Introduction to Sustainable Design

Defining Sustainable Design

One of the most widely used definitions of sustainable development is “Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”

This definition could apply to meeting any human need, such as for clothing, shelter, and food. This definition, however, is very broad based. A more concise definition of sustainability in a design context, from Governor Gray Davis’ Order on sustainable design, is:

“…to site, design, deconstruct, construct, renovate, operate, and maintain state buildings that are models of energy, water, and materials efficiency; while providing healthy, productive and comfortable indoor environments and long-term benefits…”

Key Attributes of Sustainable Design

A state plan for integrating sustainable design, called “A Blueprint for State Facilities”, notes key attributes of sustainable design as:

Siting considerations that
- evaluate proximity to public transportation and affordable housing;
- promote economic renewal;
- and analyze building design and placement options to optimize resource efficiency;

Energy, water, and materials efficiency;
Improved indoor environmental quality and comfort; and;

The use of environmentally preferable products and processes, such as
- waste diversion techniques
- recycled-content materials

Characteristics of Sustainable Design

Embracing sustainable design enhances building design. Characteristics include:
- High performance
- Good quality
- Durability
- Added value
- Acceptable cost based on life cycle assessment
- Pleasing aesthetics

Reduced operating costs
Reduced environmental impacts

Impacts of Buildings

Buildings have an enormous impact on the environment, including resource consumption, the production of pollutants, and numerous impacts to habitats and species.

Energy Consumption and Air Emissions

Worldwide, daily energy consumption requires 10,000 days to replenish depleted fossil fuels. Worldwide energy consumption will grow by 59 percent over the next 20 years, according to an annual forecast released by the U.S. Department of Energy. Carbon dioxide emissions linked to global climate change are expected to nearly double by the year 2020.

Unfortunately, even though renewable energy use is expected to increase by 53 percent between 1999 and 2020, its current nine percent share of total energy consumption is projected to drop to eight percent by 2020.

In the U.S., buildings consume 30% of energy and...
60% of the electricity produced, much of which is produced from combusting fossil fuels. Serious problems associated with non-renewable electricity production include:

- 35% of all CO₂ emissions
- 75% SO₂ emissions
- 30% of NOₓ emissions

These emissions contribute to global warming, lead to the formation of smog, and negatively impact air quality.

Energy consumption also costs building owners significant amounts over the life of the building. The Information Administration notes that commercial building owners pay approximately $15,300 per building for electricity, natural gas, fuel oil, and district heat.

**Resource Consumption**

According to the Worldwatch Institute Paper “A Building Revolution: How Ecology and Health Concerns are Transforming Construction”, in the U.S., construction annually consumes

- 40% raw stone, gravel & sand
- 25% virgin wood. Since 1950, a fifth of the world’s forest cover has been removed
- 3 billion tons of raw materials
- Up to 40% of landfill content
- Up to 15% of materials used in construction may be wasted
- Waste creates long-term hazards to human health and ecosystem

**Water Use and Quality**

In the U.S., 340 billion gallons of fresh water are withdrawn daily. In office buildings, occupants use an average of 20 gallons per day. However, water efficient strategies employed in buildings can reduce usage by 30%, significantly reducing water use.
Introduction to Sustainable Design

Water use also has to be treated at wastewater treatment plants and stormwater runoff from fertilized turf and impervious paved surfaces can pollute streams and rivers. Freshwater supply constraints also mean that building related water consumption competes with water needs in the ecosystem and in agriculture.

The U.S. Census Bureau notes that in 1995, California accounted for almost 11% of all freshwater used in the U.S.

Site Development
According to the U.S. Bureau of Census Data on Urbanized Areas, 95% of the total sprawl in California from 1970-1990 was related to population growth. Furthermore, despite accepting the densest living conditions in the country, LA sprawled 394 square miles from 1980-1990 and added 3.1 million residents.

California’s population is projected to rise from its current 35 million residents to just under 50 million in 2025. This would make California as densely populated as China is now.

Sprawl contributes to environmental problems such as:
- Disruption of habitat corridors
- Soil erosion
- Increased stormwater runoff
- Destruction of ecosystems
- Loss of agricultural land
- Air pollution related to transportation

Indoor Environmental Quality
According to the EPA:
- Indoor air is often more polluted than outdoor air, sometimes as much as 100x more polluted. This is a huge concern given the fact that Americans spend approximately 90% of their time indoors.
- Indoor air pollution is one of the top five environmental risks to public health. According to the Worldwatch Institute, in fact, Sick Building Syndrome affects 30% of new & renovated buildings. It is estimated that this translates to lost productivity totaling billions annually.

IEQ impacts occupant productivity, performance, health, and satisfaction.

Sustainable Design Principles
It is easier to grasp all of the aspects of building design, construction, and operation that might impact the natural environment or building occupants by addressing five key principles of sustainable design: Sustainable Sites, Safeguarding Water, Energy and Atmosphere, Indoor Environmental Quality, and Materials and Resources. Following is an overview of these principles as well as a few examples of opportunities to integrate related sustainable solutions. More detailed information on all of these principles will be presented during the training.

Sustainable Sites
Overall goal: Minimize the negative impact of site selection and site design. For example:
- Select building sites with access to public transportation
- Reuse a building instead of building new
- Minimize building footprint
- Encourage urban development
- Plant drought-resistant vegetation
Safeguarding Water
Overall goal: conserve water and protect water quality.
For example:
- Use low-flow fixtures
- Integrate vegetated filter strips and grass swales
- Collect and use rainwater
- Plant indigenous vegetation
- Use pervious surfaces
- Use of reclaimed or recycled water for irrigation

Energy & Atmosphere
Overall goal: Design for energy efficiency and consider renewable sources.
For example:
- Generate electricity on-site (fuel cells; photovoltaics, for example)
- Eliminate CFCs and HCFCs
- Utilize occupancy sensors
- Consider alternative power contracts
- Recover waste heat

Materials & Resources
Overall goal: Minimize the life-cycle impact of materials.
For example:
- Practice Construction Waste Management
- Specify:
  - Rapidly renewable materials
  - Certified wood
  - Recycled content
  - Low emitting materials
  - Durable materials

Indoor Environmental Quality
Overall goal: Enhance the health and comfort of building occupants.
For example:
- Include a construction Indoor Air Quality plan
- Provide for occupant control of lighting, air flow, or operable windows
Benefits of Sustainable Design
There are many benefits associated with integrating sustainable design concepts. 

**Increased Community Perception.** Environmental awareness continues to increase. Building owners who utilize sustainable design approaches send a “good neighbor” message to the community.

**Reduced Operating Costs.** One of the primary goals of sustainable design is to reduce operating costs. For the most part, this is due to reduced energy consumption.

**Reduced Liability.** A building’s healthy indoor environment can offset the trend towards increased insurance claims related to indoor air quality problems.

**Increased Market Demand/Building Value.** Buildings designed using sustainable design principles are leasing faster. Since sustainable buildings are often less expensive to operate, some building owners are willing to pay more for them.

**Increased Productivity.** Many studies show that sustainably designed buildings will increase occupant productivity. Rocky Mountain Institute’s publication, Greening the Building and the Bottom Line documents eight case studies that show that productivity gains from green design can be as high as 16 percent. Even small increases in productivity can be significant considering that personnel costs are typically more than 90% of a building owner’s costs, with the other 10% being initial construction costs and building operational costs.

**Efficient Operations & Maintenance.** Longer lasting products, less cleaning with toxic substances, increased use of control systems for water delivery and energy use can lower O&M costs. This is one of the primary goals of sustainable design.

**Regional Economic Development.** Sustainable design encourages the use of regionally or locally produced materials to minimize the energy and air emissions impacts related to transporting materials.

**Increased Employee/Occupant Satisfaction.** Studies indicate that building occupants are healthier and more satisfied in sustainably designed buildings.

**Environmental benefits** include the Conservation of Natural Resources and Reduced Waste.

National Sustainable Design Trends
California is not unique in embracing sustainable design. There are several national trends that are resulting in the increased acceptance of sustainable design principles. These include the development of Federal and State initiatives, sustainable building incentives, and the [Leadership in Energy and Environmental Design (LEED™) Green Building Rating System](https://www.usgbc.org/leed).

California Sustainable Design Training 1.5
**Federal Government Requirements**

The Federal Government has been an early leader in integrating sustainable design into projects. This was partially due to Federal Executive Orders (E.O.s) that were issued beginning in the late 1990s. The first E.O.s addressed waste reduction and energy efficiency. Later E.O.s, however, required that Federal Agencies address sustainable design comprehensively, including energy efficiency, efficient use of water, waste reduction, sustainable site planning, and indoor environmental quality. *Order 13123, Greening the Government through Efficient Energy Management*, issued in June of 1999, went so far as to require the Department of Defense, General Services and Administration and the Department of Energy to provide sustainable design training to their staff.

These are just a few of the Federal Agencies requiring sustainable design:

**Services Administration (GSA).** The GSA requires the use of the Leadership in Energy and Environmental Design (LEED™) Green Building Rating System for all new buildings funded in 2001 or later (more information on LEED™ is presented later in this chapter). All agencies (such as the Environmental Protection Agency and the Department of the Interiors) that lease space from the GSA are required to meet the GSA’s Green Lease Acquisition requirements.

**National Parks Service (NPS).** The NPS developed the "Guiding Principles of Sustainable Design". These guidelines address incorporating sustainable design into Parks' projects.

**U.S. Postal Service (USPS).** The USPS built the first "Post Office" in Fort Worth,
Texas and is currently integrating lessons learned into other facilities.

State Requirements
Many states are now following the lead of the Federal government, and making sustainable practices/design a policy or legislative requirement for their own facilities. Some of these state requirements are:

**Indiana, Executive Order, 1999.** The goal of this order is to improve the environmental performance of all state operations.

**North Carolina, Executive Order, 1999.** This Executive Order addresses environmental sustainability, reduction of solid waste, and procurement of environmentally preferable products in state government.

**Oregon, Executive Order, 2000.** Requires that all state agencies integrate sustainable design into all state projects.

**California, Executive Order 16, August 2000.** Requires that an interagency task force be established to determine how sustainable design could be integrated into all state projects.

**Maryland, Executive Order, 2001.** This Executive Order requires energy efficient and environmentally responsible facilities; sets goals for purchasing green energy; outlines energy conservation strategies.

Incentives
There are many existing incentives for sustainable design. For example,

Arlington County provides a density incentive for developers who use the LEED™ Rating System.

New York City offers green building tax credits for sustainable design. Other cities are looking at the New York City model as the basis for developing similar legislation.

Effective October 8, 2001, businesses in Oregon can get a tax credit for buildings that achieve a Silver Rating or higher under the US Green Building Council's LEED™ Rating System (more information on LEED follows).

Grants
There are both local, and in some cases, federal rebates for integrating sustainable technologies, devices, and/or systems. Most of these deal with energy efficiency. The California Consumer Energy Center has a database of state grants, rebates, and incentives.

Incentive Programs
**Savings by Design** is a program to encourage high-performance nonresidential building design and construction. Sponsored by four of California’s largest utilities under the auspices of the Public Utilities Commission, Savings By Design offers building owners and their design teams a wide range of services, including design assistance, design team incentives, and building owner incentives. This program is funded by California utility customers and administered by Pacific Gas and Electric Company, San Diego Gas and Electric, Southern California Edison Company and the Southern California Gas Company.

California Energy Commission
Notes:

1. Programs include peak load reduction, energy efficiency financing and renewable energy and distributed generation incentives. These programs lower first costs or financing costs.

California Requirements

Executive Order D-16-00
On August 2, 2000, Governor Gray Davis signed Executive Order D-16-00, which established the state's sustainable building goal. The Secretary of State and Consumer Services Agency (SCSA), Aileen Adams, was called to consult with "appropriate private sector individuals and public officials" including:
- Director of the Department of Finance
- Secretary of Business, Transportation, and Housing
- Secretary for Education
- Secretary for Environmental Protection
- Secretary of Health and Human Services
- Secretary for Resources

One outcome was the official recognition of an interagency sustainable design Force, formed to prepare policy recommendations and report annual progress in meeting the goals of the Executive Order.

Sustainable Design and LEED™
The .S. Green Building Council (USGBC) is a non-profit organization with 800+ members nationwide. Its membership includes representation from all aspects of the building industry including: product manufacturers, environmental groups, building owners, building and design professionals, utilities, city governments, the federal government, research
Introduction to Sustainable Design

institutions, professional societies, and universities.

Membership is voluntary and diverse, and operates on consensus principles. The purpose of the U.S. Green Building Council is to make sustainable design become mainstream practice.

In the mid-1990s, the USGBC responded to inquiries from its membership regarding how to define green buildings or sustainable design. The membership, after researching existing systems that rated the environmental performance of buildings, concluded that none of the existing systems fit what was needed in the U.S.

The membership developed the LEED® Green Building Rating System. The USGBC maintains administrative authority of LEED®.

Overview of LEED®

is based on accepted energy and environmental principles and strikes a balance between known effective practices and emerging concepts. The first version of was released in January of 2000. Approximately 40 buildings, called Pilot Projects, volunteered to test the system. 13 of those completed all documentation necessary to receive certification under the system. Comments from the Pilot Projects and industry professionals were used to enhance . The new version, 2.0, was released in March 2000.

The existing system is intended to be used to rate commercial and high-rise residential buildings, including new construction, major renovation, and built projects. The system is self-assessing.

LEED® Format

The rating system is point based. Each credit describes a performance-based goal. For each credit, there are a certain number of points available. For example, there is one credit called “Optimizing Energy Efficiency”. Depending on how efficient the building is expected to operate (shown using energy modeling), up to 10 points may be earned.

Credits are categorized into each of the five principle areas of sustainable design.

Sustainable Sites (8 credits/14 points)
Water Efficiency (3 credits/5 points)
Energy and Atmosphere (6 credits/17 points)
Materials and Resources (7 credits/13 points)
Indoor Environmental Quality (8 credits/15 points)

LEED® Certification Levels

There are 69 possible points in the system. Different levels of achievement can be reached depending on the total number of points obtained.

LEED® Certified: 26-32 points
LEED® Silver: 33-38
LEED® Gold: 39-51
LEED® Platinum: 52+
Total possible points: 69

Notes:

**LEED™ Example, Energy Credit 1**
Reduce design energy cost compared to the energy cost budget for regulated energy components described in the requirements of ASHRAE Standard 90.1-1999, as demonstrated by a whole building simulation using the Energy Cost Budget Method described in Section 11.

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**Other LEED™ Systems**
Since LEED™ is targeted for new commercial construction, a number of other LEED™ systems are currently under development, with a target release date of 2005.

- LEED™ for Existing Buildings: Primarily for major renovations or existing buildings.
- LEED™ Residential. For residential buildings.
- LEED™ Commercial Interiors. For interior renovation projects.

The anticipated release date for these new systems is 2005.

A *California LEED™ supplement*, which is tailored to state requirements and goals, has also been developed. It is not an adopted standard, but may be at some time in the future.

LEED™ can be used on any project at any time to set sustainable design goals.
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and integrate sustainable design. Projects may also be certified through the U.S. Green Building Council by gathering required documentation to prove that sustainable criteria have been integrated into the project.

Introductory Resources

Well-known resources for sustainable design include:

1. Building News (EBN) is a monthly publication with articles, reviews, and news stories on energy-efficient, resource-efficient, and healthy building practices.

2. Design and Construction is a free publication dedicated to the sustainable design and construction industry. Integrated Waste Management Board Green Design and Construction web site.

3. is a web site devoted to serving professionals whose work promotes sustainable design and construction.

4. This manual is being developed as part of a ten-point plan to implement the Governor’s sustainable building goal as outlined in Executive Order D-16-00 and the report Building Better Buildings: A Blueprint for Sustainable State Facilities (Blueprint). Task 7 of the Blueprint calls for developing sustainable building technical assistance and outreach tools, including a training program for state departments, as well as local government and private sector partners. This manual was developed by DGS, the Sustainable building task force, and CIWMB as one component of the sustainable building training program for state departments. This document will be undergoing constant revision as other deliverables outlined in the Blueprint are completed and technological and process breakthroughs advance the rapidly emerging field of sustainable design.