

A 20-YEAR INDUSTRY PLAN FOR COMMERCIAL BUILDINGS

EXECUTIVE SUMMARY

HIGH-PERFORMANCE  
COMMERCIAL  
BUILDINGS

A TECHNOLOGY ROADMAP

Developed by:

REPRESENTATIVES OF THE COMMERCIAL BUILDING INDUSTRY

Facilitated by:

OFFICE OF BUILDING TECHNOLOGY, STATE AND COMMUNITY PROGRAMS

ENERGY EFFICIENCY AND RENEWABLE ENERGY • U.S. DEPARTMENT OF ENERGY

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## EXECUTIVE SUMMARY

### WHAT IS THE "WHOLE BUILDINGS" APPROACH?

Today's commercial buildings employ complex and diverse technologies in their construction, operation, and maintenance. Building materials, components, and subsystems traditionally have been designed and implemented based on standardized criteria that are largely independent of one another.

Through a **whole-buildings** approach — sometimes referred to as "systems engineering" — all of the building components and subsystems are considered together, along with their potential interactions and impact on occupants, to achieve synergies. The goal is to optimize the building's performance — in terms of comfort, functionality, energy and resource efficiency, economic return, and life-cycle value.



4 Times Square  
Photo: Andrew Gordon,  
Fox & Fowle Architects

### RETHINKING OUR COMMERCIAL LANDSCAPE

Major social, economic, technological, and environmental trends are changing the way we work, learn, and play, creating new demands on commercial buildings of the future. Among these trends:

- **Knowledge-based work** will increasingly require commercial buildings that provide reliable, continuous, and instantaneous connectivity to information and electronic communications resources, as well as personalized control of lighting, temperature, ventilation, and other aspects of the interior environment.
- **Collaborative, reconfigurable workplaces** will be required for coworkers who collaborate from remote locations via advanced communications technologies and work together in person less frequently, as well as for educational facilities reliant on electronic technologies and team-based activities.
- **An aging, shifting population base** will increase the need for ease of access and mobility within commercial facilities. Population will continue to grow in our deserts and on our seacoasts (two fragile ecosystems), requiring greater attention to resource and energy efficiency and to sustainable practices in commercial buildings.
- **Urban rebirth** will increase the need to reconfigure existing buildings for new uses.
- **Construction labor shortages** brought on by demographic and economic shifts will necessitate less labor-intensive building methods and technologies.
- **Environmental and health issues** will drive demand for commercial buildings that minimize resource use and waste in their construction and operation and provide healthier indoor environments.
- **Energy issues** for the future include a growing demand for "green power" and energy efficiency in buildings, as well as for on-site power generation and a more reliable energy supply.
- **Insurance and liability issues** will exert pressure on the commercial building industry to increase the safety and longevity of buildings.

### FOUNDATION FOR PARTNERSHIPS

What are our "ideals" for commercial buildings of the future, and how do we get there? These questions have been at the heart of the commercial buildings technology roadmap process, spearheaded by representatives from many sectors of the commercial building industry as well as from the Federal government, and facilitated and documented by the Department of Energy's Office of Building Technology, State and Community Programs (BTS).

In a series of four workshops over the past two years, participants — including architects, engineers, lighting and other designers, equipment manufacturers, researchers, building owners and developers,

facility managers, building trades representatives, utility and energy service company representatives, and financiers — discussed the current state of the industry, significant trends and opportunities, and ways to align public and private RD&D with real-world needs.

Their conclusion? That commercial buildings can be dramatically reshaped in the coming decades — by combining the results of sound, but separate, research in the various fields of building technology, together with a **whole-buildings** approach that optimizes interactions among building systems and components. These high-performance buildings will be able to respond effectively to the changing needs of today's businesses while also helping to meet our national goals of environmental protection and sustainable development. *High-Performance Commercial Buildings: A Technology Roadmap* articulates workshop participants' vision for the year 2020 and defines their strategies for achieving it in four critical areas:

**Clear performance metrics.** The whole-buildings approach seeks to achieve low total costs over the life of a building by minimizing energy and resource consumption, simplifying operational and maintenance requirements, and extending building life. Developers and builders, however, generally have no stake in the long-term operating costs or performance of a building, and are rewarded based on their ability to control first costs. Measurable, defensible, and reproducible financial returns will be needed to create markets for high-performance commercial buildings.

**Technology challenges.** Research, development, and deployment efforts will be essential in realizing the vision for high-performance commercial buildings. Improvements are required in building components and equipment, as well as in how these elements are integrated within a whole-buildings, and even a whole-community, systems context. The vision calls for new technologies to overcome inefficiencies. In particular, it foresees whole-building design tools and smart, integrated building controls that enable optimized interactions among such subsystems as heating, lighting, and the building envelope.

**Requirements for process changes.** Developing a high-performance commercial building requires a team effort among building owners, architects, engineers, financiers, managers and operators, building trades representatives, contractors, and other key players. Close collaboration is needed throughout the siting, design, construction, and commissioning process to make the holistic evaluations and tradeoffs leading to optimal solutions, as well as ongoing collaboration to monitor building performance and evaluate lessons learned. This kind of integrated building design and construction process departs radically from the approach used today, in which each discipline in the fragmented development process performs its work in isolation from the others and often with very different driving goals.

**Market-transformation challenges.**

Stimulating market demand for high-performance commercial buildings hinges on demonstrating a compelling economic case. In addition, several critical barriers must be overcome:

- The high degree of industry fragmentation greatly complicates the process of implementing and marketing commercial whole-building concepts, since no single company or professional association influences the full range of disciplines and functions involved.
- Commercial building is by nature speculative and uncertain. As a result, financing tends to reward conservative practices and impede innovation.
- Commercial building locations are still determined based on an underlying assumption of cheap transportation and continued road building, skewing the way communities evaluate long-term development costs.

The roadmap developers defined four tightly interrelated strategies to address the fundamental barriers outlined above and advance the commercial buildings vision (see chart at right).

## STRATEGIES

### **PERFORMANCE METRICS STRATEGY—Establish core definitions and metrics for high-performance commercial buildings.**

**Define *what to measure*** – i.e., determine the central characteristics of high-performance commercial buildings. As part of this effort, conduct market research to determine what characteristics would be most highly valued by different categories of customers.

**Define *how to measure*** – i.e., determine methods for measuring performance of commercial buildings over time (building performance indices) and for collecting representative data on a valid scale.

**Determine how to apply the metrics** to enable key audiences to evaluate costs and benefits of high-performance building investments (including opportunities to improve the performance of existing buildings, as well as to optimize projected life-cycle value of new buildings).

### **TECHNOLOGY DEVELOPMENT STRATEGY—Develop systems integration, monitoring, and other technologies that enable whole buildings to achieve optimal, targeted performance over their life cycles.**

**Develop verifiable design and performance analysis models and tools** that enable component and system optimization (e.g., automated decision-support tools).

**Develop methods to improve interoperability** among architectural, mechanical, electrical, plumbing, and other key building subsystems, working with standards organizations.

**Develop cost-effective, reliable monitoring and control technologies** (e.g., indoor air quality sensors, wireless sensors and controls) to ensure that performance targets are met throughout building life.

### **PROCESS CHANGE STRATEGY—Create models of collaborative high-performance commercial building design and development, and establish the tools and professional education programs needed to support these processes.**

**Develop, pilot, and document new models** of collaborative whole-building design and development, and create implementation guidelines for applying such processes.

**Create tools** (e.g., software, communications) to support integrated decision-making in commercial building design, construction, operation, and renovation.

**Establish educational programs for professionals** who are key to implementing and supporting commercial whole-buildings approaches.

### **MARKET TRANSFORMATION STRATEGY—Stimulate market demand for high-performance commercial buildings by demonstrating and communicating compelling economic advantages.**

**Demonstrate and document the economic case** for high-performance commercial buildings through pilots and case studies.

**Define and promote tax and financing incentives** that would support commercial whole-building approaches.

**Develop and implement a strategic communications and marketing plan** addressing all key audiences (e.g., architects, engineers, builders, facility managers, building trade unions, financiers, insurers, policymakers, community planners, researchers, environmental groups, general public).

**Develop and promote a "brand name" and identity** for high-performance buildings (e.g., a simple, well-communicated program similar to the ENERGY STAR model).

## A NEW INITIATIVE

The U.S. Department of Energy's Office of Building Technology, State and Community Programs (BTS) is facilitating industry-led initiatives to develop a series of technology roadmaps. The roadmaps identify key goals and strategies for different areas of the building and equipment industry. *High-Performance Commercial Buildings: A Technology Roadmap* identifies a plan for integrating research, development, and deployment for the next generation of commercial buildings in the U.S.

This roadmap initiative is a fundamental component of the BTS strategic plan and will help to align government resources with the high-priority needs identified by industry. The roadmap will guide cooperation among public and private researchers, developers, architects, the many and varied participants in the commercial building industry, and other State and Federal offices to help this industry achieve its long-term vision.

## LOOKING FORWARD

How might tomorrow's "healthy, productive, and desirable" commercial buildings look and perform? High-performance commercial buildings are likely to:

**Incorporate smart, responsive technologies.** Commercial buildings will become almost "alive," using "smart" materials and systems that sense internal and external environments, anticipate changes, and respond dynamically. Energy-using components will monitor when and how much they are needed and will adjust their operation accordingly, and individualized control of lighting, ventilation, and thermal conditioning will become possible.

**Reflect sound environmental practices.** Tomorrow's commercial buildings will be highly resource-efficient and will make use of environmentally sustainable materials. They will use 30 to 80 percent less energy than 20th century buildings; some will even be net electricity exporters, generating their own power and supplying excess power back to the grid. Sunlight will be used increasingly to produce electricity as well as for daylighting.

Buildings will be designed for much greater flexibility and adaptability to reuse, as well as for complete recyclability.

**Be an integral part of sustainable community development.** Building philosophy will shift from design of single, stand-alone buildings to campuses or even communities. Resource management will be optimized through strategies such as distributed power generation. More building space will perform double duty as both commercial and residential space.

**Be recognized for their bottom-line benefits to businesses and developers.** By enhancing occupant productivity, health, and safety — and reducing life-cycle energy and operating costs — high-performance commercial buildings will make measurable contributions to the bottom line of tenant businesses. Financiers and insurers will acknowledge high-performance buildings through favorable lending and underwriting practices, and developers will realize better asset value as a result of the strong market appeal of these buildings.

**Be designed for simplicity and safety.** Future buildings will be ever simpler to construct and operate. Design and building techniques will enhance construction safety, reduce development and construction time, and cut labor intensity. Building controls and subsystems will be intuitive and elegant, requiring minimal technical expertise to operate and maintain.

## VISION

By the year 2020 —

- Successful public/private partnerships will deliver highly adaptable, sustainable, cost-effective commercial buildings.
- Advances in building design and operation will provide simple solutions to address the complex interactions of systems and equipment.
- America's commercial buildings will be valued by occupants, owners, builders, and communities as healthy, productive, and desirable places to learn, work, and play.

## CO-SPONSORS

*High-Performance Commercial Buildings: A Technology Roadmap* is sponsored by the U.S. Department of Energy in cooperation with the following organizations:

Advanced Building Systems Integration Consortium, Carnegie Mellon University  
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