



## Achieving High-Performance Federal Facilities: Strategies and Approaches for Transformational Change: A Workshop Report

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## Summary

The design, construction, operation, and retrofit of buildings is evolving in response to ever-increasing knowledge about the impact of indoor environments on people and the impact of buildings on the environment. Research has shown that the quality of indoor environments can affect the health, safety, and productivity of the people who occupy them. Buildings are also resource intensive, accounting for 40 percent of primary energy use in the United States, 12 percent of water consumption, and 60 percent of all nonindustrial waste. The processes for producing electricity at power plants and delivering it for use in buildings account for 40 percent of U.S. greenhouse gas emissions.

The scale of building design is also evolving. The focus has shifted from individual buildings to entire portfolios (groups of buildings under a single management), to neighborhoods, communities, regions, watersheds, airsheds, and economies. As the scale and scope of design have increased, the opportunities for sharing infrastructure, conserving land and open space, and preserving and regenerating environmental systems have also increased.

Greater knowledge about buildings and their impacts has led to new processes and tools for measuring and evaluating buildings' performance throughout their life cycles: planning, design, construction, operations, maintenance, retrofit, and deconstruction. New technologies are being developed that can help reduce greenhouse gas emissions and the use of fossil fuels, energy, and water and that provide electricity from renewable energy sources.

The U.S. federal government manages approximately 429,000 buildings of many types with a total square footage of 3.34 billion worldwide, of which about 80 percent is owned space. More than 30 individual departments and agencies are responsible for managing these buildings. The characteristics of each agency's portfolio of facilities are determined by the agency's mission and its programs.

Recognizing the significant role of buildings in solving national issues such as energy independence and security, global climate change, and environmental sustainability, and recognizing the opportunity for federal leadership, Congress and two presidential administrations have enacted laws and issued executive orders directing federal agencies to develop high-performance, energy-efficient, sustainable federal buildings. They include the Energy Independence and Security Act (EISA) of 2007, Executive Order 13423, *Strengthening Federal Environmental, Energy, and Transportation Management* (2007),

and Executive Order 13514, *Federal Leadership in Environmental, Energy, and Economic Performance* (2009).

Together, these mandates establish more than 20 objectives for federal high-performance buildings. The objectives include reducing the use of energy, potable water, fossil fuels, and materials; reducing greenhouse gas emissions; improving indoor environmental quality; increasing the use of recycling and environmentally preferable products; minimizing waste and pollutants through source reduction; pursuing cost-effective innovative strategies to minimize consumption of energy, water, and materials; leveraging agency acquisitions to foster markets for sustainable technologies, materials, products, and services; locating new buildings in sustainable locations; participating in regional transportation planning; and strengthening the vitality and livability of the communities in which federal facilities are located. EISA requires agencies to eliminate fossil fuel energy use in new buildings and major renovations by 2030. Executive Order 13514 directs that beginning in 2020 and thereafter, all new federal buildings that enter the planning process should be designed to achieve zero-net-energy use by 2030.<sup>1</sup>

Each mandate specifically calls for the use of a life-cycle perspective or life-cycle costing, establishes interim and longer-term goals and objectives, and establishes baselines and performance measures for evaluating progress in achieving the goals. EISA also established the Office of Federal High-Performance Green Buildings within the U.S. General Services Administration (GSA).

### STATEMENT OF TASK AND THE COMMITTEE'S APPROACH

In 2010, GSA's Office of Federal High-Performance Green Buildings asked the National Academies to appoint an ad hoc committee of experts to conduct a public workshop and prepare a report that identifies strategies and approaches for achieving a range of objectives associated with high-performance green federal buildings. To meet its charge, the committee was asked to identify the following:

- Challenges, barriers, and gaps in knowledge related to developing high-performance green federal buildings.
- Current best practices and ways to optimize resources for achieving high-performance green building objectives during planning, design, construction, operations, and maintenance for new and existing facilities.
- Best practices for reporting the outcomes of investments in high-performance green federal buildings in a transparent manner on public federal Web sites.
- Approaches, tools, and technologies for overcoming identified challenges, barriers, and gaps in knowledge.

The committee recognized up front that many other reports, papers, and books have been published and databases have been created related to various aspects of high-performance green buildings. In addition, many initiatives are under way within federal agencies and other public and private organizations, universities, nonprofit entities, and community groups, across the country and internationally. To try to capture all of the valuable and thought-provoking ideas, lessons learned, and evidence-based data from these initiatives would not be possible.

The committee determined it would focus on identifying examples of important initiatives taking place and available resources and on ascertaining how these examples and resources could be used to

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<sup>1</sup>The executive order defines a zero-net-energy building as one that is designed, constructed, and operated to require a greatly reduced quantity of energy to operate, to meet the balance of energy needs from sources of energy that do not produce greenhouse gases, and to therefore result in no net emissions of greenhouse gases and be economically viable.

help make sustainability the preferred choice at all levels of decision making. In this way, the report could also be of value to many federal agencies with differing missions, types of facilities, and operating procedures: It is up to the individual agencies to adapt the approaches to their situations.

The committee held the public workshop on July 20 and 21, 2010, met two additional times, and corresponded through conference calls and e-mail. Information was provided by federal staff from the GSA and other federal agencies; representatives of organizations that have achieved significant breakthroughs in developing high-performance green buildings, installations, campuses, and communities; and more than 60 practitioners from public agencies, industry, and academia.

### **CHALLENGES AND BARRIERS TO ACHIEVING OBJECTIVES ASSOCIATED WITH FEDERAL HIGH-PERFORMANCE GREEN BUILDINGS**

Federal agencies will need to overcome a number of challenges and barriers if they are to achieve the goals and objectives associated with high-performance green buildings. The challenges include these:

- Embedding sustainability into everyday decision making.
- Excess facilities that siphon off already constrained resources.
- The federal budget process.
- Segmented processes that fail to optimize resources.
- Lack of alignment between reporting requirements and performance measurement systems.
- Perceived higher costs of building green.
- Workforce skills and training.
- Widespread deployment of innovative technologies for high-performance buildings.
- Gaps in knowledge on a range of topics and technologies.

### **LEVERS OF CHANGE AND BEST PRACTICES**

To overcome these challenges and barriers, the committee identified “levers of change,” which it defined as “areas where federal agencies can leverage their resources to spur transformational actions and to make sustainability the preferred choice at all levels of decision making.” The levers support an overall life-cycle perspective and can be used in all phases of building design, operation, and management. They represent changes in mindset as much as changes in processes or technologies. The levers are the following:

- Systems-based thinking,
- Portfolio-based facilities management,
- Integrated work processes,
- Procurement, contracting, and finance,
- Communication and feedback for behavioral change,
- Standards and guidelines, and
- Technologies and tools.

For its report, the committee defined best practices as “processes, procedures, or technologies that aim to optimize available resources and that could be effectively applied by the GSA and other federal agencies to meet similar objectives.” The definition is intentionally broad, because new practices, technologies, tools, and processes related to high-performance green buildings are continually emerging.

The committee believed that agencies may lose opportunities to leapfrog ahead to fulfill their mandates, if the committee only recommended well-documented best practices with a history of proven results.

### **STRATEGIES AND APPROACHES FOR ACHIEVING A RANGE OF OBJECTIVES ASSOCIATED WITH FEDERAL HIGH-PERFORMANCE FACILITIES**

The committee identified 12 strategies and approaches that the GSA and all federal agencies can use to achieve a range of objectives associated with high-performance buildings and facilities. They are based on the levers of change, on the best practices, tools, and technologies identified at the public workshop and other meetings, and on the committee members' own expertise. They can be applied to portfolios of facilities and to individual building projects.

The strategies and approaches are summarized in Box S.1. Brief explanations for each follow. More detailed information, including examples of best practices, tools, and technologies for implementing the strategies and approaches, is provided in Chapter 5.

#### **BOX S.1**

##### **Summary of Strategies and Approaches for Achieving a Range of Objectives Related to Federal High-Performance Facilities**

1. Use systems-based thinking and life-cycle assessment to identify new ways to provide services and to eliminate waste.
2. Focus on community- and regional-based approaches to fill gaps, leverage resources, and optimize results.
3. Align existing federal facilities to current missions and consolidate the total facilities footprint to lower costs, reduce carbon emissions, reduce water and energy use, and optimize available resources.
4. Operate facilities efficiently to optimize their performance.
5. Aggressively implement proven sustainable technologies as a matter of course.
6. Use integrated, collaborative processes and practices to overcome conventional segmented processes that fail to optimize resources.
7. Aim for high-performance, near-zero-net-energy buildings now.
8. Measure, verify, and report performance to improve processes and change behavior.
9. Use performance-based approaches to unleash the creativity of contractors.
10. Collaborate to drive the market for sustainable products and high-performance technologies.
11. Use standards and guidelines to drive change and embed sustainability into decision-making processes.
12. Communicate successes and learn from others.

**1. Use systems-based thinking and life-cycle assessment to identify new ways to provide services and to eliminate waste.**

Systems-based thinking provides a life-cycle perspective that can overcome challenges posed by the federal budget process and by segmented work processes. As importantly, it can help federal agencies identify new ways to use resources, to substitute more sustainable resources, to eliminate waste, and to avoid narrowly focused solutions with unintended consequences.

Systems-based thinking begins with the development of goals and objectives for the activity: The more ambitious the goals, the more innovative the strategies are likely to be. A systems-based approach can be especially effective in helping federal agencies meet their goals for reducing greenhouse gas emissions, reducing the use of potable water, conserving and protecting water resources, for recycling and pollution prevention, for minimizing the generation of waste and pollutants through source reduction, and for regional transportation planning.

**2. Focus on community- and regional-based approaches to fill gaps, leverage resources, and optimize results.**

Where federal facilities occupy large, contiguous land areas, such as military bases, research campuses, office parks, embassy compounds, and the like, they have opportunities to save energy, reduce the use of fossil fuels, and reduce greenhouse gas emissions by building on-site combined heat and power (co-generation) plants, installing solar arrays and wind turbines for on-site generation of renewable energy, and installing district energy systems and other technologies. Larger-scale development also facilitates the recycling of potable water and stormwater management.

Most federal facilities are dependent, in part, on nonfederal infrastructure systems for power, water, wastewater removal, transportation, and telecommunications. Federal agencies can leverage their available resources and achieve goals for strengthening the vitality and livability of adjacent communities by forming partnerships with local communities, utility companies, and others with shared interests.

**3. Align existing federal facilities to current missions and consolidate the total facilities footprint to lower costs, reduce carbon emissions, reduce water and energy use, and optimize available resources.**

Effective portfolio-based facilities management optimizes the performance of existing buildings and other facilities in support of an organization's mission, carefully considers the addition and location of new buildings, and uses life-cycle costing for all potential investments. Federal agencies can use portfolio-based management to align their facilities with mission; to determine which facilities are excess; to identify noncapital solutions for providing required services and avoid the long-term costs and environmental impacts of new buildings; to choose sustainable locations for new buildings; to determine where space can be consolidated; and to optimize the performance of existing buildings. In these ways, effective portfolio-based facilities management can help agencies meet an array of environmental and cost objectives for high-performance facilities.

To effectively implement a portfolio-based facilities management approach, federal agencies need a well-trained workforce. The Federal Buildings Personnel Training Act of 2010, when implemented, should help federal managers strengthen the skills of their workforces for operating high-performance green buildings and for portfolio-based facilities management.

#### **4. Operate facilities efficiently to optimize their performance.**

The vast majority of facilities that federal agencies will be using in 2020, 2030, and 2040 exist today. Operating building systems as they were designed can result in significant reductions in the consumption of energy and water, and can contribute positively to all aspects of indoor environmental quality.

#### **5. Aggressively implement proven sustainable technologies as a matter of course.**

Agencies regularly replace worn-out roofs, lighting systems, heating, ventilation, and air conditioning systems, water fixtures, computers, printers, and other equipment in existing buildings. Federal agencies have significant opportunities to upgrade the performance of existing building systems through effective operations, through routine maintenance, repair, and replacement programs, and through retrofit projects. As systems are changed out, more efficient technologies can be incorporated to reduce greenhouse gas emissions and energy and water use, to improve indoor environmental quality, and to meet other objectives related to high-performance green buildings.

#### **6. Use integrated, collaborative processes and practices to overcome conventional segmented processes that fail to optimize resources.**

Integrated, collaborative work processes are essential for achieving the multiple objectives associated with high-performance facilities, including zero-net-energy buildings. They can be used to overcome the wasting of resources inherent in conventional, segmented processes and to support a life-cycle perspective.

Agencies could leverage available resources, meet public policy goals, and improve results now and over the long term by consistently implementing existing guidelines such as the “Guiding Principles for Federal Leadership in High-Performance and Sustainable Buildings.” Even greater reductions of energy use could be achieved if, during the design process, agencies considered the energy required to operate lighting, computers, servers, copy machines, appliances, and other equipment.

#### **7. Aim for high-performance, near-zero-net-energy buildings now.**

The technologies and integrated design processes needed to develop high-performance facilities, including near-zero-net-energy buildings, are already available, and some agencies are using them effectively. Federal agencies that wait until 2020 to begin designing zero-net-energy buildings will be missing a significant opportunity to leapfrog ahead to meet their goals and conserve resources. Starting now also provides the opportunity to learn how best to combine technologies and processes to achieve zero-net-energy buildings for a range of climates and locations, and to share that information with other agencies.

Historic buildings present an opportunity to create zero-net-energy buildings. Many historic structures were originally designed with passive heating and cooling coupled with natural daylighting and ventilation strategies. However, their performance may have been compromised over time through the accretion of mechanical systems and the elimination of original components. By carefully retrofitting and replacing existing systems, some historic structures can become high-performance buildings again.

#### **8. Measure, verify, and report performance to improve processes and change behavior.**

Achieving all of the objectives associated with federal high-performance facilities requires changes

in mindset as much as it does changes in processes. Change within an organization requires leadership and effective communication so that everyone in the organization understands and accepts that the objectives are the right ones to continuously pursue. Because effective operation of facility systems is dependent, in part, on the behavior of occupants, occupants need to understand how their behavior affects facility performance and why proper operation is important to their own health and safety and to their agency's mission. Best-practice organizations have long used performance measurement as a basis for good communication, for changing conventional processes, and for changing human behavior.

Because an array of performance measures has been developed to track progress toward different goals or objectives related to federal high-performance buildings, some measures conflict and create disincentives for sustainable practices. For example, agencies have been directed to (1) reduce their energy use per square foot of space and (2) reduce their total square footage of space. Reducing total square footage of space should, intuitively, also lead to reduced energy use. However, if an agency is successful in reducing its total square footage of space, its energy use per square foot may increase, and it will appear that the agency is failing to meet the objectives. This lack of alignment among performance measures undermines the achievement of what should be complementary objectives. New performance measures are being developed to track greenhouse gas emissions and carbon footprint. To the extent possible, the government and its agencies should ensure that all performance measures are aligned to achieve complementary objectives.

Other techniques, technologies, and tools that can be used to improve communication and to help change behavior in support of the range of objectives associated with high-performance green buildings are described in Chapter 5.

### **9. Use performance-based approaches to unleash the creativity of contractors.**

When new buildings or major retrofits are needed, federal agencies develop criteria for the projects and then contract with private-sector firms to design and construct them. Federal agencies can use performance-based contracts to set high-level performance goals for new buildings and major retrofits and then challenge private-sector contractors to use their creativity and expertise to design projects that meet those goals.

When several years have elapsed between the actual design of a project and its construction, the designs can become "stale," such that the project will not be state of the art when the "ribbon is cut." In these circumstances, agencies should work with contractors through charrettes or other practices to update the designs to state-of-the-art standards before construction.

### **10. Collaborate to drive the market for sustainable products and high-performance technologies.**

Federal agencies can use their purchasing power to drive the market demand for sustainable products and services. Realizing such opportunities will require agencies to collaborate with each other and with industry, universities, and nonprofits in public-private partnerships.

Agencies can also drive the demand for high-performance space through their leasing practices, as recognized in Executive Order 13514.

Federal agencies have the opportunity to drive the wider deployment of new, more resource-efficient technologies and products by using their facilities as test beds for new technologies and practices and then publicizing the test results. In this way, agencies and the private sector can create a knowledge base for new technologies and practices that will help to mitigate the risk of using them.

### **11. Use standards and guidelines to drive change and embed sustainability into decision-making processes.**

Federal agencies can meet objectives for high-performance facilities by embedding sustainable practices into their policies, design standards, acquisition and maintenance practices, contracts, and task orders, and through the use of guidelines such as green building rating systems.

Many agencies maintain their own sets of design and operations standards to address the types of facilities they typically manage. One relatively easy way to embed sustainability into everyday decision making is to review these standards and revise them as necessary to align with objectives for high-performance green buildings. Specifying Energy Star appliances and equipment, WaterSense fixtures, and FEMP<sup>2</sup>-designated electronics in contracts and task orders would result in improved energy and water performance almost automatically.

### **12. Communicate successes and learn from others.**

Sustainable practices and processes are evolving and proliferating rapidly. Federal agencies have already developed numerous databases and Web sites containing policies, guidelines, processes, tools, technologies, and evidence-based data for developing, operating, retrofitting, and managing high-performance green buildings and facilities. However, these Web sites and databases are scattered among many individual agencies and their overall value is diminished by this segmentation. Federal agencies should collaborate to determine how they can best optimize the value of such information so that it can be used more effectively by all federal agencies and so that it can be easily shared with state and local governments, with private-sector and not-for-profit organizations, and with the public.

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<sup>2</sup>Federal Energy Management Program.

# ACHIEVING HIGH-PERFORMANCE FEDERAL FACILITIES

STRATEGIES AND APPROACHES FOR TRANSFORMATIONAL CHANGE

Committee on High-Performance Green Federal Buildings: Strategies and Approaches for  
Meeting Federal Objectives

Board on Infrastructure and the Constructed Environment  
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## Preface

Buckminster Fuller once said, “The best way to predict the future is to design it.” If the United States is to meet the challenges of global climate change, energy security, and environmental sustainability, an essential element for doing so is the design and retrofit of buildings.

The numbers are well known. Buildings account for almost 40 percent of primary energy use in the United States, 12 percent of total water use, and 60 percent of all nonindustrial waste. In addition, the indoor environmental quality of buildings affects the health, safety, and productivity of the people who occupy them.

In recognition of these impacts, building design and management, building technologies, and tools for analysis and decision-support are evolving. Today it is possible to create “high-performance” buildings: buildings that are more environmentally sustainable, that support occupant health, safety, and productivity, and that are cost-effective throughout their life cycles.

The U.S. federal government has the opportunity, and the responsibility, to significantly improve the performance of its buildings and to lead the way for other large organizations to do the same. Today, the government owns or leases 429,000 buildings worldwide, containing 3.34 billion square feet of space. Congress and two presidential administrations have enacted legislation and issued executive orders aimed at transforming the existing portfolio of federal buildings into one of high-performance facilities. In addition to achieving significant environmental benefits, such a transformation will result in long-term reductions in operations, maintenance, and life-cycle costs. Given these factors, the question now is not “Why should the federal government develop high-performance buildings as a matter of course?” Instead, federal decision makers at all levels and in all agencies should be required to justify why they would continue to construct and retrofit buildings in conventional ways.

In 2010, the U.S. General Services Administration’s (GSA’s) Office of Federal High-Performance Green Buildings asked the National Academies to appoint an ad hoc committee of experts to conduct a public workshop and prepare a report that identifies strategies and approaches for achieving a range of objectives associated with federal high-performance green buildings.

The committee conducted the workshop in July 2010. The speakers included early adopters of transformational strategies for achieving a sustainable built environment. They identified regional, local,

and international initiatives involving federal agencies, municipalities, states, and universities. More than 60 practitioners from the public, private, and nonprofit sectors and academia participated in the workshop and gave generously of their time and knowledge. The committee was especially impressed by the number of federal agencies represented at the workshop and their enthusiastic support for the subject. Their ideas and others are integrated into this report.

Chapter 1, “Context,” focuses on trends in building design, operations, and management, provides statistics and other background information on federal facilities, and discusses the committee’s approach for fulfilling its statement of task.

Chapter 2, “Objectives and Challenges Associated with Federal High-Performance Green Buildings,” identifies many of the objectives related to federal high-performance green buildings as established by legislation, executive orders, and other mandates. Long-standing, well-documented challenges and obstacles that hinder achievement of the established objectives are also discussed.

Chapter 3, “Levers of Change,” identifies areas where federal agencies can leverage their resources to spur transformational actions and make sustainability the preferred choice at all levels of decision making. The “levers of change” relate to all phases of buildings’ life cycles and can be immediately used by federal agencies to overcome the identified challenges and barriers.

Chapter 4, “Best Practices, Tools, and Technologies for Transformational Change,” highlights a range of practices, tools, and technologies identified at the public workshop and throughout the course of this activity. It highlights ways that federal agencies can achieve objectives associated with federal high-performance green buildings.

Chapter 5, “Strategies and Approaches for Achieving a Range of Objectives Associated with High-Performance Federal Facilities,” synthesizes the committee’s findings and conclusions from Chapters 1 to 4 into 12 wide-ranging strategies and approaches for achieving a range of objectives associated with high-performance green federal facilities.

Appendixes D through I contain write-ups of many of the presentations given to the committee that provide practical and inspirational examples for creating more sustainable facilities. Although some of these examples are highlighted in the main body of the report, readers are urged to delve into the appendixes for additional context and ideas.

The committee thanks the following people whose presentations are the source for many of the best practices cited in the report: Hal Alguire, Jeffrey Baker, Robert Berkebile, Peter Garforth, Thomas Hall, Christopher Juniper, Greg Kats, William Miner, Mark Mykleby, Greg Norris, David Orr, and Roland Risser.

The committee was impressed by the enlightened approach taken by GSA’s Office of Federal High-Performance Green Buildings and thanks Kevin Kampschroer, Katherine “Joni” Teter, Michael Bloom, and Ken Sandler for their insights and assistance throughout. Additional leadership and valuable assistance were provided by Shyam Sunder, Dale Manty, and Paul Domich of the Building Technology Research and Development Subcommittee of the National Science and Technology Council and by Michelle Moore of the Office of the Federal Environmental Executive.

For me, it was an honor and a privilege to work with the other members of the committee. Each person was a recognized expert in his or her field. Each volunteered his or her time and expertise as a public service and melded a large and varied set of information together to produce this report.

As a group, the committee believes that the time is now to move forward aggressively to create a portfolio of high-performance federal facilities. Federal agencies have the required tools, technologies,

and knowledge. Effective implementation requires conscientious, directional, and strategic decision making at every level of government. Success will require leadership, a willingness to use collaborative approaches to overcome conventional thinking, and sustained commitment over several decades. The result will be a higher quality of life and a higher-quality environment.

David J. Nash, *Chair*  
Committee on High-Performance Green Federal Buildings:  
Strategies and Approaches for Meeting Federal Objectives



## Acknowledgment of Reviewers

The authoring committee acknowledges the significant contributions made by the workshop participants, all of whom willingly and enthusiastically volunteered their time and ideas.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this report:

Jonathan Barnett, University of Pennsylvania,  
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Alan Shimada, ENVIRON, Inc.

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by Richard N. Wright, National Institute of Standards and Technology (retired). Appointed by the National Research Council, he was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.



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