Sustainable Design: Turning Theory into Reality
Sustainable design has been a popular catchphrase for several years. Some envision it as strange, pie-in-the-sky, grass-clad structures that generate more energy than they consume, and others view sustainable design as the only possible future for a fossil fuel-based economy. Energy legislation debates highlight just how polarizing the issue has become.

While advocates on both sides have been focusing on politics, product manufacturers and building designers have been working to turn theory into reality.

True sustainability—defined as buildings that operate efficiently, comfortably, and affordably, with minimal impact on the natural environment—has not yet been achieved. Still, today’s design principles and products are creating buildings that are significantly more efficient than those of even a decade ago. Cost premiums are often offset by resulting energy savings and occupant productivity.

Integrated design—in which building systems are considered together, as a whole, rather than as individual parts—is key to sustainable design’s success. For example, more thoughtful siting can allow for better use of natural light and heat. Combined with advanced control systems and more efficient lamps and fixtures, careful siting can mean greatly reduced heat loads.

With these lower heat loads and, again, modern control technology, building-conditioning requirements can be cut dramatically. Add glass panels etched with photovoltaic cells (in appropriate geographies) and a backup system to provide off-utility operation during peak-use periods, and you get a structure that is both efficient and comfortable to occupy.

This publication provides an overview of some of the key components used in sustainable building design, along with factors that owners, architects, engineers, electrical contractors and other professionals should consider during design, specification and installation, including:

- **Integrated design**—why a sustainable building is more than just the sum of its parts,
- **Creating standards**—where to turn for guidance in implementing sustainable-design concepts,
- **Building-control systems**—how to monitor and manage building operations more efficiently, and
- **Energy options**—when to turn to alternative energy supplies.
Sustainable design is a team effort. To create truly sustainable structures, architects, engineers and contractors must think across their respective disciplines. Individual building systems may require special design and installation skills, but buildings work best when designed and constructed as a unit.

Integrated design can mean greater up-front involvement from building-team members who typically don’t enter a project until later in the building process. It also can mean more intensive design reviews across disciplines to ensure design decisions make sense and their implications are understood. Consequently, owners may see somewhat greater initial expenses. Yet, the added early effort often means fewer change orders once construction begins and almost always results in lower operating costs.

Bringing contractors into this mix early can help to ensure that project managers’ plans make sense and may help building-team members develop construction procedures that can be crucial to a project’s success. Remember that sustainable design also addresses indoor air quality and other occupant health and safety issues. Construction practices can play a crucial role in successfully meeting these goals.

For example, project leaders managing construction of the Texas Heart Institute, completed in Houston in 2003, worked closely with specifiers and contractors to ensure materials were delivered and installed as cleanly as possible. This goal was essential to the purpose of a facility designed to treat patients suffering from severe heart disease.

Ductwork was delivered sealed at both ends, and open sections were resealed following installation. Biocides were sprayed on and between walls to minimize contaminants. And no food or drink was allowed in the building during its construction.

Such efforts could not have been carried out without the full cooperation and early involvement of all building-team members.

An Action Plan to Increase Energy Performance

Three fundamental strategies can increase energy performance: reduce demand, harvest free or sustainable energy, and increase efficiency. Here are some practical steps:

- **Set a corporate energy policy**, making energy efficiency a part of operational procedures and a consideration in every business decision.
- **Perform an energy audit** to assess where energy efficiency can be improved.
- **Make general energy-efficiency improvements**. For example, turn down the thermostat, turn off machines and equipment when not in use, and install automatic lighting controls.
- **Harvest site energy** by using free resources such as daylight, ventilation cooling, and solar heating to satisfy needs for space conditioning.
- **Encourage employee participation and innovation**. This may require challenging employees’ initial assumptions about energy use.
- **Track energy costs** both before and after energy improvements. You may want to separate energy costs from transportation costs.
- **Optimize energy use** in manufacturing processes and activities. For example, capture and reuse waste heat and use high-efficiency motors.
- **Make use of net metering**, a metering and billing arrangement that allows on-site generators to send excess electricity flows to the regional power grid.
- **Choose green power when possible**. Take advantage of wind, solar, small hydroelectric, and geothermal generated power options. Over nuclear or fossil fuels.

Source: Greenbiz.com
The Issue of Standards

Sustainable design means creating more efficient buildings with less waste. That’s a goal most of us can support, but until recently, building-industry professionals have gotten little guidance on how to actually reach this goal, and what constitutes a successful effort.

As a baseline, many jurisdictional authorities have adopted the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.1, “Energy Standard for Buildings Except Low-Rise Residential Buildings.” This standard mandates many types of building-system controls and sets performance targets for everything from light fixtures to air-handling units.

The U.S. Green Building Council (USGBC)—a group including architects, engineers, builders, manufacturers, government entities and others—also has developed a series of standards and best practices, along with a certification program for both new-construction and renovation projects. The Leadership in Energy and Environmental Design (LEED) standards focus on five key aspects of sustainable design:

- Sustainable site planning,
- Water-use efficiency,
- Energy efficiency,
- Material and resource conservation, and
- Indoor environmental quality.

The LEED standards use ASHRAE 90.1 as a baseline for building energy performance, but they also offer guidance for owners and designers seeking to use resources even more efficiently. Project developers can apply for LEED certification at one of four levels: LEED certified (base-level compliance), silver level, gold level, and platinum level.

LEED standards are increasingly accepted among commercial building owners and developers. Since their formal March 2000 introduction (a pilot version of the standards was released in 1998), more than 1,300 project teams have registered their intent to seek LEED certification, and more than 108 projects have been certified, according to the USGBC.

The federal government is among those developers seeking LEED certification. A new wave of federal courthouses now reaching completion will achieve silver-level LEED compliance. Additionally, the U.S. Defense Department has been using LEED guidelines in Pentagon reconstruction efforts—both those begun in the mid-1990s and those following the Sept. 11, 2001, terrorist attacks. The DOD has developed the “Field Guide for Sustainable Construction” to educate designers, contractors and other suppliers on goals and methods for reaching sustainable design targets.
How Sustainable Design Performs

The headquarters of Madison, Wisconsin-based Affiliated Engineers has the open, airy appearance many design firms strive for. It also illustrates the environmental and economic advantages sustainable design can offer. The facility addresses competing requirements with innovative solutions, showing what can happen when building professionals work as a team.

For example, maximizing natural light—both for worker comfort and energy savings—was a primary design goal. But what about heat gain and resulting cooling requirements? Architects at Flad & Associates combined light-limiting “view” glass with a window-topping band of daylight-transmitting material to allow both broad views and deep penetration of natural light into the floor plan. The view glass costs more than traditional glazing, but the resulting reduction in heat load cut size requirements for the building’s air-handling units, providing an instant payback.

 Similarly, early involvement of the general contractor meant that procedures could be developed to maximize re-use or recycling of project waste materials. The contractor was able to document that approximately 75% of waste materials were recycled or re-used.

Finally, an extensive building-commissioning process helped to ensure system performance and savings. Commissioning brings building systems on-line in a controlled process to ensure system specifications are maintained through a full range of operating conditions, and in the context of other operating equipment. Affiliated Engineers’ commissioning cost the firm $15,000; however, savings captured through the resulting systems’ optimization totaled $30,000 in the building’s first year of operation.

Affiliated Engineer’s headquarters maximizes natural light but uses view glass that cuts the heat load. Photo courtesy of Flad & Associates. Copyright Steve Hall—Hedrich Blessing Photography.
Modern control systems are really what make many of the goals of sustainable design feasible. Today’s building-automation systems (BAS) help managers control energy costs and raise occupant comfort levels by directing energy where it’s needed, and redirecting it as needs shift.

As a result, heating, ventilating and air-conditioning (HVAC) systems in larger buildings are now rarely simply on or off. Instead, variable air volume (VAV) systems, incorporating fans powered by variable-frequency drives, deliver conditioned air where and when required, based on software and sensor readings.

New systems also are incorporating carbon dioxide (CO2) monitoring, a move encouraged by current LEED standards. High CO2 levels can make occupants sleepy and less productive. In such designs, sensors are placed in occupant areas and at air-handling-unit intakes—when internal levels climb above established setpoints, fresh-air supplies are boosted.

Internet and wireless technology are taking this kind of system responsiveness to a new level. Building management can now gain access to most control systems remotely, via web browser interfaces—meaning many adjustments can be made (and problems diagnosed) without opening walls and ductwork. And new wireless thermostats can be moved by building occupants to ensure readings reflect actual conditions of the zone they are controlling, not just the temperature of the warm, sunny spot in which the thermostat happens to be placed.

Lighting controls offer similar opportunities for cutting costs and raising user comfort, but lighting-control technology is not as advanced as that now on the market for HVAC systems. Most commercial, industrial and institutional facilities rely on fluorescent fixtures that incorporate electronic ballasts. Although dimming controls exist for such fixtures, investigators at the Lighting Research Center report that some users have indicated shortened lamp life with such installations. As a result, energy-saving lighting strategies more often involve control systems that turn off one or more lamps in each multi-lamp fixture, instead of dimming all the lamps.

(For an in-depth look at more lighting design issues, see the NECA Electrical Design Library publication, “Lighting Trends: Energy Rules and Technology Rolls.”)
Sustainable-design principles recognize that buildings are part of larger communities. Recycling efforts, material selection and water conservation are all part of efforts to minimize a building's impact on its environment. Incorporating renewable and distributed-generation resources also can help limit environmental and community impact, by reducing the amount of power a facility draws from the connected utility grid, whether on an ongoing basis or only during peak periods.

Solar power, using photovoltaic cells, offers the greatest near-term opportunities at the individual building level. “Thin-film” technology allows wafer-thin layers of electricity-generating silicon to be applied to architectural elements, such as windows and roofs. California has led the way with such installations, using rebates and other incentives to boost projects like a 370-kilowatt system recently installed on the expansive, flat roof of a Lowe’s Home Improvement Warehouse in the Los Angeles suburb of West Hills. Both British Petroleum (BP) and Shell Oil have recently entered the field, with manufacturing divisions focused on turning out photovoltaic equipment, and their production capacity, marketing clout and distribution channels could help make solar options even more competitive.

Even non-renewable energy alternatives can provide environmental, as well as economic, benefits in areas where electricity supplies are tight, by limiting demand on the overall grid during peak-usage periods. Utilities must design their generating capacity to meet their customers’ maximum expected needs. As demand for electricity continues to rise, utilities are forced to add new generating stations that may only be used a few days each year. Generating stations are difficult to site, expensive to build and consume vast amounts of natural resources to power.

This expense can be avoided if large customers are able to reduce the amount of electricity they are pulling from the grid when demand is high. Customers can accomplish this task in two ways: by turning down lights and air-conditioning systems to reduce demand and by turning to non-grid resources to meet their remaining needs. Utilities facing capacity shortfalls often provide economic and technical assistance to customers interested exploring distributed generation (DG) options.

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**Web Resources**

The following resources feature more details about sustainable design and related technologies and standards:

- Institute for Electrical and Electronics Engineers ([www.ieee.org](http://www.ieee.org))
- Solar Access ([www.solaraccess.com](http://www.solaraccess.com))
- U.S. Green Building Council ([www.usgbc.org](http://www.usgbc.org))
- Greenbiz.com ([www.greenbiz.com](http://www.greenbiz.com))
- New Buildings Institute, Inc. ([www.newbuildings.com](http://www.newbuildings.com))
- U.S. Pentagon’s Field Guide to Sustainable Construction ([renovation.pentagon.mil/sustainfieldguide.htm](http://renovation.pentagon.mil/sustainfieldguide.htm))
- Electric Power Research Institute ([www.epri.com](http://www.epri.com))
- Sustainable Communities Network ([www.sustainable.doe.gov](http://www.sustainable.doe.gov))
- The Energy Star Program ([www.energystar.gov](http://www.energystar.gov))
- Sustainable Buildings Industry Council ([www.sbicouncil.org](http://www.sbicouncil.org))
- Center for Renewable Energy & Sustainable Technology (CREST) ([www.crest.org](http://www.crest.org))
DG options for lowering peak usage range from large generator sets capable of producing up to 2 megawatts, to smaller generators, microturbines and fuel cells. Facilities also may incorporate photovoltaic and wind resources to power ongoing operations.

Regardless of the off-grid source, electrical designers and contractors must make sure that the systems can be isolated from the grid to protect utility workers from electrical shock and the overall grid from fault currents.

The new Institute for Electrical and Electronics Engineers (IEEE) standard 1547-2003, “Standard for Interconnecting Distributed Resources With Electric Power Systems,” provides guidance to ensure safe and reliable connections. Additionally, NECA will be drawing on research conducted by the Electrical Contracting Foundation to develop a National Electrical Installation Standard for photovoltaic systems to define industry best practices specifically for solar-installation projects.

Researchers also are developing new equipment to make DG connections easier. The Electric Power Research Institute (EPRI) is currently developing what it calls the GridGateway, a universal, plug-n-play interconnection device that provides utility-specific protection for on-site generation and storage. The device is intended to be installed in the base of a standard 200-amp single-phase meter and used to control and monitor any distributed resource.

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**Sustainable Building Techniques**

There are hundreds of specific building techniques and products to integrate into a green building. The most important consideration is balancing economic input with environmental benefit. Some general steps include the following:

- Gather a multi-disciplinary project team;
- Compose a vision statement that focuses on goals;
- Establish a code that builders must follow (non-degradation of site, containment of storm water runoff, etc.);
- Set a budget and a schedule;
- Research applicable laws, codes, and regulations governing renovation or building;
- Assess building site characteristics (light, water, drainage, soil, air flow, and natural environment);
- Choose materials—investigate the cradle-to-grave environmental performance of proposed materials;
- Construct with minimum impact and waste; and
- Have the building commissioned—assess whether systems perform as they should and looks for deficiencies in the building and its systems before and after occupancy.

Source: Greenbiz.com
The following monographs are $4.00 each for NECA members and $10.00 for nonmembers. Prices for bulk quantities will be quoted upon request.

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