Energy Efficient Building Design

An Online Continuing Education Course for Engineers

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(Bighorn home improvement center in Silverthorne, Colorado and an example of daylighting. Photo Courtesy: DOE)

Introduction

Incorporating energy efficiency, renewable energy, and sustainable green design features into buildings has become a top priority in recent years as building owners seek to develop environmentally friendly facilities. Because energy-efficient buildings reduce both resource depletion and the adverse environmental impacts of pollution generated by energy production, it is often considered to be the cornerstone of sustainable design. In this course, we will be looking at what low-energy design means, specific strategies to be considered, when and where to apply these strategies, and how to evaluate their cost effectiveness.

Low-energy building design is not just the result of applying one or more isolated technologies. Rather, it is an integrated whole-building process that requires advocacy and action on the part of the design team throughout the entire project development process. The whole-building approach is easily worth the time and effort, as it can save 30% or more in energy costs over a conventional building design. Moreover, low-energy design does not necessarily have to result in increased construction costs. Indeed, one of the key approaches to low-energy design is to invest in the building's form and enclosure (e.g., windows, walls) so that the heating, cooling, and lighting loads are reduced, and in turn, smaller, less costly heating, ventilating, and air conditioning systems are needed.

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In designing low-energy buildings, it is important to appreciate that the underlying purpose of the building is neither to save - nor use - energy. Rather, the building is there to serve the occupants and their activities. An understanding of building occupancy and activities can lead to building designs that not only save energy and reduce costs, but also improve occupant comfort and workplace performance.

The low-energy design process begins when the occupants' needs are assessed and a project budget is established. The proposed building is carefully sited and its programmed spaces are carefully arranged to reduce energy use for heating, cooling, and lighting. Its heating and cooling loads are minimized by designing standard building elements— windows, walls, and roofs—so that they control, collect, and store the sun's energy to optimum advantage. These passive solar design strategies also require that particular attention be paid to building orientation and glazing. Taken together, they form the basis of integrated, whole-building design. Rounding out the whole-building picture is the efficient use of mechanical systems, equipment, and controls. Finally, by incorporating building-integrated photovoltaics into the facility, some conventional building envelope materials can be replaced by energy-producing technologies. For example,

photovoltaics can be integrated into window, wall, or roof assemblies, and spandrel glass, skylights, and roof become both part of the building skin and a source of power generation.

This course has been prepared primarily for energy managers to provide practical information for applying the principles of low-energy, whole-building design in new buildings. An important objective of this course is to teach energy managers how to be advocates for renewable energy and energy-efficient technologies, and how to apply specific strategies during each phase of a given project's time line.

The course begins with an overview of the technology and a few of the items to consider in designing an energy efficient building. Chapter two explains the issues affecting new building designs as it relates to specific types of buildings. Chapter three then discusses ways to introduce energy efficiency into the design process and chapter four discusses the computer modeling involved in energy efficiency designs. Finally, chapter five provides details on two projects that have successfully implemented the concepts explained in this course.

Chapter 1: About the Technology

Buildings consume roughly 37% of the primary energy and 67% of the total electricity used each year in the United States. They also produce 35% of U.S. and 9% of global carbon dioxide (CO_2) emissions.

By following a careful design process, it is possible to produce buildings that use substantially less energy without compromising occupant comfort or the building's functionality. Whole-building design considers the energy-related impacts and interactions of all building components, including the building site; its envelope (walls, windows, doors, and roof); its heating, ventilation, and air-conditioning (HVAC) system; and its lighting, controls, and equipment. This stands in marked contrast to the traditional design process, where there is generally no goal to minimize energy use and costs beyond what is required by codes and regulations.

To achieve the desired energy reduction goals, the design team must establish minimized energy use as a high priority goal at the inception of the design process. A balanced and appropriately funded team must be assembled that will work closely together, maintain open lines of communication, and remain responsive to key action items throughout the delivery of the project.

Continuing advocacy of low-energy design strategies is essential to realizing the goal. Therefore, it is important that at least one technically astute member of the design team be designated as the *energy advocate*. This team member performs many useful functions, such as:

- Introducing team members to design strategies that are appropriate to building type, size, and location.
- Maintaining enthusiasm for the integration of low-energy design strategies as central components of the overall design solution.
- Ensuring that these strategies are not abandoned or eliminated during the later phases.
- Overseeing construction to ensure that the strategies are not thwarted or compromised by field changes.

Application Domain

The application domain for low-energy design is not so much a case of where the technology should be installed, but where it is integrated with the other elements of the project to produce an energy-efficient building that serves both the environmental and functional needs of its users. When thinking about whole buildings, it is important to consider not only the discrete components and materials but how the various parts can best work together to achieve the

desired results. That is what is meant by the phrase "integrated, whole-building design." Low-energy design strategies and renewable energy concepts can be applied to almost any type of new building.

Energy-Saving Mechanisms

In commercial buildings, low-energy design mechanisms range from a few high-profile architectural features that are solar responsive to the application of m conventional and often less conspicuous, energy conservation technolo e reconfigurations of typical building compone to those that are articulated and have surf

The low-energy design p echniques should be in this course combines a gy use such as, practical systems, devices, design concepts that shoul he building simultaneously whenever p ing to reduce achieve significant reductio use. For most non-residenti by eliminating energy-use reduction of 30% in. is required by codes and sta y using usually be achieved with litt increase in construction cost. 70% or more are possible for bstitute for (or buildings, although achieving to) electrical lighting. significant reductions can be c ng in light of the demands occasioned by budgeting constraints and cost-effectiveness criteria. For example, daylighting, coupled with dimmable lighting and light-level controls, is increasingly commonplace. An effective and highly recommended energy conservation strategy, this technology cluster is an important component of low-energy building design.

- Using natural ventilation whenever possible.
- Using more efficient heating and cooling equipment to satisfy reduced loads.
- Using computerized building control systems.

Because energy-efficiency concepts and technologies must dovetail with all other building elements, one of the most important energy-saving tools is the use of computer modeling and design software. This strategy should be used early in the design process to analyze the efficiency and cost effectiveness of candidate strategies. Detailed computer simulation results are then referred to throughout the design process, and often through the value engineering