In June 1993, President Bill Clinton established the President’s Council on Sustainable Development, which was given the mission to develop and implement bold new approaches for integrating economic, social, and environmental policies to guide this country to a more environment-friendly approach in the coming new century. In 1996, the Council issued their report *Sustainable America* that essentially started this country down the road to a new way of looking at the impact we all have on nature’s fragile and intricate framework. As a result, the word sustainability entered the lexicon of architectural, engineering, and construction communities.

Paul Hawkins, in his book *The Ecology of Commerce*, provides a precise definition of the term: “Sustainability is an economic state where the demands placed upon the environment by people and commerce can be met without reducing the capacity of the environment to provide for future generations.”

Green building construction is based upon designs that are more environmentally sensitive, and that preserve our physical resources. The two topics—sustainability and green buildings—have since become mainstream, and both public and private owners recognize the savings that can result from incorporating many of these environmentally friendly schemes into their building programs.

Advocates of green buildings can no longer be viewed as “tree huggers” as more communities and corporations seize upon new opportunities to affect savings, protect the environment, and create more public awareness of the growing need to preserve our planet. The process of building factories, office buildings, and homes has had a major impact on our ecosystem in the past, but it is a process that can be mitigated and turned around.
The Impact of Construction on the Environment

Commercial and institutional buildings have a dramatic impact on our environment.

- Buildings in the United States consume 36 percent of our total energy use and 65 percent of all electrical consumption.
- Our buildings are responsible for 30 percent of all greenhouse gas emissions.
- Buildings consume 30 percent of our raw materials.
- Buildings produce 30 percent of our total waste output—approximately 136 million tons annually.
- Buildings consume 12 percent of all potable water.

The U.S. Department of Energy reports that there are 4.6 million commercial buildings in the United States, occupying more than 67 billion square feet of space, and these buildings consume one-sixth of the world’s fresh water supply, half of the virgin wood harvested, and two-fifths of our materials and energy reserves.

This provides impetus to the sustainable movement: we must preserve what we have because our resources are not limitless.

As contractors, we have a great deal of control over our environment—from recycling asphalt, concrete, and rebars to reducing harmful emissions by properly maintaining equipment that uses fossil fuels.

What Do We Mean by Sustainability?

Sustainability, as explained earlier, is the quest to sustain economic growth while maintaining long-term environmental health. When applied to construction, sustainability means creating designs that seek to balance the short-term goals of a project with the long-term goals of efficient operating systems that protect the environment and nature’s resources. Sustainable buildings represent a holistic approach to construction that combines the advantages of modern technology with proven construction practices—using nature to enhance the building’s efficiency rather than fight it.

Using fenestration to let natural light into the building employs the latest technology of inert gas–filled insulated glass panels with low emissions coatings and thermal break frames to reduce interior space lighting requirements and diminish building heating and cooling loads, as well as their related energy costs. Oriented strand board (OSB) and medium density fiberboard (MDF) are two perfect examples of sustainability—using waste and recycled wood products to create new
products that, in some cases, are more durable and more maintenance-free than the virgin wood from which they came.

**Whole-building design**

Whole-building design is a process wherein the building’s structure, envelope, interior components, mechanical and electrical systems, and even its site orientation are viewed holistically. The whole-building concept considers site, energy, materials, indoor air quality, acoustics, natural resources, and their interrelationship with each other.

In this process, new and proven technologies are discussed, weighed, debated, and incorporated or discarded.

The benefits of whole-building design are directed toward the following goals:

- Reducing energy costs
- Reducing both capital and maintenance costs
- Reducing the environmental impact of the building to the site and environs
- Increasing occupant comfort, health, and safety
- Increasing employee productivity

The history of green building construction in this country is proof that all of these requirements can be met, and at little or no initial cost to the project. The cost-effectiveness of these green buildings, over the somewhat long term, is just beginning to be documented, and it validates their reason for being. But let’s discuss the term *sustainability* in today’s vernacular a little closer.

**LEED versus sustainability.** Sustainability is the process involved in designing and building an environmentally friendly structure, while LEED (Leadership in Energy and Environmental Design) is a trademark-protected rating system developed by the United States Green Building Council (USGBC), a program of standards and certification for accreditation purposes. LEED addresses a variety of types of construction, all with one purpose in mind: to define high-performance buildings that are environmentally responsible, healthy, and profitable. The LEED program encompasses the following:

- **LEED-NC**: New Construction
- **LEED-EB**: Existing Buildings
- **LEED-CI**: Commercial Interiors
- **LEED-C&S**: Core and Shell
LEED-H: Homes

LEED-ND: Neighborhood Development

The rating systems were developed by the USGBC committees and allow for four progressive levels of certification:

- Certified (the lowest level)
- Silver
- Gold
- Platinum (the highest level)

Six credit areas exist in each category, with points awarded for the degree of compliance.

- Sustainable sites
- Energy and atmosphere
- Water efficiency
- Indoor environmental quality
- Materials and resources
- Innovation in design

Within each credit area, a number of points can be earned, the total of which determines the level of certification achieved. For example, the total number of award points is 69.

- Basic certification requires 26–32 points.
- Silver certification requires 33–38 points.
- Gold certification requires 39–51 points.
- Platinum certification requires 52 points or more.

The Basic certification level must meet 40 percent of the LEED system; Silver must meet 50 percent, Gold 60 percent, and Platinum 80 percent.

LEED approaches construction of a green building by first focusing on the site. The total number of points available for a sustainable site, for example, is 14, with one point offered when the criteria for each element has been achieved. These 14 areas are concerned with

- Erosion and sedimentation control
- Site selection
- Urban redevelopment
- Brownfield redevelopment
- Alternative transportation—public transportation access
- Alternative transportation—bicycle-friendly
Alternative transportation—alternative fuel refueling stations  
Alternative transportation—parking reductions  
Reducing site disturbance—protecting and restoring open spaces  
Reducing site disturbance—maximizing open space  
Stormwater management—flow reduction  
Stormwater management—flow treatment  
Landscape and exterior design to reduce heat islands, nonroof surfaces  
Landscape and exterior design to reduce heat islands, roof surfaces

Government takes the LEED. According to a study released by USGBC in February 2005, 41 cities in the United States have adopted some type of LEED certification program for construction or major renovation work in their public facilities. Bidders on these designated projects will have to show proficiency in delivering LEED-certified buildings in order to be qualified.

Of the 41 nationwide municipal participants, the following shows a few program specifics:

- **Atlanta, GA:** All city-funded projects larger than 5000 square feet (465 square meters) or costing at least $2 million must meet a LEED Silver Rating Level.
- **Austin, TX:** LEED certification is required on all public projects larger than 5000 gross square feet (465 square meters).
- **Berkeley, CA:** Municipal buildings larger than 5000 square feet (465 square meters) were required to be LEED-certified in 2004; in 2006, buildings of this size must achieve Silver certification.
- **Dallas, TX:** All city buildings larger than 10,000 square feet (929 square meters) are required to have at least LEED Silver certification.
- **Boston, MA:** This city established LEED Silver as the goal for all city-owned buildings.
- **Chicago, IL:** All new city-funded construction and major renovation projects will require LEED Silver certification at a minimum.
- **Kansas City, MO:** All new city buildings must be designed to meet LEED Silver certification at a minimum. The city is participating in a LEED-EB (existing buildings) pilot program for their city hall.
- **San Francisco, CA:** All municipal new construction, additions, and major renovation projects larger than 5000 square feet (465 square meters) must achieve LEED Silver certification.
- **Scottsdale, AZ:** In March 2005, the city passed Resolution 6644 requiring all new public buildings to be certified as LEED Gold.
In Canada, the number of sustainable buildings is also growing:

- **Calgary**: The city’s sustainable building policy requires all new or significant renovations larger than 500 square meters (5380 square feet) to achieve LEED Silver certification or higher.

- **Vancouver**: All new civic buildings larger than 500 square meters (5380 square feet) have adopted green building standards LEED-British Columbia (LEED-BC). New public buildings must achieve LEED Gold certification at a minimum.

**Green buildings in the private sector**

Private developers have also recognized the value of green buildings both in terms of costs and in public relations.

The Swiss Reinsurance Tower in London reported 50-percent less energy consumption than in conventional buildings. Closer to home, the Conde Nast Building in Manhattan uses 35- to 40-percent less energy than standard construction design requires, and the Solaire, a 27-story, 293-unit, Gold-rated apartment building further downtown in Battery Park City is 35-percent more energy efficient than required by code, resulting in 67-percent lower power demands. During construction, 93 percent of recoverable materials were diverted from the local landfills. The $1 billion 1 Bryant Park building in Manhattan, when completed in 2008, will have glass double-wall technology that actually dissipates the sun’s heat, will have under-floor ducts, carbon dioxide sensors to insure the flow of fresh air, and a rainwater and waste water collection system that is estimated to save 10.3 million gallons of water annually.

Out West, Toyota embraced green building technology with their new $87 million sales campus in Torrance. This 624,000-square-foot facility has 53,000 square feet of solar panels that generate 536 kilowatts and is projected to pay for itself in seven years. Motion sensors control all of the building’s lighting, and ceramic floor tiles are made from recycled glass and recycled concrete.

**Pennsylvania in the LEED**. Pennsylvania’s Department of Environmental Protection has been at the forefront of green construction with five LEED-registered projects on stream as of 2005. The state’s first LEED Gold-level green building was built in Cambria, and this 40,000-square-foot project came in at $90.00 per square foot, slightly under comparable costs for conventional buildings. The building has triple-pane high-performance windows that ultimately reduced their heating and cooling loads savings by $20,000 in initial costs and continues to reduce operating costs. The DEP reports that their LEED Silver-level buildings cost virtually the same as conventional construction.
Even the Pentagon is interested in savings. Hensel-Phelps Construction Company, while working on a Pentagon renovation project, discovered a wheat-straw board product that was suitable to use as backer boards in electrical closets. This simple substitution of product saved the government $30,000.

Some Design-Build/Sustainable Building Guidelines

There are eight simple principles of sustainable design that Tony Loyd and Donald Caskey, senior vice presidents and principals of Orange County, California–based Carter & Burgess set as guidelines to design, construction, and operation:

- A multidiscipline, integrated approach is the key to success.
- Simple is better than complex.
- The overriding framework in these types of projects should reflect a respect for nature so that it is not depleted or harmed.
- Life-cycle costs are more significant than first costs (in the age old battle between capital versus expenses).
- Minimize energy use in the selection of building materials, mechanical systems, and appliances.
- Since maintenance of the structure is important, plan accordingly.
- Build with local materials whenever possible to reduce transportation costs. Local materials may be better suited to that environment.
- Consider passive strategies whenever possible, such as building orientation, overhangs and sun shades, thermal mass, and natural lighting.

Are green buildings more expensive than conventional construction?

A study of the cost and benefits of green buildings was conducted by the State of California after Governor Gray Davis issued Executive Order D-16-00 in August 2000 that funded the research. The complete study, titled A Report to California’s Sustainable Building Task Force—October 2003, is available on the Internet at www.usgbc.org/Docs/News/News477.pdf.

This rather detailed examination showed that while green buildings may cost more than conventionally designed buildings, the premium for sustainability is much lower than generally perceived. Figure 15.1 reveals the premium costs associated with the four certification levels established by USGBC. Figure 15.2 contains the average premium for green offices and schools.
Sustainability and Green Buildings

362 Chapter Fifteen

<table>
<thead>
<tr>
<th>Level of Green Standard</th>
<th>Average Green Cost Premium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1 – Certified</td>
<td>0.66%</td>
</tr>
<tr>
<td>Level 2 – Silver</td>
<td>2.11%</td>
</tr>
<tr>
<td>Level 3 – Gold</td>
<td>1.82%</td>
</tr>
<tr>
<td>Level 4 – Platinum</td>
<td>6.50%</td>
</tr>
<tr>
<td>Average of 33 Buildings</td>
<td>1.84%</td>
</tr>
</tbody>
</table>

*Source: USGBC, Capital E Analysis*

**FIGURE 15.1** The premium costs associated with the four certification levels established by USGBC.

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**Average Green Premium vs. Level of Green Certification**
(for Offices and Schools)

*Source: USGBC, Capital E Analysis*

<table>
<thead>
<tr>
<th>Year of Completion</th>
<th>Average Green Cost Premium</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997-1998</td>
<td>2.20%</td>
</tr>
<tr>
<td>1999-2000</td>
<td>2.49%</td>
</tr>
<tr>
<td>2001-2002</td>
<td>1.40%</td>
</tr>
<tr>
<td>2003-2004</td>
<td>2.21%</td>
</tr>
<tr>
<td>Avg. of 18 Silver buildings</td>
<td>2.11%</td>
</tr>
</tbody>
</table>

*Source: USGBC, Capital E Analysis*

**FIGURE 15.2** The average premium for green offices and schools.
While the total number of buildings surveyed in this Task Force study is not large, only 33, it does reveal that, in general, green buildings have an average premium cost of just about 1.84 percent.

Green costs are coming down every year as additional architects and engineers, equipment manufacturers, and builders become more familiar with the concept and gain greater experience in its development.

This California study indicated that minimal increases in upfront costs of about 2 percent would, on average, result in lifecycle cost savings of about 20 percent. For example, an initial investment of $100,000 to incorporate green building features into a $5 million project would result in a savings of $1 million in today’s dollars over the life of the building, according to the findings in the report.

The financial benefits of green buildings, as pointed out in the survey, includes lower energy costs, lower waste disposal costs, lower water costs, lower environmental and emissions costs, lower operating and maintenance costs, and the increased productivity and health of the workers occupying these types of buildings.

The energy costs and water savings were rather easy to predict, but the productivity and health gains were much less precise and much harder to predict. Figure 15.3 shows the percent of reduction in energy costs for certified, silver, and gold certifications.

<table>
<thead>
<tr>
<th>Energy Efficiency (above standard code)</th>
<th>Certified</th>
<th>Silver</th>
<th>Gold</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-Site Renewable Energy</td>
<td>18%</td>
<td>30%</td>
<td>37%</td>
<td>28%</td>
</tr>
<tr>
<td>Green Power</td>
<td>0%</td>
<td>0%</td>
<td>4%</td>
<td>2%</td>
</tr>
<tr>
<td>Total</td>
<td>28%</td>
<td>30%</td>
<td>48%</td>
<td>36%</td>
</tr>
</tbody>
</table>

Source: USGBC, Capital E Analysis

As discussed above, green buildings use an average of 30% less purchased energy than conventional buildings. In addition, green buildings are more likely to purchase “green power” for electricity generated from renewable energy sources. Green power purchases can take two forms:

- Customers can purchase green power directly from their utility or from a local green power provider. In this case customers are paying for electricity generated from renewable energy sources, typically by a local provider in the state or utility jurisdiction. About 40% of US electricity customers have this option.
- Customers can purchase green certificates, or green tags. In purchasing green certificates, a customer is buying ownership of the reduced emissions (and by implication the environmental and health benefits) associated with renewable power, even though the green generating facility is frequently not in the customer’s vicinity. All electricity consumers have this option.

FIGURE 15.3 The percent of reduction in energy costs for certified, silver, and gold certifications.
Let’s take a look at some of the positive effects attributable to green building construction in the California study, effects that will obviously vary from state-to-state, but which nonetheless represent an order of magnitude that can be adjusted accordingly.

**Energy Use.** These buildings were 25- to 30-percent more energy efficient when compared to ASHRAE 90.1-1999. Interactions between lighting versus heating and cooling and between fresh air and humidity control are analyzed simultaneously allowing designers to prepare a holistic approach to energy-consuming equipment and building performance. Except for isolated areas in this country, air conditioning is the overriding requirement, particularly in buildings with high occupancy rates; therefore, special attention needs to be paid to this building component. Innovative approaches to satisfying cooling loads include

- Incorporating more efficient lights, task lighting, sensors to cut unnecessary lighting, and using daylight, which will not only reduce power consumption but also reduce cooling loads
- Increasing ventilation effectiveness, which will help cut cooling loads during peak periods through improved system optimization
- Using under-floor air distribution systems; use of an under-floor plenum to deliver space conditioning typically cuts fan and cooling loads
- Commissioning in a systematic approach to insure that systems as designed are installed and are operating as planned.
- Using heat island reduction measures; increased roof reflectivity will lower building temperatures and reduce cooling loads. Albedo is the unit used in measuring the reflectivity of solar energy striking a roof—the higher the Albedo number, the higher the reflectivity.
- Generating energy onsite via photovoltaics, which in some climates can generate 20 percent of total consumption

**Projected savings**

The California study showed that the reduction in energy costs will provide the following energy savings over 20 years using the present value-cost analysis:

- Thirty-percent reduced consumption at an electricity price of $0.11 per kWh is about $0.44/ft²/yr × 20 years = $5.48 per ft².
- The additional value of peak demand reduction from green buildings was estimated at $0.025/ft²/yr × 20 years = $0.31 per ft².
- Together, the total 20-year present value of energy savings from a typical green building is $5.79 per ft².
Water conservation. Green building water conservation is divided into four sectors:

- Potable water is used more efficiently through better designs and new technologies.
- Gray water—nonfecal wastewater from bathroom sinks, tubs and showers, washing machines, and drinking fountains—is captured and used for lawn and planting irrigation.
- Onsite stormwater is captured for use onsite or to recharge groundwater tables.
- Recycled or reclaimed water is made available for other uses.

The California studies showed that, taken all together, these measures can reduce water consumption in the building to levels 30-percent lower than code requirements and can reduce exterior water demands by as much as 50 percent. In areas where water supplies are being overloaded, reclaimed water projects are taking on added importance. The Bay Area of California expects fully 50 percent of their new water supply to come from reclaiming. These reclaiming projects typically cost about $600–$1100 per acre/foot based on estimates from the East Bay Municipal Utility District.

Waste reduction. We are known as the disposable generation: use something a few times and discard it. In fact, packaging costs often exceed the value of the item these days, and that outer package always seems 500-percent larger than the product itself.

Reducing waste is a national concern and a nationwide problem. Not only are trucking and removal costs higher due in no small part to increases in gasoline and diesel fuel, but many states are simply running out of room and have no place to dump their waste. California estimates that their total annual waste, as of 1998, amounted to 33 million tons, 21 million of which is generated by nonresidential buildings. An updated study would most likely show a much higher figure.

Green building attempts to reduce waste and focus on recycling and reuse—two things which can begin during the construction process and continue on throughout the lifetime of the building.

Steps that can be taken during construction to start this process include

- Reusing and minimizing construction and demolition debris, and diverting some of it from landfills to recycling facilities. Good examples of this are recycling cast-in-place concrete to remove rebars and then converting the concrete to aggregate. The recycling of masonry materials for use as a base course under paving has proven to be an effective use of construction debris.
Source reduction—using materials that are more durable and easier to repair/maintain.

Using reclaimed materials, such as (mentioned earlier) aggregate for the base course under paving, or employing ground glass as a reflective material in asphalt paving.

Using materials that can function in a dual role (for example, exposed structural systems and ductwork, and staining concrete floor slabs).

Incorporating an existing structure into a new building program.

During the life of the building, the following can be done:

- Develop an indoor recycling program.
- Design for deconstruction.
- Design for flexibility via the use of movable walls, modular furniture, movable task lighting, and other reusable building components.

Construction and demolition diversion rates reached as high as 97 percent with some California projects and are typically 50 to 75 percent in green buildings.

Other revealing but not so apparent benefits of green buildings

The obvious effects of green building design and construction come readily to mind, but there are other subtle and compelling reasons to support this movement.

Recycling creates jobs. One interesting sidebar to this question of disposal or recycling is how it affects employment. The total impact from diversion of waste material is nearly twice as much as the impact for disposal.

A study conducted by University of California, Berkeley, revealed that one additional ton of waste disposed of in a landfill generated $289 of total output in the state economy. One additional ton of waste diverted as a recyclable generated an average of $564. Only 2.46 jobs were created for every 1000 tons of waste disposed, but 4.73 jobs were created for waste diverted as recyclable.

Productivity gains from improvements in the working environment. The quality of the working environment affects both health and productivity. A healthy environment leads to a reduction in sick days that impacts productivity. The pie chart in Figure 15.4 reflects the results of a further study by California that lists the financial benefits of LEED certified and silver buildings, and worker productivity and health are far and away the best beneficiaries to have with a green program.
Lastly, Figure 15.5, the conclusion of the California Build Task Force report is that building green is quite cost-effective, thus making lots of financial sense.

The sustainable approach to construction. The process of designing and constructing a structure to green standards involves not only the building itself but the site on which it will be located. This includes access to the site as well.

The following goals and objectives can be viewed as a primer for this form of sustainability.

<table>
<thead>
<tr>
<th>Category</th>
<th>20-year NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Value</td>
<td>$5.79</td>
</tr>
<tr>
<td>Emissions Value</td>
<td>$1.18</td>
</tr>
<tr>
<td>Water Value</td>
<td>$0.51</td>
</tr>
<tr>
<td>Waste Value (construction only) - 1 year</td>
<td>$0.03</td>
</tr>
<tr>
<td>Commissioning O&amp;M Value</td>
<td>$8.47</td>
</tr>
<tr>
<td>Productivity and Health Value (Certified and Silver)</td>
<td>$36.89</td>
</tr>
<tr>
<td>Productivity and Health Value (Gold and Platinum)</td>
<td>$55.33</td>
</tr>
<tr>
<td>Less Green Cost Premium</td>
<td>($4.00)</td>
</tr>
<tr>
<td>Total 20-year NPV (Certified and Silver)</td>
<td>$48.87</td>
</tr>
<tr>
<td>Total 20-year NPV (Gold and Platinum)</td>
<td>$67.31</td>
</tr>
</tbody>
</table>

Source: Capital E Analysis

FIGURE 15.4 The results of a study listing the financial benefits of LEED certified and silver buildings.

FIGURE 15.5 The conclusion of the California Build Task Force report.
The Site.  

**Sitework goal:** Meet or exceed standards for erosion and sedimentation control by doing the following:

- Prevent loss of soil during construction due to stormwater run-off and wind erosion.
- Prevent siltation of existing storm sewers and streams.
- Protect topsoil stockpiles for reuse, or modify soils to meet topsoil acceptable standards.

**Site utilities goal:** Reduce stormwater run-off and reuse by accomplishing the following:

- Minimize or totally eliminate stormwater run-off by carefully planning infiltration swales and basins to reduce impermeable surfaces instead of installing detention ponds.
- Retain or recharge existing water tables by minimizing disturbances, saving trees and natural vegetation, and supporting and enhancing natural landforms and drainages.
- Store roof run-off for future use as gray water or reclaimed water.
- Install onsite a small footprint, state-of-the-art treatment plant to recycle water for irrigation purposes.

**Open space and landscaping goal:** Protect and restore existing vegetation by doing the following:

- Protect trees, which enhances the value of the site and lowers cooling loads. Indigenous landscaping supports wildlife and biodiversity and does not require the level of irrigation necessary for new ground cover. It also eliminates the need for chemical treatment.
- Minimize pesticide use by installing weed cloth, mulches, and dense plantings.

**Circulation and transportation goal:** Improve circulation and decrease the need for private transportation by doing the following:

- Tie development or building to transit nodes and emphasize alternatives such as organized car pooling, water taxies (if available), buses, car sharing.

The Building.  

**During construction goal:** Reduce waste by doing the following:

- Divert at least 75 percent of construction, demolition, and land clearing from disposal as landfill.
Deconstruct all existing structures with substantial recoverable materials and dispose of them to recyclers.

Adjust new site contours to provide for a balanced site. Modify non-topsoil soils to acceptable topsoil requirements.

The Holistic Approach—Again. Energy-efficient building components are all-encompassing. Energy-efficient heating and cooling systems, and building envelope products like double/triple-glazed windows come easily to mind, as do advanced, programmable control systems. And what about foundation insulation, roof insulation, and Albedo (roof reflectivity) values? Energy-efficient plumbing fixtures and lighting fixtures with built-in power management systems improve every year. Office equipment that goes into “sleep” mode when not used not only reduces electrical costs but also lowers the heat load.

Passive solar design, the technology of heating, cooling, and lighting by converting sunlight into a power source can work effectively with other energy-efficient materials and products. Photovoltaics can supplement or replace power from local utility companies.

NREL and Oberlin College’s pilot program. The National Renewable Energy Laboratory (NREL) was established in 1974 and is the principal laboratory for the Department of Energy’s Office of Energy Efficiency and Renewable Energy. Their mission is to develop renewable and energy-efficient technologies.

Oberlin College in Oberlin, Ohio wanted to design and construct a building to serve as a model and teaching aid for students in their environmental studies program. To that end, they built the 13,600-square-foot (1260-square-meter) Adam Joseph Lewis Center on campus, containing classrooms, offices, and an atrium.

The goal of the project was to construct a building that was not only energy efficient, but also one that was able to export energy to the local grid system. In order to do so, they would install passive solar designs, use natural ventilation wherever possible, design an enhanced thermal building envelope and use geothermal heat pumps for heating and cooling. The building’s roof would incorporate an integrated photovoltaic (PV) system to allow for solar generation of electricity for the building.

After the building was completed in 2000, the NREL began to monitor the structure to evaluate its energy performance. Their findings would serve three purposes:

- Evaluate the performance of the building and several of its subsystems.
- Provide suggestions to improve the initial performance.
- Document lessons learned to improve the design of future low-energy buildings.
This study, while sophisticated in its analysis of the performance of mechanical and electrical systems, dramatically describes steps that can be taken to reduce energy demands.

NREL’s study of the Oberlin College building ended in 2003, but it stated that more work was required to fulfill the original goal of the project as being one of net energy exported, but the strides taken in this venture further the case for energy self-sufficiency.

Some of the lessons learned by NREL are generic in nature and apply to any sustainable building project:

- PV systems must be engineered to minimize transformer balance and system losses. These losses can represent a significant portion of the overall system production.
- PV systems may not significantly reduce the building demand. In this case, any small demand reduction due to PV is from load diversity.
- During summer months, on average, large PV systems in commercial buildings can export electricity from 8:00 A.M. to 6:00 P.M. From a utility perspective, this building was a net positive during daylight hours in the summertime and provided power when it was most needed by the grid.
- Control design must be completely integrated using the full capabilities of the equipment in the building, such as CO₂ sensors, motion sensors, and thermostats. A balance must be achieved between human operations and automation.
- Dark ceilings must be avoided to take full advantage of daylighting and uplighting.
- Daylighting sensors are needed in all daylit areas. It is not sufficient to rely on manual controls.
- Daylighting must be designed into all occupied areas. The daylighting design should consider additional heating and cooling loads imposed upon the building. Overglazed areas such as the atrium in this building provided abundant daylighting but resulted in additional heating and cooling loads.
- Specifications for heat pumps must work with appropriate groundwater temperatures.
- Electric boilers can be employed as a back-up source if they are used sparingly and do not cause excessive demand charges on the building. Controls and staging are essential for the integration of limited-use systems such as these.
The Greening of Existing Buildings

The LEED Certification—EB was established to deal with the upgrading of existing buildings to green standards. JohnsonDiversey is a manufacturer of cleaning and hygiene products located in Sturtevant, Wisconsin. It is housed in a 277,440-square-foot building, built in 1997, 70 percent of which is office space, while 30 percent is devoted to research laboratories. It is a breakaway company from SC Johnson Inc. in Racine, Wisconsin, the well-known producer of Johnson’s Wax. JohnsonDiversey’s legacy for innovation extends back to the parent company in Racine, which was among one of the first corporations in America to recognize the importance of good architecture and its positive effect on the working lives of their employees. The Frank Lloyd Wright–designed SC Johnson headquarters in Racine was not only a monument to progressive corporate policy when built in 1936 but remains so today with its famous lily-pad columns in the building’s main room. SC Johnson Wax voluntarily eliminated CFCs, that ozone depleting refrigerant, from their aerosol product line in the 1970s, and led the development of more environmentally compatible propellant products.

In 2004, the Sturtevant facility at JohnsonDiversey earned its LEED certification as an existing building for a structure containing 80,000 square feet (7435 square meters), about 30 percent of its 278,000-square-foot (25,836 square meters) building.

Their LEED certification included the following modification/remediation measures:

- Native prairie plants and restored wetlands were developed on more than half of the 57-acre site.
- Stormwater collection for turf grass reduced potable water use by 2 to 4 million gallons per year.
- Low-flow fixtures reduced water use.
- More than 50 percent of solid waste was recycled.
- Ninety percent of interior space receives reflected light.
- Personal environment controls are installed at each work station.
- Rapidly renewable, locally available materials such as maple wood are used throughout.

Several innovative programs exist at the site, some of which do not involve substantial cash outlays, and one that is as simple as encouraging alternative transportation choices.

Of the 580 parking spaces provided, 10 percent (or 58) are reserved for hybrid vehicles, while 16 car/vanpool spaces are allotted to encourage car pooling. The personal environment modules (PEMs) installed
in 93 percent of the total building office area allow for the individual control of temperature, air flow, lighting, and acoustics at each designated workstation.

JohnsonDiversey converted water usage from 2.5 gallons per minute (gpm) to 0.5 gpm by installing aerators on all lavatory faucet fixtures, and additionally reduced usage from 2.5 gallons per minute to 1.8 gpm by the installation of aerators on all shower fixtures. In combination with flush valve replacement diaphragms rated at 1.6 gallons per flush (gpf) for toilets to 0.5 gpf for urinals, they have reduced water use performance to very low levels.

They have reduced waste disposal through a vigorous recycling program and employee awareness, and have distributed a recycling card to each employee providing information on what is to be recycled, where to take recyclables, and who to contact for questions. Twenty-four recycling areas for cans, plastics, and glass are situated throughout the building, where the recyclables are collected and emptied into large containers on the loading dock.

Table 15.1 shows their annual waste generation profile.

For all construction projects within the building, they require that staff or contractors recycle and/or salvage at least 30 percent by weight any construction, demolition, or land-clearing waste.

Items like toxic materials source reduction were addressed by inventorying such things as existing light fixtures and bulbs. They now purchase 32W T-8 Alto lamps from Phillips that have a mercury content of 18.6 parts per million (ppm), which is considerably under the limit of the 25.0 ppm code.

The Green Building Rating System for Existing Buildings was issued in October 2004 and is referred to as LEED-EB. USGBC launched Version 2.2 of the Green Building rating systems in late 2005, reflecting experience gleaned from comments made regarding the previous iteration. A direct dialog with ASHRAE resulted in new calculations in order to achieve some performance goals. New application guides for health-care facilities, schools, and laboratories are also in the works.

**TABLE 15.1 The Annual Waste Generation Profile of the SC Johnson Headquarters**

<table>
<thead>
<tr>
<th>Item</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garage</td>
<td>208,000 lbs</td>
</tr>
<tr>
<td>Waste-recycled</td>
<td>74,800 lbs</td>
</tr>
<tr>
<td>Paper</td>
<td>116,480 lbs</td>
</tr>
<tr>
<td>Commingle (cans, glass, plastic)</td>
<td>5200 lbs</td>
</tr>
<tr>
<td>Total waste stream</td>
<td>404,480 lbs</td>
</tr>
<tr>
<td>Total recycled</td>
<td>196,480 lbs</td>
</tr>
<tr>
<td>Percent recycled</td>
<td>49 percent</td>
</tr>
</tbody>
</table>
As the Green Building movement spreads across the private and public sector, new opportunities await those design and construction firms that become intimate with the requirements of sustainable structures.

Thus, as you can see, it is easy to be green—and also profitable.
Sustainability and Green Buildings