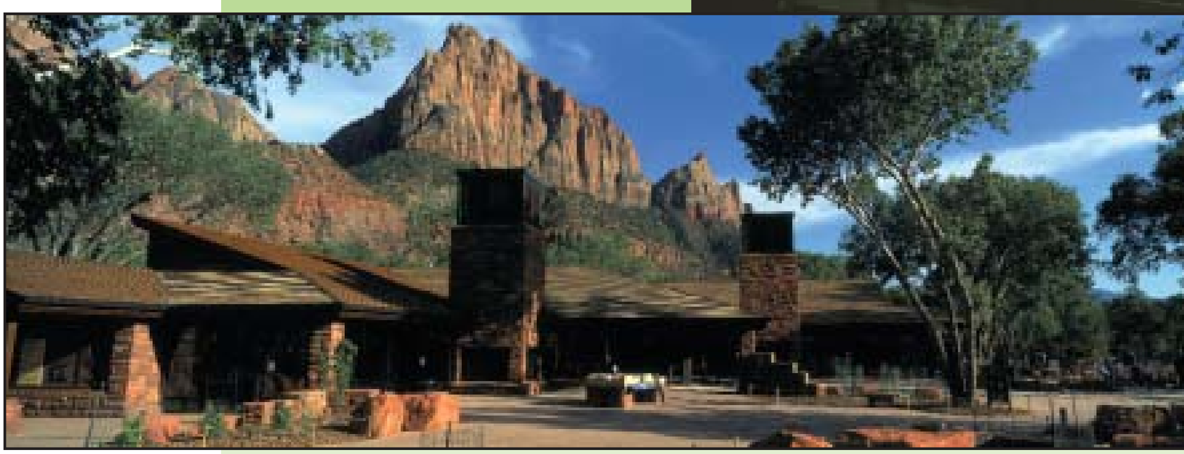
The Business Case for

SUSTAINABLE DESIGN IN FEDERAL FACILITIES



FEDERAL ENERGY MANAGEMENT PROGRAM

U.S. Department of Energy

Energy Efficiency and Renewable Energy

Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

The Business Case for

SUSTAINABLE DESIGN IN FEDERAL FACILITIES

Preface

The ethic of good economic and environmental stewardship is well established in the Federal government. The commitment of the Federal workforce to the sustainable use of natural resources runs deep. Yet, as concerns about the environmental and societal consequences of modern development increase and many agency budgets are being redirected, Federal decision-makers face new challenges. How can the government expand efforts to make public facilities energy efficient, secure, and healthy while minimizing their impact on the environment and providing good business value?

In addressing this question, many decision-makers initially believe that limited Federal budgets make the cost of meeting this challenge prohibitive. They assume that we must choose between environmental protection and economic efficiency. But, the real answer lies in sustainable design. Sustainable design does not have to increase the cost of constructing and operating a facility, and in some cases may actually lower first costs as well as often reducing operating costs and environmental impacts.

The Business Case for Sustainable Design in Federal Facilities dispels many misconceptions and provides a better understanding of the Federal government's effort to build a more sustainable real estate portfolio. The report illustrates many innovative ways that Federal agencies – of all sizes and from all parts of government – are using sustainable design principles to extract greater efficiencies from our public buildings and the tax dollars that pay for them. It also provides significant financial evidence from research findings and case studies that sustainable design is a smart business choice.

For more detailed information on the costs and benefits of sustainable design, download a copy of a complementary resource document on this topic at http://www.eere.energy.gov/femp/resources.

Acknowledgements

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On the cover:
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U.S. Department of Energy
Federal Energy Management Program (FEMP)
in collaboration with the
Interagency Sustainability Working Group

August 2003

Introduction

> The Federal government has many leaders in this field already, and together we can demonstrate that a sustainable building is healthier, more environmentally sound, operationally and economically viable, and the way we should be doing business.
>
> John L. Howard, Jr., Federal Environmental Executive

More than 15 years ago, in an era of increasing concern for population growth and the health of the global environment, sustainable development was first defined by the U.N. World Commission on Environment and Development. In the 1987 Bruntland Report, it was defined succinctly as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs."

This far-reaching concept of sustainability has three cornerstones:

- Environmental stewardship – protecting air, water, land, and ecosystems, as well as conserving resources, including fossil fuels, and thereby preserving the Earth's resources for future generations.
- Social responsibility – improving the quality of life and equity for individuals, communities, and society as a whole.
- Economic prosperity – reducing costs, adding value, and creating economic opportunity for individuals, organizations, communities, and nations.

In relating these principles to Federal buildings and facilities, the *Whole Building Design Guide*[1] describes a "sustainable" approach as one that supports an increased commitment to environmental stewardship and conservation, resulting in an optimal balance of cost, environmental, and societal benefits while still meeting the mission of the agency and the function of the intended facility or infrastructure.

The benefits of employing these principles are many. Building owners and operators can realize financial benefits including reduced waste disposal costs, reduced water and energy bills, and lower operating and maintenance costs. Other benefits, though not as well documented and often overlooked, include better occupant health and reduced absenteeism, increased worker productivity, heightened security, more effective recruitment and retention of top employees, and improved public image for organizations that build and operate sustainably.

Sustainable building owners also gain economic benefits associated with lower liability, reduced risk, and lower permitting costs resulting from early community acceptance and approval of sustainable projects. Society as a whole also reaps economic benefits in the form of reduced costs from air and water pollution and lower infrastructure costs.

Many indicators in the building industry point to fundamental changes that will reshape the way we design, construct, and operate buildings. Just three years ago, for example, no standardized system existed to evaluate a high performance green building, and only a few buildings across the country exhibited comprehensive sustainable design features.

Today, a diverse mix of more than 800 private and public buildings, comprising 91 million square feet, have registered for third-party certification under the nationally recognized Leadership in Energy and Environmental Design (LEED) green building rating system developed by the U.S. Green Building Council. Fifty-eight projects have completed certification and more than 700 are in the pipeline. Of these, 40 percent are state and local government projects and 10 percent are Federal projects.[2] Of the remaining 50 percent, many projects are registered by large private sector companies including Johnson & Johnson, Toyota, BP, Frito Lay, and Ford Motor Company.

Integrated Design

To reap full financial benefits, sustainable design must be considered at the outset of any project. Many design decisions, such as siting, shape, and building envelope, cannot be easily changed once a project is underway; yet they can mean the difference between a high performance building and a mediocre one. So, it is important to invest in smart design up front.

One concept, generally accepted as a first step, is to form an integrated, multidisciplinary design team. The team should include building owners, architects, engineers, landscape designers, maintenance/operations staff, general contractor and key subcontractors, cost consultants, and end-use representatives. This team works together at the earliest conceptual stages of a project, often using a workshop process referred to as a design "charrette." The purpose of the charrette is to develop a "whole building" design that best meets the economic and environmental interests of all parties.

Another concept that characterizes sustainable design is the integration of the specific architectural and mechanical features of the facility to minimize energy and resource use and reduce cost while maintaining comfort. When the project team commits early to a high level of building integration, they can fully explore and evaluate cost-effective trade-offs before commitments and contractual obligations are initiated.

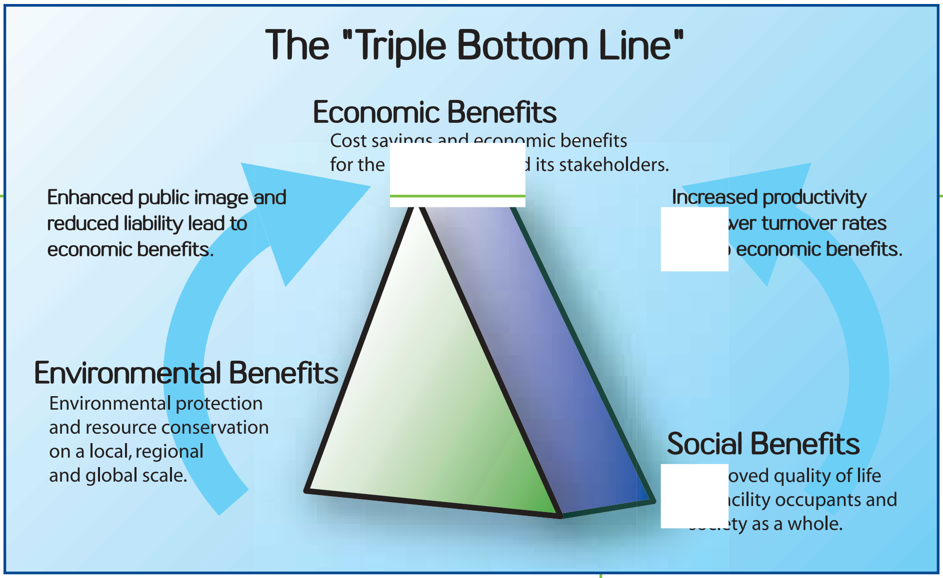
The team can achieve a sustainable design by integrating six fundamental strategies:

- Maximize the potential of the site;
- Minimize energy and resource consumption;
- Protect and conserve water;
- Use environmentally preferable products and materials;
- Enhance indoor environmental quality; and
- Optimize operational and maintenance practices.[3]

By employing these strategies, sustainable buildings in many cases can be constructed at the same or lower cost than conventional buildings. In other cases, integration of high-performance features can increase first costs from an average of two to seven percent, depending on the design and extent of features added.[4] Many of these features, however, generate operating cost savings that exceed additional first costs in a relatively short period of time. After that payback period, additional savings continue to accumulate over the life of the project.

The Federal Sector

The business case for sustainable design takes on special meaning when discussed in the context of the Federal government. The government has always been a leader in the green building movement, and efforts are paying off—literally. The government's energy use in its standard buildings has dropped 23 percent per square foot since 1985, saving taxpayers $1.4 billion annually.



Savings of this scale are the direct result of a number of Federal laws and Executive Orders that set energy efficiency and renewable energy goals for Federal agencies. For example, the Energy Policy Act (EPAct) of 1992 required all agencies to install energy and water conservation measures that have a payback period of less than 10 years.

Issued in 1999, Executive Order 13123 mandated energy reduction goals beyond EPAct levels, and required agencies to apply sustainable principles to design and construction of new facilities. The Order further requires Federal managers to use building lifecycle analysis on all projects.

Yet, many project managers still have trouble designing sustainable buildings. Because operating and maintenance (O&M) costs are appropriated separately from capital expenditures, they find it difficult to apply lifecycle cost analysis and consider capital and O&M collectively. Capital budgets are usually pre-set for construction projects, so increasing the budget to include the additional first cost of many sustainable design features is difficult, no matter how short the payback period may be.

Despite these difficulties, Federal facility managers, building professionals, and financial officers have become increasingly creative and adept at designing sustainable projects with no additional first cost expenditures. The following sections of this report offer examples of how Federal agencies can make sustainable design a standard practice rather than the exception.

We at the Department of Energy believe there can be a sound business case for the use of sustainable design options, and we encourage all Federal agencies to incorporate these options whenever possible.

—David Garman
Assistant Secretary
Office of Energy Efficiency and Renewable Energy
U. S. Department of Energy

Benefits of Sustainable Design

	ECONOMIC	SOCIETAL	ENVIRONMENTAL
SUSTAINABLE SITING	Reduced costs for site preparation and clear-cutting, and parking lots and roads. Lower energy costs due to optimal orientation. Less landscape maintenance cost.	Improved aesthetics (e.g., better appearance of site to neighbors). Increased transportation options for employees.	Land preservation. Lower resource use. Protection of ecological resources. Soil and water conservation. Reduced energy use and air pollution.
WATER EFFICIENCY	Lower first cost (for some fixtures). Reduced annual water costs. Lower municipal costs for wastewater treatment.	Preservation of water resources for future generations and for recreational and agricultural uses. Fewer wastewater treatment plants and associated annoyances.	Lower potable water use and pollution discharges to waterways. Less strain on aquatic ecosystems in water-scarce areas. Preservation of water resources for wildlife and agriculture.
ENERGY EFFICIENCY	Lower first costs, when systems can be downsized due to integrated energy solutions. Up to 70% lower annual fuel and electricity costs; reduced peak power demand. Reduced demand for new energy infrastructure, lowering energy costs to consumers.	Improved thermal conditions; better occupant comfort satisfaction. Fewer new power plants and transmission lines and associated annoyances.	Lower electricity and fossil fuel use, and the accompanying air pollution and carbon dioxide emissions. Decreased impacts of fossil fuel production and distribution.
MATERIALS & RESOURCES	Decreased first costs due to material re-use and use of recycled materials. Lower costs for waste disposal. Decreased replacement cost for more durable materials. Lower municipal costs for new landfills.	Fewer landfills and associated nuisances. Expanded market for environmentally preferable products. Decreased traffic due to use of local/regional materials	Reduced strain on landfills. Reduced virgin resource use. Healthier forests due to better management. Lower energy use for material transportation. Increase in local recycling market.
INDOOR ENVIRONMENTAL QUALITY	Organizational productivity improvements due to improved worker performance, lower absenteeism, and reduced staff turnover. Lower disability/ health insurance costs. Reduced threat of litigation.	Reduced adverse health impacts. Improved occupant satisfaction and comfort. Better individual productivity.	Better air quality inside the facility, including reduced volatile organic emissions, carbon dioxide and carbon monoxide.
COMMISSIONING; OPERATION & MAINTENANCE	Energy cost reduction. Reduced cost of dealing with complaints. Longer building and equipment lifetimes.	Occupant productivity, satisfaction, health, and safety.	Lower energy consumption, as well as air pollution and carbon dioxide emissions and other environmental impacts of energy production and use.

Financial Benefits

Siting

When an agency has the luxury of choosing the site for a building, it should take full advantage of this critical factor to increase a building's energy efficiency. Energy use can be dramatically reduced through appropriate orientation of a building to the sun. In addition, sustainable siting can reduce the costs of adverse environmental impacts by taking into account local habitat, agricultural lands, parkland, and wetlands, and reduce the likelihood of property damage due to flooding and mudslides. The inherent environmental benefits of a sustainable building can also be a significant advantage when dealing with zoning officials, regulatory bodies, and other interested parties. This can in turn speed the approval process and reduce legal, engineering, and other early costs associated with permits and environmental impact studies.

Same or Reduced First Costs of Construction

Through integrated design and use of sustainable materials and technologies, the first cost of a sustainable building can be the same as or lower than that of a traditional building. Through good planning and by eliminating unnecessary features, it is possible to offset the cost of more expensive sustainable features that not only meet environmental goals, but also result in lower operating costs. The design team intentionally conducts a trade-off exercise – e.g., trading the cost of optional features against the cost of features that will result in environmental or social improvements.

For example, by taking advantage of southern exposures, improving the energy efficiency of windows and walls, and spending more on daylighting, building designers can reduce the need for heating and cooling at the building's perimeter and reduce the need for electric lighting. This in turn allows designers to downsize the HVAC system plant and ductwork and the quantity of electric lighting so that there is no increase in the first costs of construction.

The Pennsylvania State DEP Cambria building is a good example of how first costs were reduced and long term value increased through integrated energy and design decisions. When designers first proposed an upgrade to high efficiency triple-glazed, double low-e windows, the developer balked at the $15,000 increase in cost. He was won over, however, when they were able to demonstrate that this upgrade would allow them to eliminate the perimeter heating zone for a savings of $15,000, downsize the heat pumps for another $10,000 savings, and gain $5,000 worth of additional leasable space as a result of smaller equipment and ducts.

Several key design and construction strategies that can reduce first costs include:[5]

- Re-using/renovating older buildings and using recycled materials;
- Optimizing energy systems and related building elements for energy efficiency and low lifecycle cost;
- Eliminating unnecessary finishes and features;
- Avoiding structural over-design and construction waste; and
- Reducing project size.

While a wide array of environmentally preferable building materials and products are more expensive, some can also have lower first costs, such as:

- Concrete with slag content or fly ash – up to $1.00 less per ton;
- Low-volatile organic compound (VOC) paint and recycled paint – $3 and $15 per gallon less expensive, respectively;
- Certified wood products – certified wood doors may be up to $150 less than traditional doors; and
- No-water urinals – over $280 less per urinal, because of lower plumbing costs.

Several Federal agencies, including the U.S. Navy, the Department of the Interior, and the Environmental Protection Agency (EPA), have designed and constructed sustainable buildings with no increase in previously budgeted building costs.

When EPA first received the construction budget for its campus at Research Triangle Park, North Carolina, they did not know how they could meet their environmental goals. However, by trading off some non-essential features, they were able to incorporate many sustainable building features at the same cost.


Atlantis Energy, Inc.

Thoreau Center for Sustainability at Presidio National Park, San Francisco

Sustainable materials often do double duty. The skylighted entryway at the Thoreau Center for Sustainability at Presidio National Park, San Francisco, CA, uses photovoltaic cells that are laminated to the skylight glass to produce electricity as well as to provide shade and daylight.

As one example, they replaced four-lane roads with two-lane roads, which had negligible impact on commuters and preserved acres of natural habitat. At the same time, this change reduced construction costs by $2 million.

Creating a space efficient design is another strategy to reduce first costs. The design team for the Zion National Park Visitors Center in Springdale, Utah made an early decision to move a number of exhibit spaces outdoors under permanent shade structures. This decreased the indoor floor space and the associated systems, and reduced the overall construction costs by 30 percent.

Lower Lifecycle, Utility, and O&M Costs

It is surprising to many experts and professionals that design and construction expenditures, the so-called "first costs" of a facility, account for just 5 to 10 percent of the total expenditures an owner will make over the span of a building's service lifetime. In contrast, operations and maintenance costs account for 60 to 80 percent of the total lifecycle costs.[6] Most features that increase first costs can significantly reduce lifecycle costs. Even for projects loaded with high value features, higher first costs are often recovered within three to five years.

Energy Cost Savings

Savings in energy costs of 20 to 50 percent are common as a result of integrated design, site orientation, energy efficient technologies, on-site renewable energy systems, natural daylight and ventilation, and downsized equipment. To illustrate this concept, FEMP developed and compared two detailed energy models of a prototype 20,000 square foot Federal building. The base case model simply met ASHRAE 90.1 energy requirements[7] while the second "sustainable" model optimized both energy and lifecycle cost savings. The results show that energy costs can be reduced below the base case by 37 percent by including a package of integrated energy savings measures that increase first costs by less than 2 percent, and provide a simple payback of 8.7 years. The sustainable model had a net lifecycle savings of over $23,000 during the course of the assumed 25-year lifetime.[8]

Sandia National Laboratories invested considerable design effort to improve the energy efficiency of their new Process and Environmental Technology Laboratory (PETL) in Albuquerque, New Mexico. Using energy modeling and life cycle costing to select advanced energy efficient systems, they reduced annual energy costs by more than 40 percent compared to preliminary design. Although the cost of the advanced features added just under $700,000 to the total building cost of $28.5 million, the projected annual energy savings of more than $200,000 pays back the higher first costs in less than four years. Actual annual savings have exceeded the savings projected by energy modeling.

An important aspect of achieving energy efficiency in a new building is "commissioning." Commissioning refers to the process of testing the performance of building systems to satisfy both the designers' intent and occupants' needs. Because of the interactive synergies between the various mechanical and electrical equipment and systems and the overall building architectural features, sustainable buildings require proactive commissioning.[9] Although commissioning adds a small portion to the up-front costs (0.5 to 1.5 percent of total construction costs or 1.5 to 2.5 percent of mechanical system costs), the annual energy savings are likely to recoup those costs in the first few years of operation.

In addition to commissioning a building before occupancy, buildings designed for sustainability should include a rigorous O&M program throughout their lifetimes. Studies of commercial buildings estimate an O&M-related energy savings potential of between 5 and 30 percent. One component of such a program can be the periodic recommissioning of equipment. The noted commissioning firm, Portland Energy Conservation, Inc., estimates an average cost of $0.17/ft^2$ for recommissioning existing buildings. If we assume that commissioning can deliver a 10 percent reduction in energy use, Federal buildings can make up the cost of commissioning in just 1.4 years on average.[10]

Water Cost Savings

A number of off-the-shelf technologies lower indoor water consumption and save money. Ultra-low-flow showerheads pay back in 1.5 years; low-flow faucet aerators pay back in four months; and no-water urinals have an immediate payback because they cost less to install than their traditional counterparts. Many Federal sites across the country have installed no-water urinals and other water saving devices with great success. Facilities can also lower potable water consumption by utilizing non-potable water for productive uses on site, installing re-circulating cooling water systems, initiating leak detection and maintenance activities, and using sustainable landscaping techniques.

Landscape Maintenance Cost Savings

Sustainable landscaping techniques decrease the costs for lawn mowing, fertilizers, and irrigation. PNNL recently compared a sustainable storm water management system—one that combines a porous gravel parking area with a rainwater collection system where rainwater is stored for supplemental irrigation of native landscaping—to a conventional asphalt parking area and a standard corrugated pipe storm water management system. The sustainable storm water system increases first costs by about $3,000, but saves more than $500 a year in maintenance costs alone, resulting in a payback of less than six years.[11]

Likewise, a sustainable landscape design that uses a combination of native warm weather turf and wildflowers to create a natural "meadow" area is compared to traditional turf landscaping of Kentucky blue grass that requires substantially more irrigation, maintenance, and chemical application. Although the study calculates the incremental first cost of the sustainable landscaping approach at $2,500, avoided irrigation, maintenance, and chemical costs add up to more than $3,000 in annual savings and therefore a payback of less than one year.[12]

Lower "Churn" Cost

A 1997 survey conducted by the International Facilities Management Association (IFMA) determined that, on average, 44 percent of building occupants move internally within a given year. This is called the "churn rate."[13] In government buildings, the churn rate appears to be somewhat lower at 27 percent.

Using a prototype 20,000 square foot office building, which serves approximately 100 occupants, annual churn cost savings between $35,000 and $81,000[14] could potentially be achieved if the building included moveable wall partitions and raised floor systems with under-floor HVAC and cabling instead of traditional ceiling systems. Although the cost of under-floor systems can sometimes be slightly higher up front, they make it much easier to install air handling systems, as well as cabling for electric outlets, computers, and telephones. Plus, the air handling equipment usually costs less for under-floor systems than systems in the ceiling.

Sustainable design approaches and new technologies are proving that we can save energy and resources without sacrificing our comfort and efficiency. We are encouraging sustainable design in every way possible.

—Beth Shearer
Director
Federal Energy Management Program
U. S. Department of Energy

CASE STUDY: Nathaniel R. Jones Federal Building and U.S.Courthouse, Youngstown, Ohio

Peter Aaron/Esto

SUSTAINABLE DESIGN FEATURES

- Brownfield redevelopment
- Recycled and locally supplied building materials
- Recycling of construction waste
- Daylighting
- Low-emitting materials
- Native, low-water plants and no irrigation

Land Use

In redeveloping the site, a 79,000 sf. paved area was restored and landscaped with native vegetation, eliminating the need for irrigation and saving over 1 million gallons of water at an approximate cost of $2,000 each year. All earth and foundation materials excavated from the original site were reused, saving over $70,000.

Peter Aaron/Esto

Sustainability in building design, construction, and operation is fundamental to and indivisible from our core agency mission of providing a world-class workplace for the federal workers and superior value for the American taxpayer.

F. Joseph Moravec
Commissioner,
Public Buildings Service
General Services Administration

Completed ahead of schedule and under budget in September 2002, the new Nathaniel R. Jones Federal Building and U.S. Courthouse in Youngstown, Ohio was designed and constructed shortly following the establishment of GSA's Construction Excellence Program. The program objectives are to increase efficiency, reduce construction costs, and improve building value. To meet these objectives, the Courthouse project team incorporated many sustainable design principles, which resulted in a U.S. Green Building Council LEED certification and a positive impact on downtown Youngstown's cityscape.

The building sits on a restored brownfield site. Previously paved areas were naturally restored and replanted with native vegetation, thereby reducing impervious areas by 58 percent. Reuse of excavated earth and foundation materials, as well as reusing and recycling all concrete, steel, and metal debris, saved the project over $100,000. Additionally, as a result of the building materials and design, which incorporates strategies such as daylighting, the facility will save 10 percent in electricity bills and 22 percent in heating costs over a similar facility, resulting in estimated annual savings of $20,000.

The team incorporated regional design traditions and local, recycled building materials to convey dignity and strength appropriate to a Federal courthouse. The LEED-certified building was recognized for using over 62 percent of locally-manufactured materials.

Building Materials

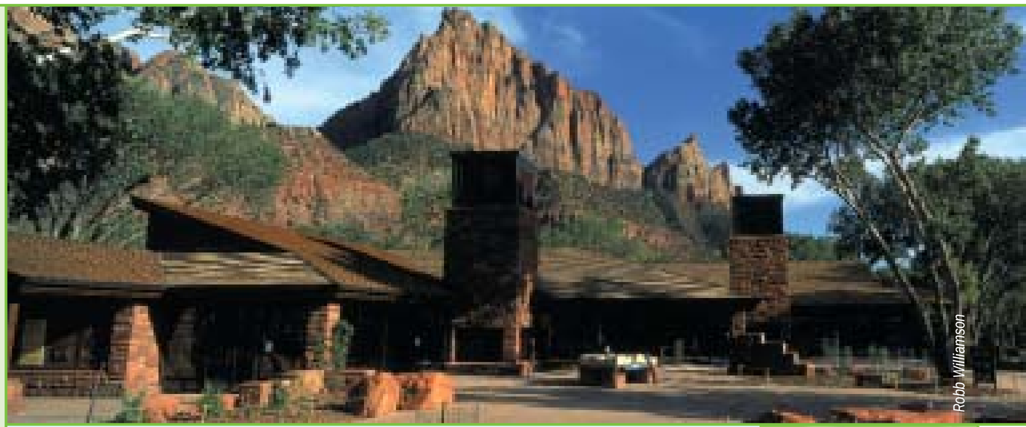
The majority of building materials—such as structural steel with 90 percent post-consumer recycled content—were manufactured locally. 600,000 pounds of recycled concrete were crushed and reused, saving $30,000.

Peter Aaron/Esto

Indoor Environment

To avoid health problems, the building uses low-VOC recycled carpeting. Additionally, 75 percent of the indoor space is daylit, presenting a brighter, improved work space with better outdoor views for employees.

CASE STUDY: Zion National Park Visitors Center
Springdale, Utah


Robb Williamson

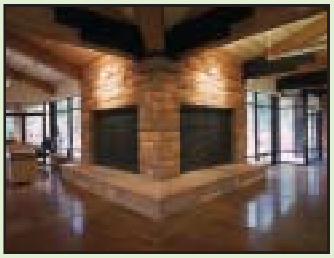
SUSTAINABLE DESIGN FEATURES
- Natural ventilation and evaporative cooling
- Passive solar heating
- Daylighting and sunshading
- Computerized building controls
- Uninterruptible power supply

Heating


Paul Torcellini

A passive solar wall, shaded in summer, provides heating of the open spaces and private offices located adjacent to the wall. Heat from the sun is trapped between a pane of glass and a black, selective coating. A masonry wall stores the heat for release into the building later in the day.

Cooling


Robb Williamson

Passive down-draft cooltowers bring the temperature down when natural ventilation is not adequate. Water is pumped onto a honeycomb media at the top, cooling the air by evaporation. The cool air descends naturally through the tower and into the building. Strategically placed windows eliminate hot air and optimize circulation.

Electricity


Robb Williamson

Minimal electric lighting costs and no need for air conditioning significantly reduce operations and maintenance costs as well as the peak electric load. A 7.2 kW photovoltaic system provides the majority of electricity needed by the building.

An integrated design team of architects, engineers, and energy consultants used a “whole building design” for the Zion National Park Visitors Center. From the onset of the conceptual plan through the completion of the commissioning process, the team worked together to ensure that the building envelope and systems complemented each other to achieve dramatic environmental benefits and significant cost reductions.

The Center costs less to operate because it uses 70 percent less energy than would a comparable facility. Savings are due in part to the building overhangs, clerestory windows, roofline, and materials selection. Lighting needs are met primarily with daylighting, complemented by a high-efficiency electric lighting system and related controls. By installing a passive solar wall and a few radiant panels that provide the heat, the designers avoided the entire cost of a central heating system, the need for a hot-air furnace or boiler, and all the expenses associated with ductwork and piping. These energy efficient features save approximately 250,000 kWh and $14,000 per year.

While the integrated design team applied sustainable features to reduce energy costs, they kept the building cost comparable to that of a "typical" building. This was primarily due to an early decision to move many of the exhibit spaces outdoors, which decreased the building size, construction materials, and floor space required for building support functions (ducts, large blowers, chillers, and boilers). In fact, this project’s construction cost (excluding the photovoltaic system) was estimated to be about 30 percent less than a conventional visitor center.

An integrated design team of architects, engineers, and energy consultants employed a “whole building design” philosophy when planning the Zion National Park Visitors Center.

This sustainable building’s construction cost was about 30 percent less than that of a conventional visitors center.

When the entire system is considered, the first cost difference is usually small, and the annual churn savings quickly recoups the cost. The under-floor system also enables individual occupants to personally control ventilation rates and temperature, further enhancing their comfort and productivity.

A case study for the Rachel Carson State Office Building, a Pennsylvania government office building with 1,500 work stations, indicates that a high-performance green building with a raised floor system would achieve annual cost savings of more than $800,000.

Reduced Liability and Risk

The Environmental Protection Agency classifies indoor air quality as one of the top five environmental health risks today. According to a study by the American Medical Association and the U.S. Army, health problems caused by poor indoor air quality cost 150 million workdays and about $15 billion in lost productivity each year in the United States.[15] Exacerbating the drain on the economy caused by this preventable health problem, the issue of sick building syndrome (SBS) increasingly ends up in the courts where the financial costs continue to mount.

BusinessWeek's June 5, 2000 cover story reported that "sick building" cases, often filed against building owner/operators, are becoming more and more common. Building owners and operators face high-cost lawsuits when their buildings are claimed to have caused illness among occupants—whether the case is won, lost, or settled.

- In 1995, a Florida state jury awarded Polk County, FL almost $26 million to enable it to correct the A&E firm's design and construction flaws in its eight-year-old courthouse. (The actual renovations ended up costing $37 million.)

- In 1996, a jury found DuPage County, Illinois, responsible—as the building owner—for health-related complaints at its $53 million courthouse, calling the problems a result of improper building operation and maintenance.[16]

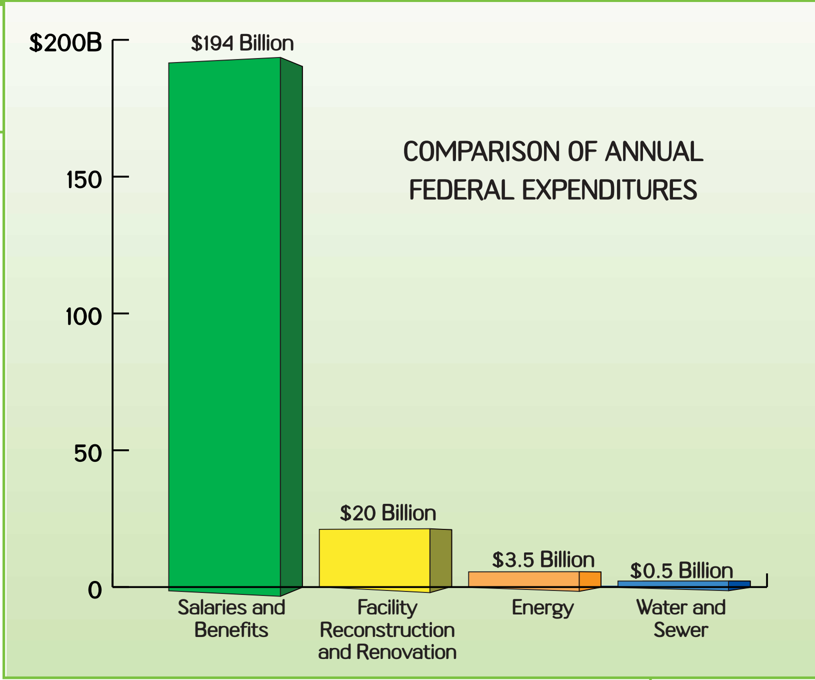
The fact that both builders and owners of buildings have been held liable highlights the importance of addressing indoor air issues in all stages of building design, construction, and operation. With the recent explosion in mold-related claims, for example, insurance companies have begun to take defensive action with mold exclusion clauses and premium rate hikes. On the other hand, some insurance companies are willing to offer lower insurance premiums for buildings and facilities with positive environmental effects. DPIC—the nation's largest liability insurer—offers a 10 percent credit for organizations that practice commissioning. Hanover Insurance offers 10 percent credits for earth-sheltered or solar buildings on the basis of reduced fuel-based heating systems and fire risk.[17]

Improved Productivity and Health

While poorly designed and operated facilities can create serious health problems, a number of studies show that sustainable buildings can have positive impacts on occupants. A growing body of research and empirical evidence indicates that building occupants have a higher satisfaction level, better health, and improved personal productivity in high performance buildings.

Given that labor costs dwarf other building operating expenses, large organizations cannot afford to overlook sustainability features that can lead to enhanced productivity and improved worker health. Comparing relative operating costs for a commercial building, on average, annualized costs for salaries and benefits amount to $200 per square foot—compared with $20 per square foot for bricks and mortar and $2 per square foot for energy.[18] Likewise in the Federal sector, as a percentage of total expenditures, personnel costs far exceed energy or building maintenance costs. (See the chart on the next page for annual Federal expenditures for personnel versus construction and utilities.[19])

Sustainable design for healthy interiors involves use of low-VOC materials (paint, carpets, fabrics, etc.); good ventilation and personal control of temperature and lighting; daylighting and views of the outdoors (while avoiding glare); and noise control through use of acoustic buffers, floating floor slabs, and sound insulation. With effective trade-offs, none of these individual features need to collectively increase the total construction budget.



Improved Worker Performance and Operational Productivity

Emerging research studies point to a strong correlation between healthy buildings and labor productivity. Many experts agree that the worker performance benefits associated with sustainable building technologies and practices overshadow the savings associated with more measurable building performance gains. Several case studies indicate a direct correlation between sustainable design and productivity increases from 6 to 16 percent.

- Reno Post Office: Due to a $300,000 lighting and HVAC renovation, worker productivity increased by 6 percent. Energy savings came to more than $22,000 per year, with an additional $30,000 savings from eliminating recurring maintenance costs. Including these savings, productivity gains were worth $500,000 per year.[20]

- Pennsylvania Power & Light: A simple $8,000 lighting upgrade resulted in an annual electricity cost reduction of approximately $2,000, for a 24 percent return on investment and a payback of four years. More significantly, however, productivity jumped 13 percent, worth more than $44,000 per year, reducing the payback period from four years to 69 days.[21]

- West Bend Mutual Insurance: This insurance company's new headquarters, with daylighting, advanced energy technologies, and personal workspace controls, decreased annual electricity costs by 40 percent. The building was subject to a rigorous study by Rensselaer Polytechnic Institute, which concluded that "...the new building produced an increase in productivity of approximately 16 percent."[22] Since the company's annual salary base was $13 million, a 16 percent productivity increase could be translated into a dollar value of $2,080,000 per year.

Drawing on a wide review of research on indoor air quality and thermal conditions, researchers estimate that providing workers with temperature control of just three degrees (plus or minus) may result in performance increases of 7 percent for typical clerical tasks, 2.7 percent for logical thinking tasks, 3 percent for skilled manual work, and 8.6 percent for very rapid manual work.[23, 24]

A study of windows and views in seven buildings in the Pacific Northwest found that employees in work areas with windows were 25 percent to 30 percent more satisfied with lighting and with the indoor environment overall, compared to those with reduced access to windows.[25] Window views may be especially effective in providing micro rest breaks of a few minutes or less, which have positive impacts on performance and attention.[26]

Better Worker Health and Reduced Absenteeism

A recent study by Lawrence Berkeley National Laboratory found that commonly recommended improvements to indoor environments could reduce health care costs and work losses from communicable respiratory diseases by 9 to 20 percent; from reduced allergies and asthma by 18 to 25 percent; and from other non-specific health and discomfort effects by 20 to 50 percent. The same study estimated that potential national savings from health and productivity gains after indoor environmental quality improvements would fall somewhere between $17 to 48 billion.[27]

CASE STUDY: Naval Base Ventura County - Building 850

Port Hueneme, California

Sustainable design is an integrated approach to facility engineering and management. Since sending out policy over five years ago, the Naval Facilities Engineering Command has been following a course of action demonstrating engineering leadership through a proactive commitment to environmentally sustainable facilities. Word is getting out that the Navy is providing leadership in sustainable development, that we are leveraging the benefits of integrated design of shore facilities in harmony with the environment to reduce the total cost of ownership of facilities.

–Rear Admiral Michael R.Johnson,
Chief of Engineers,
Naval Facilities
Engineering Command

The designers of Building 850 wanted to fully demonstrate sustainable design and construction practices that can be applied to other Navy projects and facilities throughout the Federal government. The building serves as a learning center where technologies are highlighted and displayed, including an interactive touch screen computer kiosk that provides a real-time view of building energy demands and green features.

An expanded interdisciplinary design team engaged in a series of workshops to ensure efficient integration of building systems that would reduce first costs as well as operating costs. For example, the design team incorporated daylighting and natural ventilation systems to downsize HVAC equipment. They also optimized the building envelope, minimized internal loads, and generated on-site power from renewable sources. As a result, Building 850 will save 64 percent in lighting, 46 percent in plug loads, 67 percent in heating, and 43 percent in cooling expenses each year.

The designers also wanted to create a highly productive work environment through space planning, lighting quality, thermal comfort, and indoor air quality. All work areas have outdoor views, and nearly all visual task areas are daylit with windows and clerestories.

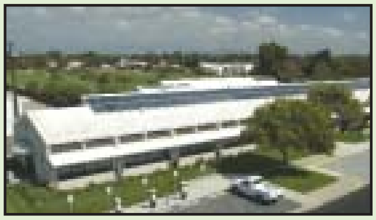
SUSTAINABLE DESIGN FEATURES

- Photovoltaic power generation
- Solar water heating
- Daylighting
- High-efficiency lighting and HVAC equipment
- Natural ventilation
- Recycled and healthy building materials
- Sustainable landscaping
- Gray water recovery system

Water

Waterless urinals, low-flow toilets, automatic lavatory faucets, and low-flow showerheads have a short pay-back period by reducing indoor water consumption by more than 40 percent. Captured rainwater and reclaimed lavatory gray water are used for toilet flushing. Outdoors, drought-tolerant native plants require minimal irrigation.

Energy



A 30 kW photovoltaic array supplies 68 percent of the total annual energy for the building. It can provide 100 percent of the building's power needs on sunny days during months when there is little or no cooling load. Excess power is routed to the electrical grid for other base requirements.

Lighting

The design makes use of 100 percent natural daylighting during normal working hours. High efficiency lighting provides additional illumination during the evening hours or cloudy conditions; a microprocessor lighting control system uses dimming ballasts and photo sensors to maintain desired lighting levels.

CASE STUDY: Environmental Protection Agency Campus
Research Triangle Park, North Carolina

SUSTAINABLE DESIGN FEATURES

- Preservation of old-growth trees
- Minimal disruption to habitats and wetlands
- Native plantings and natural treatment of stormwater runoff
- Sunshading and daylighting
- High-efficiency chillers, boilers, and fume hoods
- Water-conserving toilets, urinals, and faucets
- Recycled building materials
- Recycling of construction waste

Landscaping

Landscaping with indigenous plant materials saved money on irrigation, fertilizer, and pesticides. Biofiltration methods cost no more than the construction of curbs and gutters for handling stormwater runoff. Runoff is treated naturally using soil and plants to remove contaminants.

Building Materials

Durable materials save money on long-term maintenance expenses. Materials include local brick; recycled-content concrete; recycled asphalt; sustainably-harvested wood from certified sources; low-VOC paints, adhesives, caulks, and sealants; and recycled-content products such as gypsum board, ceiling tile, and rubber floor tile.

Daylighting

An open floor plan maximizes daylighting of interior spaces. Daylighting provides 70 percent of the lighting requirements in the offices and 43 percent in the labs.

When designing its new campus at Research Triangle Park, EPA committed to build a high-performance facility at a reasonable cost with reduced environmental impacts. A multi-disciplinary design team evaluated a wide range of options at every step of the design to balance cost, functionality, and environmental performance. As a result, they successfully integrated sustainable features into a state-of-the art laboratory and office complex at no extra cost to the original budget.

The team chose to eliminate various non-critical building features in order to meet a group of pre-set environmental goals and reduce increases in first costs. For example, the team wanted minimal disruption to surrounding woodlands, so they traded off 700 of their total 2,500 parking spaces and constructed a multi-story parking garage rather than pave a larger lot in concrete. EPA then offered employees incentives for carpooling and alternative transportation.

Many other environmental strategies resulted in significant economic savings. Replacing four-lane roads with two-lane roads preserved natural habitat and saved $2 million on construction. Optimizing glass in the atrium saved $200,000 on construction and an estimated $130,000 in energy bills over 20 years.

EPA produced a healthier, more productive facility and lowered the total project cost by $30 million. Annual energy costs are 40 percent less than a similar facility, saving approximately $1 million per year.

The team's sustainable design produced a more productive facility and lowered the total project cost by $30 million.

Arizona Army National Guard Ecobuilding

The Arizona Army National Guard's Ecobuilding in Phoenix is an adobe style office building that is completely independent of conventional utilities, including electricity, sewer, and municipal water. It is constructed with many recycled materials, including 5,000 used tires and windows taken from buildings previously scheduled for demolition. Other sustainable strategies include a closed-loop wastewater treatment system; passive solar design; daylighting; solar-powered evaporative cooling; and rainwater harvesting and collection. The building is powered by four 400w wind turbines and an 18 kW PV array. Each year the building saves approximately $6,750 in electricity costs and 60,000 gallons of water.

Recent studies are also demonstrating how certain features of sustainable buildings have a positive impact on health and well-being, and lead to lower absenteeism:

- A study of absenteeism among 3,720 employees at a large East Coast company found that the absenteeism rate was 35 percent lower in offices with higher ventilation rates. The study showed that an annual cost savings of almost $25,000 per 100 employees could be achieved through a one-time investment of $8,000 per 100 employees in improved ventilation systems.[28]

- A study of 11,000 workers in the Netherlands found that absenteeism due to sick building syndrome is likely to be 34 percent lower when workers have control over their own thermal conditions.[29]

Other financial impacts occur when building occupants are uncomfortable because building maintenance engineers spend unnecessary labor hours dealing with complaints. One study estimated that simple efforts to increase comfort could result in a 12 percent decrease in labor costs attributed to responding to complaints.[30] Another report indicated that personal controls for HVAC systems (which can be implemented only by using under-floor air distribution systems rather than ceiling systems) reduces complaints to as low as 10 calls per 1,000 employees per year.[31] Less time dealing with complaints leads to more time to complete preventative maintenance, better equipment longevity, and lower operating costs overall.

Improved Image

While difficult to quantify, the positive image associated with an agency that builds or occupies sustainable buildings can result in employee pride, satisfaction, and well-being. This can translate into reduced turnover, improved morale, and a more positive commitment to the employer. These effects can also develop the building owner's reputation as a desirable employer, which in turn creates a business advantage for attracting, recruiting, and retaining talented employees and reducing labor replacement and training costs.

A high performance building is one of the most externally visible expressions of an organization's commitment to sustainable values. In addition to employee morale, an organization that owns and operates a sustainable building will tend to capture intangible value through stakeholder awareness and respect. The building's distinctive character can be a symbolic message to visitors, community officials, and the public. Key messages conveyed by a sustainable building include technological advancement, business innovation, and concern for the environment. When the building reinforces the primary mission of the organization (e.g., environmental protection, energy efficiency, technological innovation), this "image value" is particularly powerful.

Environmental and Societal Benefits

Sustainable design also provides a number of environmental and societal benefits including reduced infrastructure requirements, improved safety and security, increased power reliability, and less pollution.

Improve Occupant Safety, Increase Electricity Reliability, and Enhance National Security

Since September 2001, public agencies and private companies have focused great attention on building security issues, especially in high-visibility public places and government office buildings. Federal facilities will no doubt receive a large share of the nation's total investment in security upgrades. As a result, large Federal facilities offer significant opportunities to integrate energy efficiency measures with security-driven investment decisions. This integration encompasses capital investments and operating practices, including building envelope components, mechanical equipment, lighting, ducts, and on site-power generation. Considering these issues in a whole building approach, the resulting energy savings may be able to reduce the net cost of security improvements. Calculating and building in the energy savings would make the security improvements more affordable and allow them to be incorporated more extensively than would otherwise be possible.

Just a few features with a dual benefit of security and energy efficiency[32] include:

- Tighter building envelopes reduce energy losses from infiltration while reducing entry of airborne hazards released outside;
- Daylit spaces may be easier to evacuate in the event of a threat accompanied by a power outage;
- On-site, renewable power systems improve reliability during grid-connected power outages;
- Window upgrades may improve blast resistance as well as thermal and optical performance; and
- Security lighting designed in concert with automated sensing and surveillance systems can improve detection capabilities while reducing the need for constant high nighttime lighting levels.

The Pentagon renovation project provides good examples. The Department of Defense reports that a spray-on wall coating selected to improve blast-resistance at the Pentagon also improves the air-tightness of the building envelope, saving heating and cooling energy and protecting against releases of airborne chemical and biological agents. New blast resistant windows are also 50 percent more energy efficient than the original windows. Photo-luminescent signs marking evacuation routes are easier to see than conventional ceiling mounted exit signs and require no standby power. Finally, zoned climate control systems make it easier to control smoke and manage the spread of chemical or biological toxins, while also reducing heating and cooling energy use and improving indoor air quality.

From a national perspective, energy efficiency and renewable energy technologies also contribute to U.S. domestic security by lowering our dependence on imported oil and gas. Moreover, critical and essential services provided by government agencies depend on reliable power for their operations. Buildings powered by on-site renewable or super-efficient energy systems, such as photovoltaics and fuel cells, are less susceptible to supply interruptions due to unpredictable circumstances such as natural disasters, power glitches, and world events.

Reduce Infrastructure Costs

By carefully locating and siting Federal facilities, and reducing the resources and raw materials required to service them, Federal agencies can reduce the need for new roads and other infrastructure investments – costs born by neighboring communities.

Some examples include:

- Site buildings near public transportation; include design features that encourage alternative transportation rather than use of personal vehicles in order to reduce air pollution and avoid highway expansion;
- Redevelop brownfield sites or locate new buildings in downtown areas rather than suburban or rural greenfield sites in order to stimulate urban economic development and reduce or eliminate infrastructure costs for new power supply, sewer systems, and roads;

National Institutes of Health, Louis Stokes Laboratories/ Building 50

The energy-efficient design of the National Institutes of Health, Louis Stokes Laboratories/ Building 50 includes desiccant energy recovery wheels, variable air volume systems, variable frequency drive motors, programmable high efficiency lighting, daylighting, occupancy sensors, and efficient water fixtures. With these high-performance features, the facility uses less than half the energy of a conventional laboratory building.

- Use recycled materials and construction waste management practices in order to reduce the need for new landfills; and
- Conserve water to reduce the size and need for new water treatment plants.

Reduce Pollution and Ecosystem Impact

From construction through operation and demolition, buildings and infrastructure consume vast quantities of energy and natural resources and thereby result in many adverse impacts, including:

- Acid rain and mercury pollution that damage vegetation, wildlife, and human health;
- Spills and runoffs of oil and toxic materials that spoil marine ecosystems and contaminate ground water and soils; and
- Air pollution that affects human health, alters weather patterns, and disrupts the atmosphere.

To mitigate these impacts and avoid the societal costs associated with them, sustainable design includes choosing sites that do not disturb agricultural lands, habitats for threatened species, wetlands, parklands, and natural or cultural relics. It can also involve reuse of existing buildings or siting new facilities on brownfields. Designers consider how to best orient the building to the sun; use topography to optimize building energy factors; and locate near public transportation, among other considerations.

Environmental benefits associated with sustainable design do not always translate into cost savings for building owners. But in some cases they can. For example, in New Jersey and five other states, building owners receive emission credits when they invest in energy efficiency and thereby reduce the air pollution associated with electricity. Building owners sell these emission credits on the open market to power plants and others, for prices ranging from $90 to $272 per ton of emissions.[33]

As this report demonstrates, great progress has been made in developing sustainable building methods that have far less environmental impacts. Accelerating the trend of sustainable design will result in significant benefits to society, including protection of our air and water and restoration of natural ecosystems.

Conclusion

The Federal government is the nation's largest landlord, with more than 500,000 buildings and facilities. As such, it has a tremendous opportunity and a clear responsibility to lead by example on sustainable design and construction, and will reap many financial and other benefits by doing so. These benefits include:

- Same or reduced first costs. Integrated natural heating and cooling, daylighting, recycled materials, efficient space planning, and the use of new technologies can in many cases reduce first costs of construction and environmental impacts;

- Lower operating and maintenance costs. Energy and water saving technologies, indigenous landscaping, commissioning, and longer-lasting materials can save money over their lifetimes that far exceed their higher first costs;

- Better health and increased productivity. Studies link worker health and productivity to sustainable features including good ventilation, personal controls, daylighting, and low-VOC materials. Organizations can lower absenteeism, improve quality, and increase output when buildings are more comfortable and healthier places to work;

- Enhanced security. Sustainable design can improve occupant safety, increase electricity reliability, and enhance security of government operations; and

- Better image. Community acceptance and political support, ease of siting and permitting, and ability to attract and retain top employees have all been attributed to sustainable facilities.

Federal decision-makers should continually challenge themselves to:

- Establish sustainable design goals early in the planning stages and aim for a minimum of a LEED Silver rating, with additional emphasis on energy efficiency and indoor air quality;

- Bring together a multi-disciplinary design team with all building stakeholders, and include them in a design charrette at the outset of the project;

- Strive for a "whole building" design that integrates the architectural and mechanical features of the building in relation to its environment;

- Evaluate lifecycle costs in all design and financial decisionmaking;

- Consider making new types of trade-offs, including foregoing certain traditional building electives in order to pay for some more expensive sustainable features; and

- Maintain a commitment to integrate sustainable design principles and practices throughout the design, construction, and operation of the facility.

These challenges are sizable but achievable. Meeting them will result in buildings that are better suited to live and work in, as well as a healthier environment, a stronger economy, and a more secure future.

PRIVATE SECTOR CASE STUDY: Herman Miller Marketplace
Zeeland, Michigan

Herman Miller constructed the building at an economical $89 per square foot.

Sustainable design is not only being implemented in the Federal sector. Many private sector companies are instituting sustainable design policies and practices as part of their standard operations.

With a strong commitment to sustainable design, Herman Miller, Inc. built a model for environmentally sound, economically viable, and productive places to work. Sustainable strategies for natural light and fresh air, as well as siting, energy use, and materials, were incorporated into the project from the beginning. The result was a Gold LEED certification and operational cost savings that make the building a national benchmark for sustainable and energy efficient design.

The close working relationship between the architect, client, and contractor helped ensure the project's success. Project budgets and sustainable goals, such as increasing HVAC efficiency and minimizing electric lighting, were continually tracked throughout the project. As an additional motivator, the lease agreement also tied the base rent directly to achieving at least a Silver LEED rating.

Herman Miller constructed the building at an economical $89 per square foot—$46 per square foot less than they have spent on traditional construction of their other offices—saving more than $4 million. In fact, the facility saved 33 percent in building costs; 44 percent in utility costs; and 66 percent in churn costs over a traditional 100,000-square-foot building with a 7-year lease. Operational cost savings are documented at more than $1 million over the lease term.

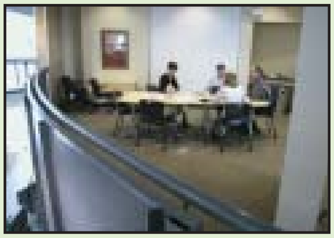
We are deeply committed to sustainable architecture. Our experience has proven that these investments can also deliver significant financial returns.

Mike Volkema
Chairman, President and CEO, Herman Miller

SUSTAINABLE DESIGN FEATURES

- Daylighting and open floor plan
- Operable windows and occupant thermal controls
- High-efficiency and task lighting
- Computerized building controls
- Low-water use fixtures
- Recycled and locally-supplied building materials
- Indigenous, drought-resistant vegetation

Indoor Environment



The company wanted to create a "great place to work" in order to attract the best talent and retain top employees. The building has an open floor plan with large exterior windows and high ceilings to increase daylight. Employees can control both temperature and lighting in their personal work areas.

Land Use

To benefit the community and reduce the environmental impacts of commercial development on the environment, green spaces were incorporated into the parking lot and its size was decreased. Special parking spaces close to the building encourage carpooling and the use of alternative fuel vehicles.

Energy

The building incorporates an efficient HVAC system that reduces energy costs by 40 percent. Carefully selected, high efficiency light sources combine with daylight to minimize lighting system energy demands.

Endnotes

1 *Whole Building Design Guide*, www.wbdg.org/design

2 U.S. Green Building Council. 2003. *Building Momentum: National Trends and Prospects for High-Performance Green Buildings.* Washington, D.C.

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5 Many of these concepts were outlined in "Building Green on a Budget," found at: http://www.betterbricks.com which cited: *Environmental Building News*, May 1999.

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8 Federal Energy Management Program, U.S. Department of Energy. 2003. *The Business Case for Sustainable Design in Federal Facilities* (Resource Document). http://www.eere.energy.gov/femp/resources

9 U.S. General Services Administration and U.S. Department of Energy. 1998. *Building Commissioning Guide Version 2.2*. http://www.eren.doe.gov/femp/techassist/bldgcomgd.html

10 Portland Energy Conservation Inc., *What Can Commissioning Do For Your Building?* (Brochure from the Federal Energy Management Program, U.S. Department of Energy).

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12 Federal Energy Management Program, U.S. Department of Energy. Op. Cit.

13 The churn rate is defined as the total number of moves made in a 12-month period, divided by the total number of occupants, multiplied by 100 (to obtain a percentage).

14 This figure assumes 27 moves at a savings of approximately $3000 per move (which is the rough difference between a "construction" move and a "furniture" move.)

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17 Mills, E. 2003b. "The Insurance and Risk Management Industries: New Players in the Delivery of Energy-Efficient Products and Services." *Energy Policy*. Lawrence Berkeley National Laboratory. Report No. LBNL-43642. http://eetd.lbl.gov/emills/PUBS/Insurance_Case_Studies.html

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Resources

Useful information on sustainability, high performance buildings, and the green building industry

Web sites

BetterBricks: http://www.betterbricks.com

Environmental Building News: http://www.buildinggreen.com

Environmental Design + Construction: http://www.edcmag.com

Federal Energy Management Program Federal Greening Toolkit: http://www.eere.energy.gov/femp/techassist/greening_toolkit/

Federal Energy Management Program Greening Federal Facilities: http://www.eere.energy.gov/femp/techassist/green_fed_facilities.html

Federal Energy Management Program Low-Energy Building Design Guidelines: http://www.eere.energy.gov/femp/prodtech/low-e_bldgs.html

Laboratories for the 21st Century: http://www.epa.gov/labs21century/

Office of the Federal Environmental Executive: http://www.ofee.gov/

Planet GSA: http://hydra.gsa.gov/planetgsa/

Rocky Mountain Institute: http://www.rmi.org

Sustainable Buildings Industry Council: http://www.sbicouncil.org/

U.S. Department of Energy High Performance Buildings: http://www.eere.energy.gov/buildings/highperformance/

U.S. Environmental Protection Agency: http://www.epa.gov/greenbuilding/green.htm

U.S. Green Building Council: http://www.usgbc.org/

Whole Building Design Guide: http://www.wbdg.org/

Federal Guidance

GSA's Design Excellence Program Guide: http://hydra.gsa.gov/pbs/pc/design_excell/

Key rules and legislation affecting Federal facilities: http://www.eere.energy.gov/femp/resources/legislation.html

U.S. Department of Interior's Guiding Principles of Sustainable Design: http://www.nps.gov/dsc/dsgncnstr/gpsd/

U.S. Department of Housing and Urban Development's Guide to Deconstruction: http://www.huduser.org/publications/destech/decon.html

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A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. By investing in technology breakthroughs today, our nation can look forward to a more resilient economy and secure future.

Far-reaching technology changes will be essential to America's energy future. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a portfolio of energy technologies that will:

- Conserve energy in the residential, commercial, industrial, government, and transportation sectors
- Increase and diversify energy supply, with a focus on renewable domestic sources
- Upgrade our national energy infrastructure
- Facilitate the emergence of hydrogen technologies as vital new "energy carriers."

THE OPPORTUNITIES

Biomass Program
Using domestic, plant-derived resources to meet our fuel, power, and chemical needs

Building Technologies Program
Homes, schools, and businesses that use less energy, cost less to operate, and ultimately, generate as much power as they use

Distributed Energy & Electric Reliability Program
A more reliable energy infrastructure and reduced need for new power plants

Federal Energy Management Program
Leading by example, saving energy and taxpayer dollars in federal facilities

FreedomCAR & Vehicle Technologies Program
Less dependence on foreign oil, and eventual transition to an emissions-free, petroleum-free vehicle

Geothermal Technologies Program
Tapping the Earth's energy to meet our heat and power needs

Hydrogen, Fuel Cells & Infrastructure Technologies Program
Paving the way toward a hydrogen economy and net-zero carbon energy future

Industrial Technologies Program
Boosting the productivity and competitiveness of U.S. industry through improvements in energy and environmental performance

Solar Energy Technology Program
Utilizing the sun's natural energy to generate electricity and provide water and space heating

Weatherization & Intergovernmental Program
Accelerating the use of today's best energy-efficient and renewable technologies in homes, communities, and businesses

Wind & Hydropower Technologies Program
Harnessing America's abundant natural resources for clean power generation

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FEMP

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