

# *Commercial Buildings as Clean Domestic Energy Assets by 2025?*

## *DOE's Roadmap for a Net-zero Energy Built Environment*

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### ABSTRACT

A net-zero energy building (NZEB) is a highly energy-efficient residential or commercial building that, over the course of a year, uses renewable technology to produce as much energy as it consumes from the grid. In the commercial sector, building owners and tenants stand to realize attractive returns on their NZEB investments while reducing their carbon footprints. Considering that buildings are our nation's highest energy-consuming and carbon-emitting sector, NZEBs have a vital role in reducing U.S. energy demand and greenhouse gas emissions (GHGs).

This article outlines the U.S. Department of Energy's (DOE's) goals for the energy use by our nation's commercial buildings, the research and development (R&D) efforts most critical to realizing NZEBs, and DOE's strategy of collaborating with the private sector to speed the arrival of NZEBs in the marketplace.

### INTRODUCTION

In 2007, the more than 4.8 million commercial buildings in the United States used 18% of the country's energy and were responsible for 18% of its GHGs [1]. If current building trends continue through 2030, 1,210 square miles of new commercial floor space will add 580 million metric tons of CO<sub>2</sub> to the atmosphere. The vast scale and scope of energy consumption and emissions in the building sector demand a correspondingly large response.

DOE's Commercial Building Initiative is pursuing an aggressive, targeted R&D portfolio to discover the breakthrough technologies necessary for exemplary energy-performance levels in commercial buildings. At the same time it is engaging with market actors to encourage widespread adoption of energy-efficient technologies, interactive design tools, and best practices—all toward the effort to enable marketable, affordable net-zero energy commercial buildings in all climate zones by 2025.

## THE NET-ZERO ENERGY COMMERCIAL BUILDING INITIATIVE: NZEBs BY 2025

The Net-Zero Energy Commercial Building Initiative (CBI) drives the Commercial Building program's activities. The establishment of this initiative and its accompanying goals was specifically called for in Section 422 of the Energy Independence and Security Act of 2007 (EISA).

### **The CBI's Goals**

- Improve the whole-building energy performance in new construction by 50% by 2015 and by 70% by 2025, relative to ANSI/ASHRAE/IESNA Standard 90.1-2004. A 70% reduction in whole-building energy use, combined with renewables, provides NZEBs.
- Improve existing building stock energy performance by 50% by 2030 relative to the Commercial Buildings Energy Consumption Survey (CBECS) 2003 baseline.

To achieve these goals, DOE established the National Laboratory Collaborative on Building Technologies (NLCBT), which enables DOE to leverage the strengths of the Pacific Northwest National Laboratory, Oak Ridge National Laboratory, Lawrence Berkeley National Laboratory, Argonne National Laboratory, and the National Renewable Energy Laboratory to serve the goals and priorities of CBI. In addition to conducting R&D, the NLCBT is tasked with developing and maintaining a commercial buildings roadmap that describes activities and milestones that are intended to lead to commercially viable NZEBs in new commercial buildings by 2025. The roadmap will address the many aspects of the commercial building industry from design through construction, commissioning, operation, and retrofit. It will explore the research and technology development needed to achieve net-zero energy commercial

buildings in the desired time frame, as well as the activities needed to overcome market impediments to full implementation of such buildings in the market. This will be presented in a rank-ordered list of research, development, demonstration, and deployment (RDD&D) needs to attain DOE's aggressive goals.

This roadmap, now in development, will be reiterated as technologies are developed and milestones realized. But even at this early stage, DOE has insight into the R&D breakthroughs and market engagement activities necessary to reach net-zero energy performance.

## TARGETED R&D

Current commercial buildings must become 60% to 70% more energy efficient to get to a level at which renewable technologies can supply the balance of energy needs. These reductions will come from technological advancements in building components such as windows, heating, ventilating, and air conditioning (HVAC); building-wide systems controls; and improved understanding of how occupant behavior affects a building's energy performance. In some cases, when current low-energy and zero-energy buildings fail to meet the levels of savings modeled in their designs, occupant behavior is a primary factor [2]. Understanding and attempting to alter occupant behavior will ultimately be a huge step in realizing NZEBs. It is important to understand how these and other factors degrade building performance over time.

The following arenas are currently being targeted for significant technological advancements:

### **Indoor Environmental Quality (IEQ) and Efficient Ventilation**

An estimated 1.2 quads of primary energy are used annually for ventilation in the commercial sector, which is 7% of the sector total [3]. DOE is supporting studies to evaluate a pair of air cleaning technologies that in combination could reduce ventilation requirements by 50%, with corresponding energy savings. The technologies are:

- Activated carbon fiber systems to clean indoor air of volatile organic compounds (VOCs) with frequent carbon regeneration using unconditioned outdoor air

- Use of manganese dioxide as a room temperature catalyst for destroying formaldehyde—a key indoor VOC not removed by activated carbon.

## **HVAC**

HVAC, the largest commercial building energy consumer, accounts for more than 31% of the total commercial building sector's energy consumption, with space heating, space cooling, and ventilation accounting for 12.1%, 12.6%, and 6.7%, respectively. An aggressive effort to develop low-energy commercial building heating and cooling systems is needed to help realize the NZEB goal.

DOE is currently focusing on HVAC research in the following areas:

- Evaporative pre-cooling technology
- Magnetic heating and cooling
- Minimizing air-conditioning energy use while maintaining acceptable IEQ in office buildings
- Cost-effective integration of efficient low-lift base-load cooling equipment.

## **Refrigeration**

Refrigeration is the largest energy end use in grocery stores. DOE is researching ways to reduce refrigeration energy loads, utilize the waste heat, and eliminate leakage of HFC refrigerants, which are potent greenhouse gases.

## **Electric Grid and Energy Storage**

Breakthrough research is needed to reduce the cost and enhance the performance of integrated renewable energy and energy storage systems. Such advancements are needed if the promise of net-zero energy performance is to be realized in actual buildings. Among many advantages, effective storage would greatly increase the "value" of on-site renewable energy generation and would offer security benefits as well. In addition, the emerging potential of a "smart grid" offers the opportunity to make intelligent buildings an integral "part" of that grid—with potential systems-wide benefits (and savings in energy and dollars) for the country.

### Miscellaneous Energy Loads

Currently, the Energy Information Administration (EIA) estimates that “other” or miscellaneous” energy uses account for one-third of total energy used in the commercial sector, and EIA projects that this category will account for more than half the sector’s growth through 2030 as shown in Figure 1 [4]. This significant category needs to be more clearly understood and defined so that specific inefficiencies can be addressed.

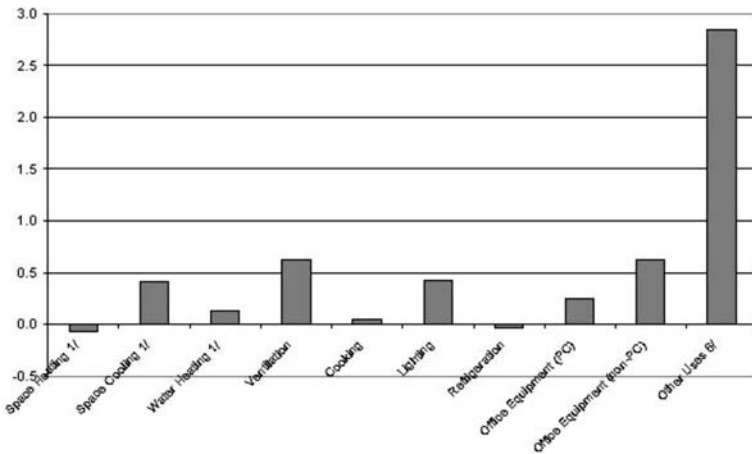


Figure 1. Projected Change in Commercial Building Energy Demand by End Use 2008 through 2030. (Primary Quadrillion Btu)

### MARKET ENGAGEMENT

While research and development of new technologies in these areas is critical to reaching NZEBs, market penetration and adoption of technologies by the public and private sectors are vital to achieving real, substantive change in energy use throughout the country. DOE’s market engagement strategy is designed to leverage DOE’s resources with partners in the commercial sector to accelerate adoption of new technologies.

The Commercial Building Energy Alliances (CBEAs) and Commercial Building National Accounts (NAs) are the primary channels through which DOE is enabling effective technology transfer to all commercial building sectors. These efforts partner private sector companies with

DOE and the NLCBT on solutions for the commercial building stock—one of clean domestic energy assets with low operating costs. CBEAs and NAs work in tandem and are supported by the crosscutting activities directed by DOE to directly support CBEA and NA goals.

### **Commercial Building Energy Alliances**

DOE has launched CBEAs in the retail, commercial real estate, and hospital sectors. These alliances link commercial building owners, managers, and operators, who want to reduce the energy consumption, greenhouse gas emissions, and operating expenses of their buildings. Members of the alliances are afforded direct access to the advanced technologies, analytical tools, and capabilities emerging from DOE and the national laboratories. These informal associations function in a number of capacities:

- Share best practices, energy-use measurement, and benchmarking—in essence, serving as organic, real-time information networks
- Identify federal R&D that is needed to advance the business case for energy-efficient buildings
- Deploy advanced technology through coordinated technology procurements by alliance members and information sharing within commercial subsectors
- Conduct deployment, dissemination, and technical assistance activities to encourage and assist adoption of technologies, practices, and policies
- Develop training materials and courses for building professionals and trades to be deployed by alliance partners
- Develop and disseminate public education materials on the benefits and cost-effectiveness of high-performance, energy-efficient buildings.

The commercial buildings sector has responded favorably to these efforts, with membership in each alliance representing nearly 20% market share of its respective business sector. In addition, leaders in each sector (i.e., Walmart, Grubb & Ellis, and Hospital Corporation of America) have taken active roles on the alliances' steering committees, which discuss the status of the alliances and subcommittees, share lessons learned, and identify emerging technologies of relevance. CBEA subcommittees, with lab support, focus on particular technology areas

or industry sub-sectors and work on such projects as technology procurements or benchmarking. Each alliance will develop best practices information, guides, and other materials as they prioritize their needs on an annual basis. DOE will launch two additional CBEAs: the Higher Education Energy Alliance and the State and Municipal Energy Alliance, in 2010.

### **Commercial Building National Accounts**

Commercial Building National Accounts are companies working to transform their building delivery and management processes to construct and retrofit buildings that will achieve unprecedented energy savings. The resulting projects, and the insight, detailed measurement, and verification that accompany them, will inform DOE's R&D portfolio going forward. The projects also will provide operational and cost data needed to make a solid business case for investment in high-performance buildings.

The National Accounts work closely with the CBEAs, sharing information and identifying promising technologies for field testing. National Accounts companies are automatically members of their respective CBEAs, and thus work closely with alliance members to identify promising technology for field testing and share best practices.

For its National Accounts projects, DOE targets companies or organizations that design, build, own, manage, or operate their own buildings (e.g., Macy's, InterContinental Hotels Group). These companies and organizations are likely to be continually investing in building and retrofit projects and offer the most potential for replication of high-performance building solutions throughout their building portfolios.

Each National Accounts (NA) company works directly with a Commercial Building Design Team (CBDT), which is comprised of a national lab as the CBDT lead investigator, and expert design consultants (e.g., A/E firms, HVAC consultants), to create, test, and validate design concepts that will move the industry toward net-zero energy commercial buildings. Specifically, new NAs agree to two of the following:

- Construct a new building that uses 50% less energy than ASHRAE/IESNA Standard 90.1-2004
- Retrofit a building that uses 30% less energy than the CBECs baseline or 30% less than the mean of their building portfolio
- Upgrade one technology throughout their building portfolio that

will result in a 40% to 50% energy reduction as compared to the mean of the portfolio.

Ultimately, NAs will select the design and associated efficiency level that meets their cost constraints and operating needs. However, the full spectrum of choices, as embodied in the building design package, from 30% to 50% energy savings or greater, will be analyzed and documented so that CBEA members have the ability to make alternative choices.

### **Alliance Activities**

DOE supports activities that directly assist the goals of the CBEAs and NAs. Currently, there are four major thrusts: procurements of advanced technologies; development of technology solutions tools; ongoing technology evaluation and screening to bring promising technologies to the attention of CBEA members; and regular supplier summits to facilitate communication between CBEA members and suppliers and manufacturers of energy-efficient technologies for the commercial sector. These activities are supported by technical assistance from the NLCBT.

### **Technology Procurements**

The purpose of technology procurement is to bring superior products to market faster and cheaper than normal by harnessing the combined purchasing power of CBEA members. Alliance members selected LED (light-emitting diode) parking lot lighting as the first technology procurement. In 2009, Retailer Energy Alliance Steering Committee member Walmart installed LED lighting based on the CBEA-drafted specifications in the parking lot of their Leavenworth, Kansas, store. The NLCBT is monitoring and validating actual field performance of these lights, which have the potential to use 40% less energy than traditional parking lot lighting. If deemed viable, Walmart intends to upgrade parking lot lighting in all of their sites. Other CBEA members may follow suit, thus accelerating widespread adoption of this technology.

### **Commercial Technology Solutions**

Commercial technology solutions are interactive tools (primarily Web-based) through which commercial building designers, engineers, and operators can get expert, holistic guidance on how to improve the efficiency of their building systems. In consultation with DOE, CBEA

members determine the technologies to target and work with the national laboratories to design and create a tool that gives customizable best practices and strategies on design, controls, installation, and commissioning of a particular technology.

The first solution tool, Commercial Lighting Solutions (CLS), was released this year at [www.lighting-solutions.org](http://www.lighting-solutions.org). It is an interactive Web tool for retail spaces provides energy savings projections based on user input and selections. The solutions are designed to meet or exceed energy savings levels needed to qualify for tax incentives. Commercial users and designers can also use the Web tool to document performance against energy goals that support end-user applications for incentives and rebates from utilities and state or regional energy efficiency programs. The CBEAs will also look at solutions focused on daylighting, supermarket refrigeration, and packaged commercial HVAC. These tools can be updated as associated technology evolves, ensuring continued viability for achieving the latest in energy efficiency improvements.

### **Technology Identification and Screening**

Validating the performance claims for new technologies is one of the biggest challenges commercial building owners face when trying to reduce energy consumption. DOE's technology identification and screening process is designed to alleviate this challenge for building owners and accelerate the application of "proven" technologies in commercial buildings. This activity also supports identification of suitable technologies for possible application of the technology procurement process described above.

The screening process allows suppliers, manufacturers, and developers to nominate promising energy-efficient technologies for testing and evaluation by DOE and the national laboratories.

Nominated technologies are put through a four-step screening process that includes:

1. Evaluating whether the technology can be applied to new and existing commercial buildings
2. Assessing the technology's commercial availability, technical feasibility or risk, and technological embodiment
3. Analyzing the technology's energy savings, cost effectiveness, and non-energy impacts

4. Summarizing the technology's overall fit for achieving the alliance's goals.

Information on the most promising technologies are shared with CBEA members, who can then make purchases based on verified performance data.

### Supplier Summits

CBEA members, in conjunction with DOE and organizations such as ASHRAE and IES, host supplier summits to forge a communication path between commercial building owners and operators—to identify their energy efficiency needs—and suppliers—to challenge them to find ways to meet those needs. The annual HVAC and lighting summits have attracted a large number of suppliers that learn more about DOE's initiative, the barriers to purchasing energy efficiency equipment (i.e., short warranties, inconclusive evidence on product performance and life cycle, and upfront cost differentials), and the market need for energy-efficient technologies.

## CONCLUSION

Buildings are the largest single source of energy demand and GHG emissions in the United States. If widely adopted, net-zero energy commercial buildings can effectively address both of these concerns. DOE thus set an aggressive Commercial Building Initiative goal to create the technology and knowledge base for cost-effective net-zero energy commercial buildings by 2025. The Commercial Buildings Team is gratified to have many public and private sector partners that are committed to this vital endeavor.

### References

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4. Annual Energy Outlook 2009, Table 5. Available at [www.eia.doe.gov/oiaf/aeo/](http://www.eia.doe.gov/oiaf/aeo/)

index.html. The figure shows several end uses declining in absolute terms by small amounts in space heating and refrigeration.

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#### ABOUT THE AUTHOR

**Brian J. Holuj** is a Presidential Management Fellow at the United States Department of Energy. He works in the Office of Energy Efficiency and Renewable Energy as a Commercial Buildings Technology Specialist with a focus on leveraging public-private partnerships to achieve net-zero energy buildings in the commercial sector. In this capacity, he works directly with the Department's National Laboratories and private sector commercial partners to design, implement, and evaluate cutting-edge technologies and best practices at demonstration sites throughout the country. Prior to this, Brian received a Bachelor of Science in Aviation Human Factors from the University of Illinois and worked for several years in robotics and automation. He returned to academia in 2007 to pursue a Master of Public Administration and a Master of Arts in International Relations at the Maxwell School of Citizenship and Public Affairs. During his graduate studies, Brian conducted energy policy research at the Pentagon and the U.S. Embassy in Baku, Azerbaijan.