up at the exposed glass collector tubes. The unfortunate result was the loss of approximately 40,000 liters of water, as well as the chemicals

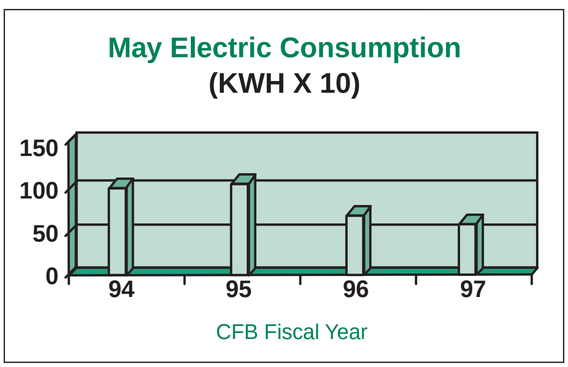
Wooden sculpture at entry was not sufficient to protect the vulnerable solar arrays.

required to treat the system. This weekend activity was curtailed only after the Maintenance Manager took it upon himself to sleep at the facility for several weekends to thoroughly assess the routine. The solution was to prohibit parking in the federal building lot after normal business hours. The beer-bottle-throwing episodes stopped soon thereafter.

Another dangerous problem resulted from the fact that some sections of the collector array were higher than the system expansion tanks. This resulted in air being trapped within the glass collector tubes, causing overheating and sometimes even complete explosion!

Normal problems of leaks and routine maintenance were difficult, because the high-tech concentrating system was composed of virtually one-of-a-kind parts. Frequently, damaged tubes, gaskets, grommets, and "O" rings had to be fabricated from scratch.

Solar array problems were compounded by the need for re-roofing as building age approaches twenty years. Re-roofing would require that the solar array be completely removed; a labor intensive and very expensive task. A thorough life-cycle cost analysis of several options led to the conclusion that the solar energy system should be decommissioned. In fact, the system never performed up to design predictions and proved very costly to operate. The collector array has been abandoned in place until re-roofing begins. The absorption chiller and hot water storage tanks have been removed. All associated water and chemical losses have stopped. The expensive (approximately $5,000.00 per year) chemical treatment of the system has also been stopped.



In 1986, the 360 KW electric boiler was replaced with a 1339 MBH gas fired boiler. In 1996, the single large gas boiler was subsequently replaced with ten smaller (175 MBH) more efficient gas fired packaged boilers. Now it is possible to stage the supply of hot water at a more efficient rate, with sufficient reserve. Another advantage is that boiler maintenance can be more easily scheduled and performed.

Based on life-cycle cost analysis, GSA replaced the aging and less efficient 60 ton absorption chiller with two new 60 ton centrifugal chillers in May 1996. The new chillers have four separate compressors that work independently. If the cooling load is 15 tons or less, a single compressor operates. If the cooling load is between 15 and 30 tons, two compressors operate, and so on. This staged chiller design is substantially more efficient than a chiller of the same size with only one compressor. The installation of a 113.5 liter electric water heater means that there is now no gas usage in the facility during the cooling season.

GSA also addresses another energy loss which occurred through the automatic sliding doors. The facility manager observed that both sets of doors remained open for substantial periods allowing infiltration of large volumes of unconditioned air. The sliding doors were replaced with manual hinged doors. To remain ADA compliant they also installed one set of electrically operated handicapped access doors.

A number of other routine improvements have been made, such as; installing motion detectors, lighting upgrades from magnetic ballast to electronic ballast and 32 watt lamps, "ambient-light-sensing" and automatic dimmer controls, replacing 250 watt mercury vapor lights with 50 watt high pressure sodium lights. All motors 3.73 kw (5hp) and above were replaced with high efficiency motors and variable-speed drives. While the above improvements may seem mundane, they have a short pay back time and provide substantial energy savings.

These initiatives and improvements have saved the facility thousands of dollars. Now, during the cooling season there is no gas consumption. In spite of the fact that the absorption chiller was replaced by two electric chillers, overall electricity usage has been reduced. The energy usage in 1985 was 40813 BTUs/GSF and in

New packaged boilers are able to satisfy varying demand much more efficiently.

1996 the consumption was 26584 BTUs/GSF a decrease of 34.9 per cent!

Perhaps the single most important improvement in the operation of this facility is the pro-active approach exhibited by the maintenance staff. The facility manager (on-site maintenance) conducts several tours each day to determine if there are problems with the facility, systems, equipment, or any occupant complaints. There is a very good rapport between the maintenance staff and all the occupants. Thus any problems that arise are handled quickly and professionally. This effort is reflected in the GSA customer satisfaction surveys. These independent surveys are consistently 95 to 100 per cent positive.

This says it all; a proud maintenance staff cares for their customers.

V Merritt Island Launch Annex:
Savings Complementing a Critical Mission

The reason for MILA's existence - the Kennedy Space Launch Program. The Shuttle is assembled here...

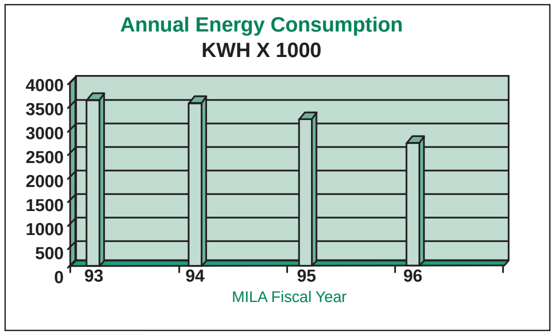
- MILA is a vital link in the National Space Program: mission failure is simply out of the question.
- They have combined Maintenance and Operations and mission accomplishment into a single, cohesive program.
- "Affirmative Procurement" controls the aquisition and distribution of hazardous substances on the site.
- Their Reliability Centered Maintenance Program combines reactive, preventive and proactive maintenance with predictive testing and inspection.

...and launched from here!

The mission of Merritt Island Launch Annex (MILA) is to track and communicate with space vehicles during launch, landing, and while in orbit and in view of the station.

The official name of this complex operation is the NASA Spaceflight Tracking and Data Network. MILA is actually a unit of NASA's Goddard Space Flight Center, in Greenbelt, MD, but is a tenant at the Kennedy Space Center; where control of launch and landing of the space shuttle is performed. After launch, control of shuttle missions is transferred to NASA's Johnson Space Center in Houston. Orbital communication with manned spacecraft was formerly maintained through a series of land-based antennas spread around the globe. Today the Network receives and processes orbital data from a satellite system called the Tracking and Data Relay Satellite (TDRS) which communicates to a ground station in White Sands, New Mexico. The TDRS system has replaced most of NASA's Ground Stations used in the 1960's. The MILA Ground Station remains in use because of its location at the Launch Complex and is a vital link in the national space program.

To accomplish this critical mission, MILA operates redundant antenna and computer systems. These systems are backed by un-interruptible power supplies and emergency generators. All of this equipment requires inordinately large amounts of power tending to overshadow potential benefits to be gained from energy, maintenance, and environmental programs. The highly professional organization at MILA has, nevertheless defined M&O and mission accomplishment into a single, cohesive program. They have cleverly sought and found numerous ways of running their site more efficiently. The main areas of focus are:



- Replacement of old power and mechanical equipment with newer, highly efficient equipment
- Insulation improvements in computer rooms
- Extensive user awareness and reinforcement provided by the integrated Energy Committee
- Reliability Centered Maintenance Program
- Staff and space consolidation, in tandem with advances in computer technology

Redundancy is important at MILA. There are three tracking antennas at the site; two large primary antennas and a smaller one for backup during periods of scheduled maintenance on the larger ones. A fourth remote antenna (Ponce de Leon), located 50 miles up the coast, is necessary to cover an idiosyncrasy in the shuttle launch trajectory.

MILA provides its own power during shuttle launch and landing, using the local utility during non-critical periods; again to achieve the highest possible safety factor. After a fifteen minute warm-up period, four diesel generators are sequenced on-line for primary power. This is done prior to the astronauts boarding the shuttle to ensure a seamless operation. Two additional generators are held in reserve. The six engines provide a combined capacity of over 1,950 KW.

The staff at the MILA complex is a close-knit group that has found harmonious ways to communicate needs and to provide mutual support. For example, AlliedSignal, the MILA maintenance

Redundancy is mission essential; maintenance of the MILA antennas is one of the most important jobs.

contractor, shares equipment, not only with NASA, but also with EG&G, KSC's Base Operations Contractor.

Additionally, they have established several joint committees built on these constructive relationships that enhance mission and cost savings. MILA participates on the KSC Energy Committee which provides the leadership and maintains the organizational discipline required to implement needed change.

The PDL antenna was enclosed to prevent corrosion from salt air. High humidity levels within the enclosure, however, did lead to corrosion. A 13 KW regenerative dissicant dryer was installed and was later replaced with a more efficient 3-ton refrigerated dryer (A/C) unit.

The Ponce de Leon (PDL) tracking site provides communication with the space shuttle during a brief period when the primary antennas at MILA are "blacked out" (unable to communicate) due to aluminum particles in the shuttle's exhaust plume. The black-out begins as the shuttle trajectory changes from vertical and continues until burn-out and separation of the solid rocket boosters. The PDL antenna is an interesting energy story as well (see Sidebar). MILA has recently established computer control of the PDL generators saving considerable time formerly required to travel there just to flip switches or perform routine maintenance operations.

In order to perform its mission, MILA must cohabitate with its animal neighbors. The MILA location in the swamps and dense vegetation of central Florida, means that animals and wetlands are generally protected by law. The feeling one gets on approach to the MILA complex is that of a game preserve. Wetland ditches filled with several feet of swamp water lie on each side of the access road. The trained ear can hear the sounds of alligators, eagles, egrets, and frogs for a quarter of a mile before reaching the entry gate.

MILA has learned to live and work in this environment very well. When an osprey family was found nesting on top of an antenna tower that needed to be dismantled for refurbishment, MILA personnel immediately saw the need for caution. They contacted local wildlife officials who informed them that the birds were in fact a protected species. MILA then took action to relocate the osprey. They cautiously placed the chicks in a cardboard box, partially disassembled the tower, and gently lowered the nest by crane to the ground. They then moved the entire nest, with chicks, to a platform constructed on top of a telephone pole they had "planted" nearby. They were thrilled when the parent ospreys found their new home. Similarly, when an eagle was found on KSC property, video surveillance cameras were mounted nearby to monitor the bird's peace and safety.

They have also taken other action to protect animal species, including humans. They have implemented a program called "Affirmative Procurement" which controls the acquisition and distribution of hazardous substances on the site. All requisitions go through a screening process to ensure that recyclable and recycled products are procured and that only needed quantities of hazardous materials are ordered. Screeners search a chemical data bank to find less toxic, environmentally-friendly substitutes. The result is fewer hazardous materials to be dealt-with or disposed-of.

These cabinets house banks of computers which process electronic data from space.

The energy conservation program at MILA is a major success story. Four years ago, MILA achieved the NASA energy conservation goal of 20 percent reduction simply by replacing old equipment. The program did not stop there, however. Not resting on their laurels for a moment, they went to less obvious, but equally rewarding methods. For example, they addressed a perennial heat/cool problem that occurred in the spaces containing the MILA shuttle-tracking computers. In those rooms, conditioned air was delivered to the large banks of electronic equipment cabinets through the raised-floor system and exhausted from the cabinets tops. The problem came when large quantities of cooling air escaped through a variety of holes in raised floor panels and through

This simple method of insulating cabinets resulted in both cooling and heating savings.

open cabinet doors. The result was cold occupants, turned-up thermostats calling for heat, and complaints to the maintenance staff. The solution was twofold; one, to stuff foam insulation into all the unnecessary holes and two, to set the damper under each cabinet to flow the minimum amount of cooled air necessary for the equipment in it.

Although a relatively small site, MILA has made many “minor” improvements that contribute to overall energy savings. They replaced two oil-fired boilers with a single natural gas boiler. Utility meters were installed to track consumption patterns. MILA personnel have defined a philosophy and established a policy, that energy saving and maintenance are intimately, inextricably tied together. The results have been amazing. They have installed:

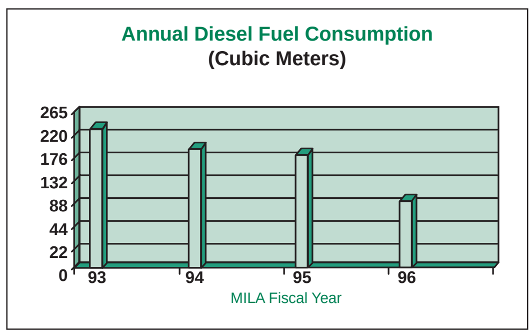
- Photo-voltaic perimeter lighting,
- High efficiency Interior lighting,
- Electronic ballasts,
- Light-control motion sensors,
- Small, screw-type chillers, and
- Reduced-capacity air handler motors.

Photo-voltaic panels provide solar power for perimeter lights.

In addition to hardware changes, the management philosophy encourages active participation and ownership "buy-in" for improvement programs. Their Reliability Centered Maintenance (RCM) program was self-initiated. RCM combines four elements; reactive maintenance, preventive maintenance, predictive testing and inspection (PT&I), and proactive maintenance. Proactive maintenance is the foundation of the program and includes three major features: design for maintainability, life-cycle planning, and facility system equipment (f/s/e) condition assessment. RCM applies each of the four maintenance elements where most appropriate; based on the consequences of failure and mission impact. This proper combination produces optimum reliability at minimum maintenance cost. Combined benefits far exceed those resulting from use of any single maintenance technique.

Under the RCM program, lubrication oil and hydraulic fluid from antennas are sent periodically for laboratory analysis. Following laboratory recommendations, maintenance personnel can safely extend the period between oil/fluid change cycles. They have found that reductions in unnecessary routine maintenance also allow more time for surveying the condition of other equipment. They initiated both thermography inspection and laser alignment programs. These programs allow them to pinpoint and correct trouble spots prior to total equipment failure. Correct alignment decreases power requirements and extends equipment life. NASA headquarters has recently published an excellent manual on RCM techniques.

The initiatives described above have saved the site thousands of dollars. Diesel fuel usage dropped a whopping 51 per cent in only three years, from 236,232 liters in 1993, to 114,085 in 1996. In the same short period, consumption dropped a very respectable 20 per cent; from 3,752,340 KWH to 2,913,331 KWH. Some of these reductions resulted from consolidation of staff, but even so, the BTU/SQ.METER/YR, which is a more accurate reflection of occupied load, dropped 38 per cent! In 1993, the figure was 624,000 and in 1996, it was 386,716.



During this period, and in spite of the other improvement programs in progress, MILA's contractor (AlliedSignal), applied for and was certified in the ISO 9001 program. Attaining certification in this coveted program requires an extensive, multi-year effort. Industry regards this achievement as the pinnacle of management success. It is the most comprehensive standard in the ISO 9000 series of international quality assurance and management standards. Certification requires that the competing firm prove its credentials in such areas as management responsibility, documentation, inspection and testing, corrective and preventive action systems, quality, audits, and training. The process is iterative, in that the competing firm continually upgrades processes until they are sufficiently refined to warrant certification. MILA responded to over 125 corrective action requests before reaching their goal; clear testimony to their tenacity and concern for quality.

There are no surprises at MILA. The people there have taken a very successful program, found ways to improve it, and spared no effort applying those improvements. It is a proud operation, performing its mission extremely well, while also saving energy and managing environmental resources.

At KSC there is still time to protect endangered species. This eagle's nest is monitored by video-camera.

VI Naval Station Everett:
Not Your Father's Navy

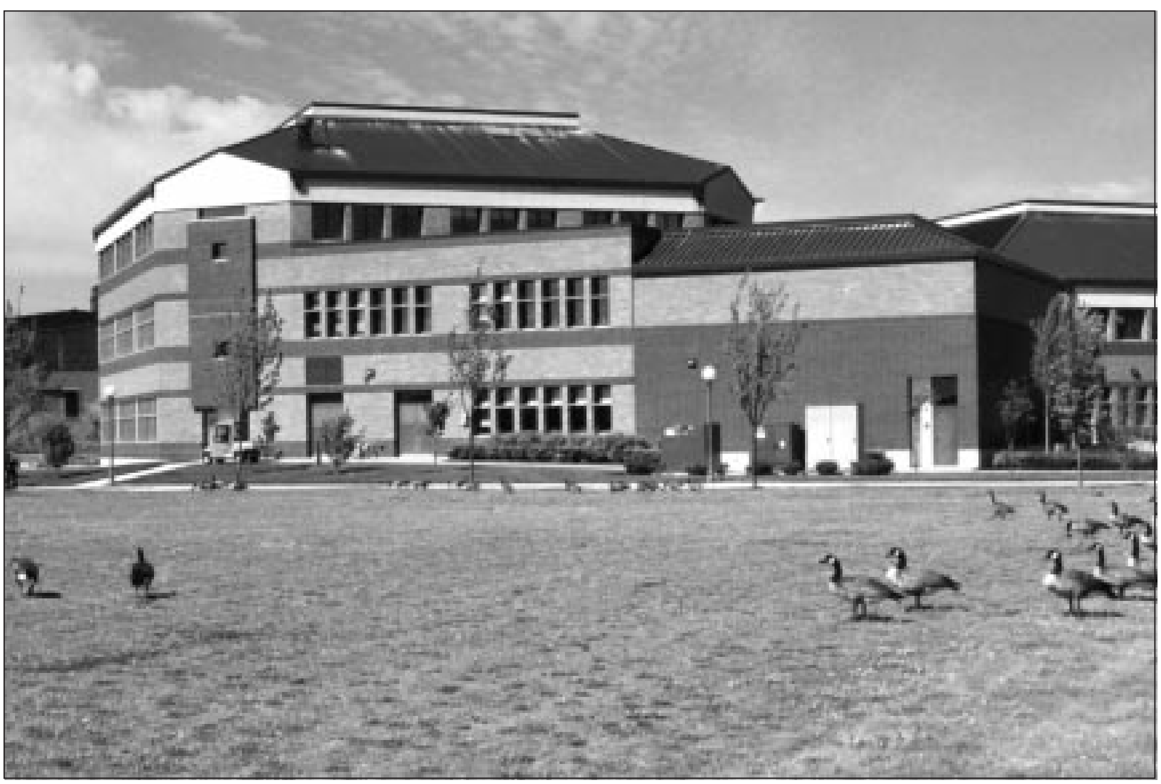
When you enter Naval Station Everett, you feel you are on a college campus.

- The NSE Master Plan was carefully designed so that the installation would be an energy and environmental showcase.
- State-of-art, computer-controlled Steam Plant meets the needs of the land installation and provides steam and compressed air to ships at berthing piers.
- Stand-alone hazardous substances building isolates all hazardous waste generated at the facility.
- PWMA (Public Works Management Automation System) provides computerized, bar-coded, real-time data on all maintenance activities.
- DDC (Direct Digital Control) staff remotely control and fine-tune equipment set points to accommodate building orientation and even, the preferences of individual occupants.
- Teamwork and an active self-help program have fostered a pervasive attitude focused on constant improvement.

The naval station at Everett, Washington is the newest Department of Defense installation in the United States. As such, it was carefully planned and designed to be an energy and environmental showcase and a model of personnel efficiency. A strong focus on innovation and a philosophy of constant improvement were instilled at the outset of planning. These attitudes continue in the day-to-day operations of the installation and are further evidenced by a long list of betterment projects planned, or in place, before construction of the master plan is even completed.

Naval Station Everett (NSE) is homeport to the carrier Abraham Lincoln. Two piers at the south end of the site accommodate the carrier, two destroyers, two guided missile destroyers, and two guided missile frigates. Administrative functions and line operations are performed at the small, compact homeport site right on Puget Sound. Family service functions are performed at Smokey Point, a sister location several miles inland.

Entering the NSE gate, one finds the atmosphere of a college campus, or perhaps even a nature park. The visitor is greeted by Navy personnel moving briskly to their next appointment amidst quacking ducks, honking Canada Geese, and “screaming” terns. In the distance, you may spot the “Abe” Lincoln. You won’t see many motor vehicles, but may cross paths with one of the four electric cars used for shuttling personnel and materials around the station. There is a feeling of calm,

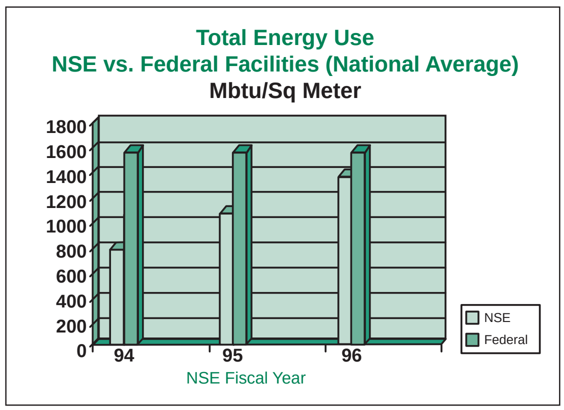


The atmosphere is very relaxed, but also highly productive.

stability, and cohesiveness at this installation. This is true, in spite of the fact that there are 31 “tenant” organizations (a tenant is not part of the parent command and therefore owes no “allegiance” to the installation).

A number of innovative features were included in the NSE master plan. A state-of-the-art silt-deflection jetty has successfully minimized the need for channel dredging. A wave attenuation barrier, of unique design, protects the two berthing piers from high seas. A new technique was developed to construct the electric vaults for the piers and then to float them into place. The NSE engineering staff boast that they have the finest “vaults” in the Navy. Below-floor water tubing heats the kids at the Child Development Center. At Smokey Point bio-filtration ponds capture environmental pollutants from parking lot runoff before they reach adjacent wetlands. The list could go on and on.

Energy conservation was a major factor in the master plan. An energy conservation program should center around the biggest energy consumer. At NSE this was the “steam plant” which actually houses steam boilers, air compressors, and chillers. This plant provides steam and compressed air to ships at the berthing piers.



The steam plant received careful architectural and engineering design attention. On all sides of the building, six-foot high translucent clerestory windows provide natural light and reduce interior lighting requirements. Exterior lighting is provided by sensor-actuated high-pressure sodium lamps. All piping and tanks are well insulated to reduce energy loss and to maintain comfortable ambient temperature within the building.

State-of-the-art computer systems control all equipment in the plant. Five boilers, ranging in capacity from 175 kwh to 1,050 kwh, are cycled on and off as needed to achieve the greatest fuel economy. All boilers are equipped with the following:

- High-efficiency burners with oxygen trim system to maximize fuel/air ratios; (83 to 85.5 per cent efficiency, 2 per cent excess air),
- Turn-down ratio of 8 to 1 (maintains high efficiency at low load),
- Economizers using stack flue-gas to preheat boiler feed water,
- Flue gas recirculation to preheat entering combustion air,
- Blow-down heat recovery units to preheat treated water entering de-aerating tank.

Four chillers with multi-stage compressors and total capacity of over 200 tons, provide chilled water for the installation. Compressors are sequenced, looped, and manifolded to satisfy cooling demand most efficiently.

Reciprocating air compressors occupy one end of the plant in a separate room from boilers and chillers.

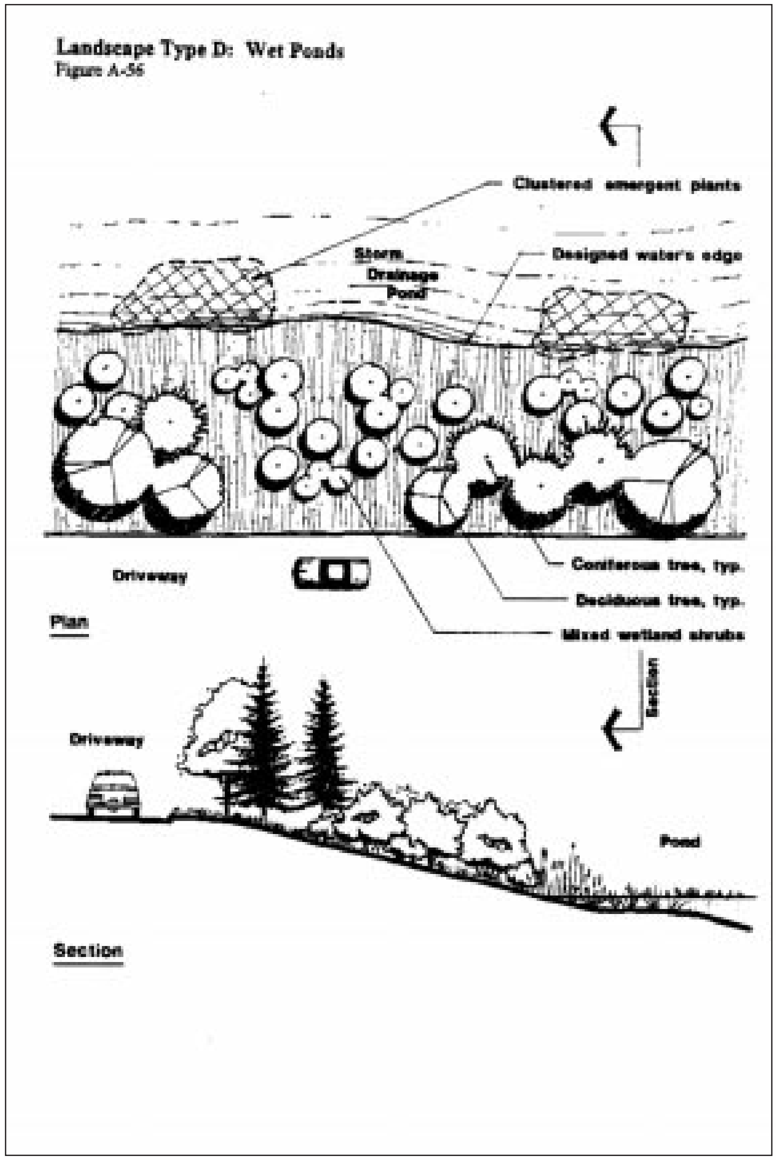
Even the natural gas used to fire the boilers is purchased at a reduced rate because the installation has negotiated a special price by means of a gas curtailment program offered through DFSC.

It seems you could eat off the floor. A great deal of pride is being displayed here.

Several environmental features of the NSE master plan deserve mention. A stand-alone hazardous substances building was constructed to contain and isolate all hazardous waste generated on the installation. NSE also built an oily-water containment facility to prevent the accidental release of oil residuals into the storm drainage system.

At Smokey Point the landscape was designed to address environmental concerns. The storm drainage system mitigates water quality impacts and moderates increased runoff caused by the development (biofiltration ponds mentioned earlier). Upland transition areas adjacent to roadways were planted with a mixture of deciduous and evergreen trees; planted in groups of 3 to 5, at intervals of 30.5 meters. On lower slopes adjacent to a larger pond on the site, a mix of wetland-adapted trees and shrubs were used. The balance of the groundplane was hydroseeded with a grass mix adaptable to the varied conditions of the zone.

The latest technology is used to manage the expenditure of energy within the buildings at NSE. Two direct digital control (DDC) systems are used; one of which is considerably newer. Facility maintenance staff are intimately familiar with their idiosyncrasies and differences and have raised their use to an art form. DDC staff have learned to fine-tune setpoints for different locations in different buildings, and even for different orientations within them, in the continuing effort to maximize comfort and energy efficiency. The DDC system monitors dynamic information from each building and controls heating and cooling equipment within that building, as necessary. The ability to schedule start and stop times of virtually any piece of equipment attached to the DDC system saves many thousands of utility dollars annually.



An innovative runoff recovery system reflects the thoroughness of even the landscape master plan.

In the near future, Naval Station Everett will install a base-wide Utility Monitoring System (UMS) which will interface with the DDC system. The UMS will record data from electric and natural gas meters to further improve programming strategies and allow improved billing and cost accounting. The system will provide alarm monitoring of selected equipment and will send acquired information to strategically placed alarm printers.

One NSE system warrants special attention. It is called PWMA (Public Works Management Automation System) and is the heart of the facility maintenance management program at the station. This program tracks customer service work requests, emergency service tickets, preventive maintenance items, standing job orders, and property records. On one phone call, customers place a work order, receive a tracking number, and are told an approximate time when work will be completed. Simultaneously, the work order is entered into the system, assigned to the proper shop(s), and dispatched. A bar-code system tracks, and produces records of personnel assigned, material used, and time spent on the job; producing a

For ease of maintenance, these highly efficient lights can also be lowered to the ground.

very accurate record of work efficiency. The PWMA reduces downtime of energy-using equipment, greatly improving energy efficiency.

PWMA creates a centralized data source for personnel at all levels of the organization with interest in customer, budget, facility, or general maintenance activity. It provides data to assist with preparation of annual inspection summaries and shop scheduling requirements. This system is an extremely valuable tool. It is so finely tuned and so well-defined, that it operates practically on its own. PWMA provides a model for the facility management industry that should be replicated wherever possible.

The real key to an efficient energy conservation program is the people. NSE personnel are very involved, and care deeply about what happens on their site. They are proud of what they do, where they work, and the “branch of service” to which they belong. A number of specific activities and projects reflect the prevailing attitude.

NSE has formed an Energy Management Team (EMT) that includes installation personnel and tenants and conducts quarterly meetings. The ECC promulgated a strict charter defining an energy management program that outlines goals, guidelines, and requirements patterned after the Navy’s Energy Mission statement; “to reduce energy costs, reduce petroleum fuel usage, and increase use of renewable energy”. Specific Navy goals are to:

- Reduce energy consumption per square meter by 30 per cent by the year 2000 (relative to 1985) without compromising military readiness, sustainability, quality of life, or safety,
- Train all shore facility energy managers,
- Implement to the maximum extent practical, all shore facility energy projects with a payback of less than 10 years.

The Energy Management Team is working very well and making vast strides. It uses a team approach and maintains a very positive attitude.

One NSE energy project in place since July 1997, is a gas tele-metering station that provides data on natural gas use at NSE to the Defense Fuels Supply Center's (DFSC) Direct Supply of Natural Gas (DSNG) Program. As a requirement of this tele-metering program, NSE forecasts their site's gas use. With this this information, DFSC is better able to predict their demand, manage and monitor energy use, route the gas at higher rates to those who do not use tele-metering and forecasting, and in exchange, offers the site a more favorable rate. Although there is a penalty clause for poor management of gas use, NSE has managed very well. The savings from this program are approximately $25,000 annually in cost avoidance.

NSE will be one of the first Navy stations to take advantage of a DOE initiative called Super Energy Services Performance Contract (ESPC). Through this program, pre-qualified contractors conduct energy audits to produce a "Save Energy Action Plan" which is left with the installation for implementation. This program is focused entirely on ways to save energy money within federal agencies. NSE will make good use of this program; NSE personnel have been tireless in their efforts to find and implement better energy conservation methods. Other projects currently being considered are upgrade to more energy-efficient lighting fixtures, installation of automatic controls for lights and HVAC equipment, and window upgrades at an older, remote recreational facility.

One of the many projects completed by volunteers. Here the seamen built barbecue pits and a sauna on their own time.

To ensure the efficient daily operation of their facilities, NSE is participating in a building operator certification program sanctioned by the Northwest Energy Efficiency Council and supported by the Bonneville Power Administration. Training courses cover fundamental principles of building systems, basic procedures to improve energy efficiency, equipment reliability, development and implementation of a preventive maintenance (PM) program, and troubleshooting equipment and building systems. The NSE goal is to have all building operators achieve Level 1 certification. They are also sending personnel to "energy audit" training to give them the ability to conduct in-house facility audits.

These training programs are already producing tangible results. After attending an Energy Audit Training program, the Energy Conservation Manager immediately implemented a project to reduce "demand charges" (levied by utility companies as compensation for the electric capacity which must be provided during peak demand periods; such as; the hottest or coldest days of the year). The project, which will be completed in February 1998, is the installation of capacitors to correct low power factors. The project will produce savings of over $45,000/year.

Another returning student proposed a project to replace conventional emergency exit signs with Light Emitting Diodes (LED) signs for additional savings of hundreds of dollars per year/per building. Other

"Take care of your people, and they will take care of you." The children are left in the hands of competent care-givers.

energy saving proposals catalyzed by the training courses and being investigated are installation of low-voltage fluorescent lights and ballasts and solar-powered exterior lighting.

The personnel on this installation are believers in the benefits of energy conservation but they aren't necessarily waiting for appropriated funds to become available for projects they feel are important. They have created a very active "self-help" program that is producing remarkable results. A current project at the laundry facility in the pier area is construction of a deck and gazebo where sailors, just returning from sea, can relax and look out over the sound as they await their laundry. As one Chief put it, "instead of just watching their clothes go 'round and round', they can go outside and watch the seals and terns". But they can also learn something about energy and the environment. The planks for the deck are made from recycled plastic milk bottles and lighting will be powered by photo-voltaic electric panels. This project, being accomplished with volunteer labor, will benefit all on the installation and is already a source of great pride. A side benefit of all such projects is that the sailors care about the finished product and will go to considerable lengths to ensure its longevity.

The final story of why things are working so smoothly at NSE lies in that same one word - "people". The people at NSE work well to-

Giving back to the base is a good indicator of how much they care at NSE.

gether; as a team. As the military saying goes, they are determined to "cooperate and graduate". An attitude of caring and concern is exhibited by all. This attitude is contagious. The Master Chief in charge of energy conservation seems to know everyone on the installation by first name, and even seems to know a little about each individual's family! The personnel at Naval Station Everett are performing their mission very efficiently while keeping the well-being of the sailor in mind. The men and women of Naval Station Everett have found a better way of doing business. It is a true success story.

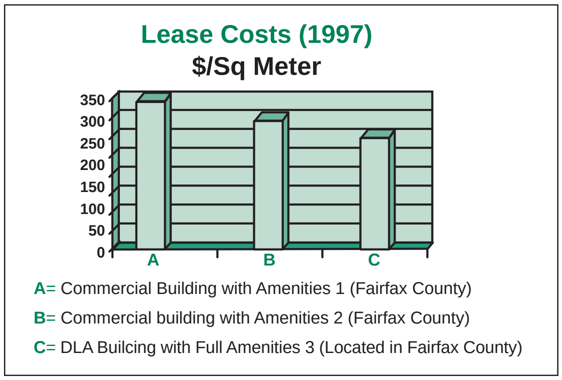
Visiting Naval Station Everett, Washington, was a most rewarding experience, professionally as well as aesthetically.

VII Defense Logistics Agency:
High Tech but *Caring Customer Service*

The impressive, new DLA Headquarters incorporates the latest in modular design.

The Defense Logistics Agency (DLA) has found a way to combine technology with customer service. The facility management staff have used computer technology to provide responsive, efficient facility support to customers. Neither the facility nor its efficient operation occurred randomly. The success of the facility operations program centers around:

- An integrated, computer-aided, facility management program.
- A professional and dedicated facility management staff.
- A competitive environment demanding efficiency every day of the year.



DLA compares quite favorably with commercial buildings in the DC area.

Spectacular and inviting atrium provides warmth, "openness", and light.

The building is located on Fort Belvoir's north post. It is a large building (83 600 square meters) of modular construction. The layout is straightforward, with a simplistic design and efficient functionality.

The four-story central spine of the building is daylit from end to end. Working areas are double-loaded off the spine; with enclosed offices on the interior and open-plan cubicles with view of the floor-to-ceiling window walls on the exterior. Along the first floor of the spine, free-standing structures containing special services such as travel, credit union, and snack bar are interspersed among furniture arranged for assembling and dining. Three levels of open balcony, complete with steel-cable railings, thread their way above the spine below. Modules are separated by stair and elevator towers.

The entry lobby in the center of the building is glazed front and back with skylight above and double stairways leading down to cafeteria and up to conference and library spaces. The rear of the building is curved and provides a

Aeration of the retention pond, which collects parking lot runoff, allows it to be used to water landscaping.

view of the pond and high aeration water-jet. The pond was conceived and functions as both retention pond for parking lot runoff and a source of irrigation water for landscaping.

DLA tenants have access to other amenities as well:

- 160-person conference room (top-secret-cleared)
- Child development center (opening fall 1998)
- Reference library
- Video-conference studio
- Cafeteria
- Athletic facility
- Parking for over 3,000 vehicles

An ice storage plant (26,375 KW) produces ice at off-peak times. The ice plant was designed to assist the primary cooling system (three 1,758 KW chillers). The ice system has proven capable of providing primary cooling for substantial periods.

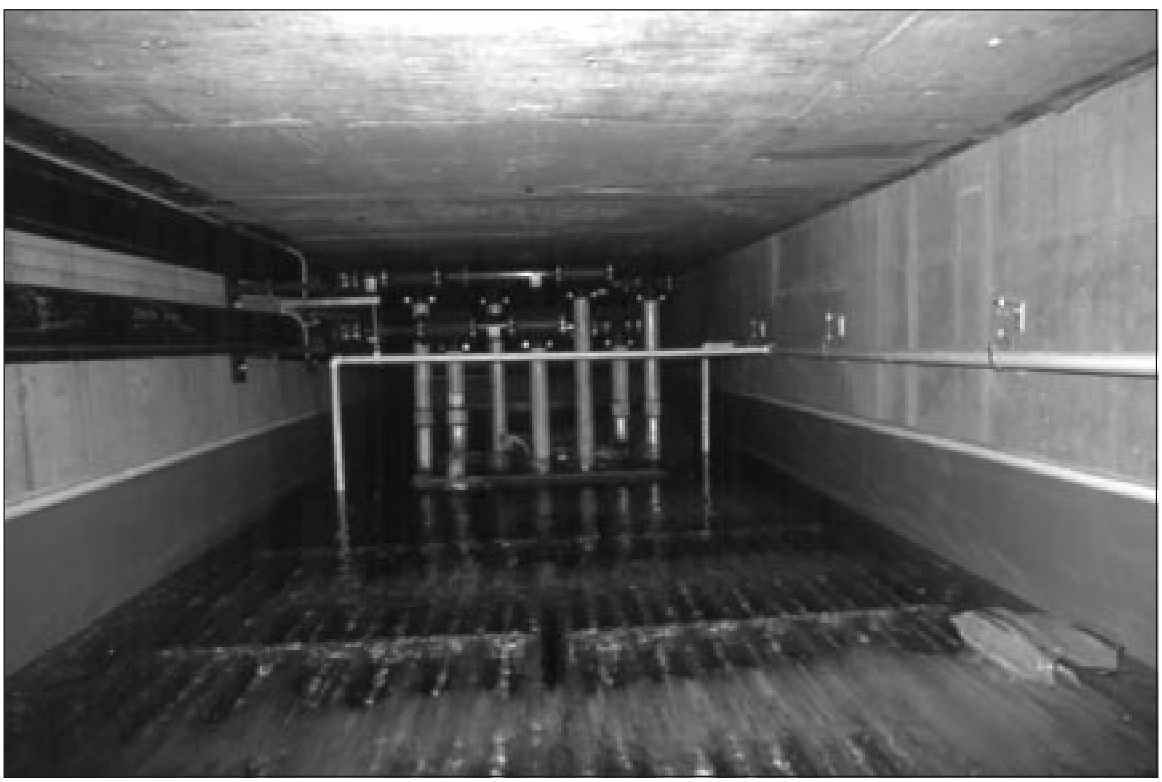
The heating plant uses 3-5 million BTU/hr boilers with electronic modulation and total capacity of 15 million BTU/hr. Variable air volume

(VAV) control is used throughout the facility with a total of 1,400 dual-duct VAV boxes equipped with time clocks for after hours shutdown. The HVAC system is controlled by an Energy Management System with direct-digital control using 8,700 data points. Each data point can be individually addressed to monitor and modulate environmental conditions. Facility management staff can control the system with lap-top computers from anywhere within the building.

Mail is delivered using a “robotic” mail delivery system. The cart stops for loading and unloading, without apparent human direction, controlled by magnetic strips on the floor.

The facility management staff investigated a range of computerized maintenance management systems (CMMS) and computer-aided facility management (CAFM) software. A CAFM was selected and put to use in managing the facility.

The planning process for this facility began in 1989 when the previous home of DLA was selected for closure by the Base Realignment and Closure Commission (BRAC). A management team was established to find suitable office space for the 3,600 personnel to be moved from Cameron Station, in Alexandria, VA. The planning team which included all major tenants, assessed the needs and input received from heads of



This “ice plant” is the heart of energy conservation for the DLA building. It has the capacity to provide “primary” cooling for substantial periods.

numerous organizations who would be involved in the BRAC relocation.

Planning for the new building began late that same year after suitable office space could not be found. Given up to four years for economic analysis and environmental impact statements, at least one year for design, and two-years for construction - this was destined to be no routine construction or move schedule.

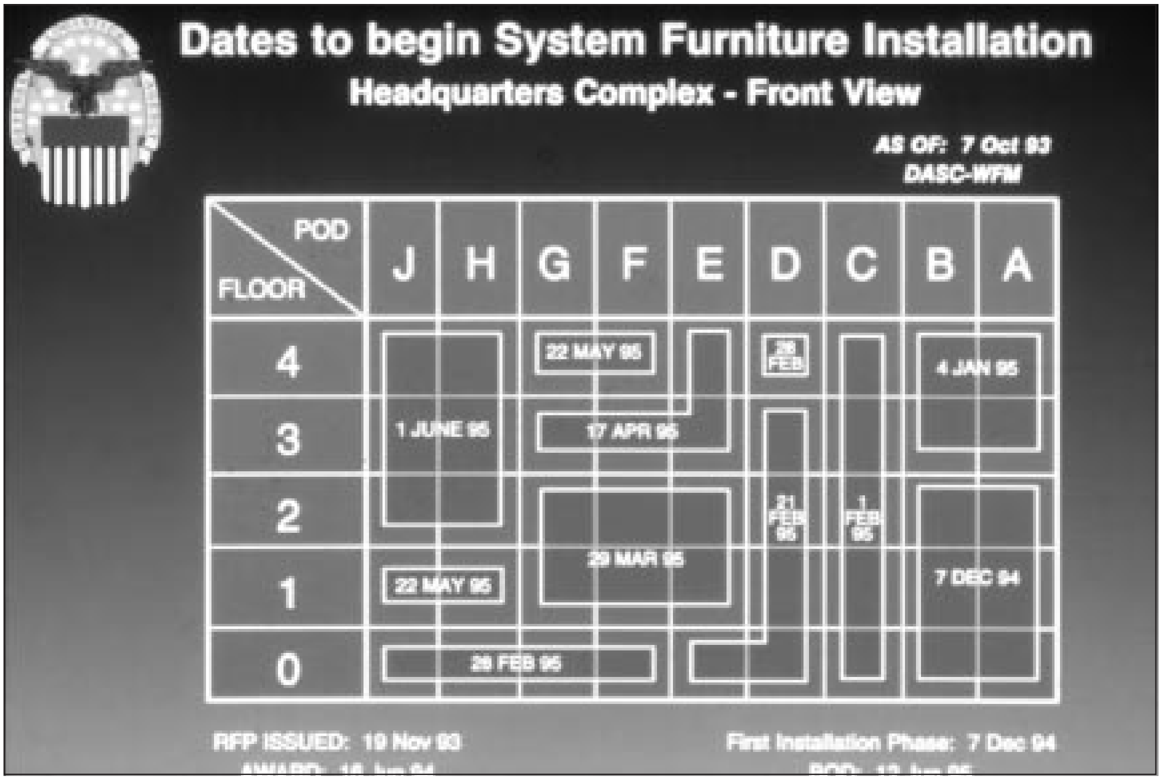
The immaculate chiller room at DLA is adjacent to the underground ice plant

In 1992 a core group from the DLA planning team moved to the construction site to manage the project first hand. The leader of the team would become facility manager of the new building. The team was planning for the full life-cycle of the building.

At some point it became apparent that the construction would not be complete in time to meet the BRAC deadline. A range of options were investigated and rejected. After reviewing the construction scheme starting from the beginning, it was decided to make drastic revisions. The original plan to finish space vertically one floor at a time was abandoned in favor of a pod-by-pod concept. The new plan allowed DLA to begin occupying one end of the building as construction continued toward the other end. The least essential central entry pod was completed last.

Over the Fourth of July weekend of 1995, six months behind the original schedule, the exodus from Cameron Station began. In three months the move was completed, on time.

This process succeeded only because of planning. The “move team” launched a campaign to get tenant organizations to buy into this unconventional process. Incoming personnel were briefed on occupant “rules” and move procedures. They were asked to pack Thursday, and report to



Furniture was selected, bought, and installed with occupant involvement.

work at the new Headquarters on Monday. Move coordinators were issued color-coded T-shirts; the same color as their packing labels. Over two thousand hard-hats were issued to incoming personnel.

Food wagons arrived at the site daily because the cafeteria was in the last pod to be completed. Occupied portions of the building were sealed with plastic in the attempt to keep dust and debris away from computer equipment. Heating and cooling systems were severely over-tasked.

As if all the above weren't enough; we now get to the heart of why DLA is a model of life-cycle management. When construction was completed, the facility management team did not receive as-built drawings. They obtained computer-aided drafting and design (CADD) drawings from the project architects.

They hired a part-time college student to update the drawings. The updated drawings were then incorporated into the CAFM system (CADD is one of the CAFM modules). To this day, the updates to the architectural and furniture arrangement drawings continue. For accountability and maintenance tracking purposes, operating equipment, computer equipment, and architectural elements were bar-coded and entered into the CAFM system.

The facility manager then made one of the wisest decisions. DLA hired the construction contractors to perform the first year of "warranty" maintenance. Equipment manufacturers and installers had been required to provide pertinent literature from which initial preventive and predictive maintenance procedures were developed. The bar-code system was and still is used to record O&M projects.

O&M data accumulated during the first year was used to develop outsourced maintenance contracts. This database is also used to determine rent charges (assessed quarterly, rate adjusted annually) that tenant organizations will pay. Rents are calculated to 1/1000th square meter and include several building services. The life-cycle replacement value of equipment and furniture is included in the quarterly rent.

When space modifications are requested, proposals including CADD design, cost estimate, and timelines are prepared so that tenants know what is to be paid for. Customized CAFM screens were developed for maintenance supervisors and tenants. These screens provide a direct link to the appropriate CAFM data; allowing supervisors to close O&M jobs and tenants to review data pertinent to their operation.

We have just described a range of "high-tech" customer care; but DLA also provides customer care with a human touch. Occupants were consulted during selection of new furniture for the facility. Personal touches, such as these, helped to ease the anxiety of the move and to

Early CAD layouts indicated that there was insufficient space in the original design. Two modules were added.

develop a rapport with the occupants of the new building. Two design features of the building were widely perceived as too austere. Some large concrete walls in the open work areas were not scheduled to be painted. When occupants described the appearance of these unfinished walls as "drab", the facility management staff responded quickly. After researching possible options, an inexpensive speckled paint treatment was selected. Up close, the paint has the look of polished stone; from a distance it looks like a carpet weave covering. Plants were added to soften the look in the common areas lining the central spine.

Through attention to detail and a genuine concern, every effort was made to satisfy the needs of the clients. Facilities management staff received training in customer service. The facility manager considered the training money well spent.

Success at DLA was neither unexpected nor uneventful. As described, many obstacles had to be overcome to ensure the efficiency of the facility and to address occupant concerns. Final evaluation of many energy and environmental design features is not complete, but early indications are positive. This facility is run like a business - rent is charged to compensate the government for services provided. The building was completed on-time and within-budget; but the real proof of the building's efficiency is manifested in the rents. Comparable facilities in the area are fetching over $325/square meter; DLA charges less than $250. With the list of features described above, it is a real bargain. The building has maintained an occupancy rate well over 80 per cent since opening - a true testimony to efficient success!

Appendix A

Facility Contact Information

If you have questions or comments about the findings in this document, please feel free to contact these professionals at the phone numbers listed.

USDA

Mr. Ed Murtagh
United States Department of Agriculture
1400 Independence Ave., S.W.
Washington, D.C. 20250
Tel. 202-720-5961 • Internet: ed.murtagh@usda.gov

Carbondale

Mr. Robert Bausch
Carbondale Federal Building
250 W. Cherry St.
Carbondale, IL 62901
Tel. 618-457-3666 • Internet: bob.bausch@gsa.gov

MILA

Mr. Tony Ippolito
Station Director/MILA Tracking Station
Building M5-1494
Mail Code: MILA
Kennedy Space Center, FL 32899
Tel. 407-867-3512 • Internet: tony.ippolito@gsfc.nasa.gov

Naval Station Everett

Master Chief Kevin D. Evans
Naval Station Everett
Public Works Department
2000 West Marine View Drive
Everett, WA 98207-5001
Tel. 425-304-3668 • Internet: evansk@everett.navy.mil

DLA

Gary Simpson
Defense Logistics Agency
Administrative Support Center
8725 john J. kingman Road
Ft. Belvoir, VA 22060-6220
Tel. 703-767-2049 • Fax 703-767-2048

For additional information about the NIBS Facilities Maintenance and Operations Committee, please contact:

Alexander (Sandy) Shaw
NIBS
1090 Vermont Avenue, NW, Suite 700
Washington, DC 20005
Tel. 202-289-7800 x.129 • Fax 202-289-1090
Internet: sshaw@nibs.org

Appendix B

NIBS Facility Maintenance and Operations Committee

William Brodt, Chairman
Facilities Engineering Branch
National Institutes of Health
Building 13 Room 2W48
9000 Rockville Pike
Bethesda, MD 20892

David J. Adams
Museum of Natural History, 79M, MRC 131
10th and Constitution Avenue
Washington, DC 20560

Ken Bever
Hartford Steam Boiler
One State Street
PO Box 5024
Hartford, CT 06102-5024

Bob Blackwell
Life Cycle Engineering, Inc.
5301 Robin Hood Road, Suite 108
Norfolk, VA 23513-2406

Edward G. Brewer
Manager Maintenance Engineering
Metropolitan Washington Airports Authority
Washington National Airport
Washington, DC 20001

James A. Carelock, Jr., P.E.
General Engineer
U.S. General Services Administration
PBS Property Management
18th and F Streets, NW
Washington, DC 20405

James Carmine Code 09B2
EFA Chesapeake
Naval Facilities Engineering Command
901 M Street, SE, Building 212
Washington, DC 20374-5018

Charles N. Claar, P.E.
Director of Research
International Facility Management Association
One East Greenway Plaza, Suite 1100
Houston, TX 77046-0194

David R. Conover
Senior Program Manager
Battelle Pacific Northwest Laboratories
901 D Street, SW, Suite 900
Washington, DC 20024-2115

Richard Coullahan
Vice President, Facilities Division
Parsons Brinckerhoff Energy Services, Inc.
465 Spring Park Place
Herndon, VA 22070

Stevan Csanady
FSC Proponent
NAVFAC Engineering Command
200 Stovall Street (Code 13146)
Alexandria, VA 22332

Paul C. Davia
LANTDIVNAVFACENGCOM
1510 Gilbert Avenue, Code 1614
Norfolk, VA 23511-6287

Ronald V. Descheneaux
Program Manager, Facilities Division
Parsons Brinkerhoff Energy Services, Inc.
Spring Park Technology Park
465 Spring Park Place
Herndon, VA 22070

Richard W. Earl
Program Manager, Facilities Division
Parsons Brinkerhoff Energy Services, Inc.
Spring Park Technology Park
465 Spring Park Place
Herndon, VA 22070

Christopher Forth
Joe Montross
TruGreen Chemlawn
8800 Kelso Dr.
Box 7824
Baltimore, MD 21221

Nick Ganick
Gobbell Hays Partners, Inc.
215 Fifth Street
Nashville, TN 37219

Bill Gebhart
NAVFAC, Code 922
200 Stovall Street
Alexandria, VA 22332

Steve Glazner
Director of Communications
APPA: Assoc of Higher Education Facilities Officers
1643 Prince Street
Alexandria, VA 22314-2818

Bill Harper
LANTDIVNAVFACENGCOM
1510 Gilbert Avenue
Norfolk, VA 23511-6287

K. Quinn Hart, P.E.
Mechanical Engineer
Systems Engineering
HQ AFCESA/ENM
139 Barnes Drive, Suite 1
Tyndall AFB, FL 32403-5319

Charles Hastings
Square D Company
15850 Crabbs Branch Way, Suite 210
Rockville, MD 20855-2622

William H. Hoffman
President
QuestCo. Inc.
218 N. Washington, Suite 46
Easton, MD 21601

Bob Hohenberg
Quality Assurance Specialist
U.S. Army Center for Public Works
7701 Telegraph Road
Attn: CECPW-FM
Alexandria, VA 22315-3862

Eric Jackson
Naval Facilities Engineering Command
Atlantic Division
1510 Gilbert Street, Code 1614E
Norfolk, VA 23511-6287

Heather James
Calibre Systems, Inc.
5111 Leesburg Pike, Suite 514
Falls Church, VA 22041

Peter Johnson
Office of Fee Developer (PCT)
General Services Administration
18th & F Streets, NW, Room 3326
Washington, DC 20405

Eli Katz
1105 Scott Oak Street
Hollywood, FL 33019

Chester A. Kirk, Jr., P.E., CPE
Asst. Superintendent, Senate
Office Buildings
First & C Streets, NE, Room SD-G45
Washington, DC 20510

Oleh Kowalskyj
Supervisory Engineer
Veterans Medical Center (FM-138)
500 W. National Ave.
Milwaukee, WI 53295

Greg Krisanda
Branch Chief, FAC/PS
Department of State
PO Box 12248 Rosslyn Station
Arlington, VA 22219

Craig Lasseigne
Landis & Gyr Powers, Inc.
1000 Deerfield Parkway
Buffalo Grove, IL 60089-4513

Barbara Lobrano
Director of Sales
Thomas Publishing Company
5 Penn Plaza, 8th Floor
New York, NY 10001

Richard McCrone (138C1)
Department of Veterans Affairs
810 Vermont Avenue, NW
Wahington, DC 20420

Steve McGibney
Office of Fee Developer (PCT)
General Services Administration
18th & F Streets NW Room 3326
Washington, DC 20405

William Morrison
ANGRC/CEC
Air National Guard Engineering and Services
3500 Fetchet Avenue
Andrews AFB, MD 20331-6008

Angie Naill
NAVFAC, Code 111
200 Stovall Street
Alexandria, VA 22332

Martin B. Newdorf
Department of Energy, FM-20
1000 Independence Avenue, SW
Washington, DC 20585

Andrew M. Perkins, Jr., Col.
ODASD(I)IM
400 Army Navy Drive, Suite 206
Arlington, VA 22204

Charlie Pittinger Code JX
Facilities Engineering Division-NASA
Two Independence Square
300 E Street, SW
Washington, DC 20546

James Plamborg
Sverdrup Facilities, Inc.
1001 19th Street, North, Suite 700
Arlington, VA 22209

Kent Reed
Leader Computer Integration Construction Group
National Institute of Standards and Technology
Gaithersburg, MD 20899

Tom Reemelin
Defense Logistics Agency
4819 Tabard Place
Annandale, VA 22003

Fidel Rodriguez
US Army Center for Public Works
ATTN CECPW-EB
7701 Telegraph Road
Alexandria, VA 22315-3862

Harvey Shultz
NORTHNAVFACENGCOM
10 Industrial Highway, MSC 82
Lester, PA 9113

Dana (Deke) Smith, AIA
Deputy Director Installation Management Reform
Office of the Deputy Under Secretary of Defense
(Industrial Affairs and Installations)
400 Army-Navy Drive, Suite 206
Arlington, VA 22202-2885

Ronald Smith
Chief, Building Operations Branch
Food and Drug Administration
Div of Facilities & Engineering Management
200 C Street, SW
Washington, DC 20204

William C. Thorson
Acting Director, Administration & Maintenance
US Dept of Housing and Urban Development
451 7th Street, NW, Room 4124
Washington, DC 20410

Michael J. Tillar
Executive Director
American Institute of Plant Engineers
8180 Corporate Park Drive, Suite 305
Cincinnati, OH 45242

Jeanne Trelogan
Property Management Specialist, CFM
GSA - PBS - PXOB
Room 4330
1800 F Streets, NW
Washington, DC 20405

Bill Troumbley
Installations Directorate
National Guard Bureau
111 South George Mason Drive
Arlington, VA 22204-1382

Anthony Vajda
USA Center for Public Works
7701 Telegraph Road
Alexandria, VA 22315-3862

M. Karen Walker
Pacific Northwest National Laboratory
901 D Street, S.W.   Suite 900
Washington, DC 20024-2115

Michael Weise
The Trane Company
2020 North 14th Street, Suite 408
Arlington, VA 22201

NIBS Consultative Council

Marvin J. Cantor, FAIA - Chairman, Architectural Offices
William H. Freeman, Jr. - Vice Chairman, Armstrong World Industries
Tom Frost - Secretary, BOCA International
Stephen B. Altizer, Clark Services, Inc., Div. Of Clark
Francis W. Biehl, P.E., Biehl Engineering, Inc.
Peter H. Billing, Institute for Business and Home Safety (IBHS)
Kenneth E. Bland, P.E., American Forest & Paper Association
Liza K. Bowles, NAHB Research Center
Dr. Andrew J. Fowell, Bldg and Fire Research Laboratory, NIST
C. Randal Gardner, United Association of Journeymen & Apprentices of Plumbing & Pipefitting Industry
David M. Hammerman, P.E., Howard County Dept of Inspections, Licenses and Permits
David B. Hattis, Building Technology, Inc.
Michael Jawer , Bldg Owners & Managers Assoc International
John B. Kelso, AIA, Kelso & Easter, Inc.
William E. Koffel, Koffel Associates, Inc.
William Kojola, Laborers International Union, Health & Safety Department
Frederick Krimgold, VA Polytechnic Institute & State University
David L. Ledvinka, OCC/NIBS
Gabor Lorant, FAIA, Gabor Lorant Architects, Inc.
Joseph R. Loring, P.E., Joseph R. Loring & Associates
W. Max Lucas, Ph.D., University of Kansas,
Charles A. Maresca, Jr., Associated Builders and Contractors
Vernon McDougall, United Brotherhood of Carpenters, Health & Safety Fund of North America
Dariush (Nick) Nikpourfard, Manufactured Housing Institute
Anthony R. O'Neill, National Fire Protection Association
Kenneth C. Pearson, ASTM Headquarters
O.L. Pfaffmann, Woods Construction, Inc.,
Todd S. Phillips, American Institute of Architects
Robert J. Pollock, Underwriters Laboratories, Inc.
Judit A. Quasney, National Institutes of Health
James A. Rossberg, Structural Engineering Institute, American Society of Civil Engineers
Mark Stephen Scott, CR, MARK IV Builders, Inc.
Dr. Paul A. Seaburg, University of Nebraska, College of Engineering & Technology
Dana K. Smith, Office of the Secretary of Defense
Richard A. Vognild, P.E., CBO, Southern Bldg Code Congress Intl., Inc.

NIBS Board of Directors

Thomas I. Young, FCSI, CCS - Chairman, SHG Incorporated
Steve M. Hays, P.E., C.I.H. - Vice Chairman, Gobbell Hays Partners, Inc.
Mary Ellen R. Fise, Esq. - Secretary, Consumer Federation of America
Michael L. McCune - Treasurer, Argus Real Estate, Inc.
Jack E. Buffington, P.E., Mack-Blackwell National Rural Transportation Study Center
Warren Friedman, Ph.D., CIH, HUD Office of Lead Hazard Control
Charles A. Gueli, Merrill Lynch Credit Corporation
Frank Hanley, International Union of Operating Engineers
J. Lee Hauser, P.E., N.C. Department of Insurance
William H. Hoffman, QuestCo, Inc.
John D. Hopkins, Jr., Owens Corning
James R. Irvine, The Conifer Group
Gerald H. Jones, P.E., Kansas City, MO
Jack Kelley, P.E., Nickerson & O'Day, Inc.
John H. Miller, P.E., Close, Jensen and Miller, P.C.
Monte L. Phillips, Ph.D., P.E., University of North Dakota
Arnold J. Prima, Jr., FAIA, Washington, D.C.
H. Terry Rasco, FAIA, Witsell Evans & Rasco, P.A.
Walter Smittle, III, Fire Marshal, State of West Virginia
David T. Still, Weyerhaeuser Company
Christine M. Warnke, Ph.D., Hogan & Hartson