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Green building

Green building (also known as **green construction** or **sustainable building**) refers to both a structure and the application of processes that are environmentally responsible and resource-efficient throughout a building's life-cycle: from planning to design, construction, operation, maintenance, renovation, and demolition.[1] This requires close cooperation of the contractor, the architects, the engineers, and the client at all project stages.[2] The Green Building practice expands and complements the classical building design concerns of economy, utility, durability, and comfort.[3]

US EPA Kansas City Science & Technology Center. This facility features the following green attributes:

- LEED 2.0 Gold certified
- Green Power
- Native Landscaping

Leadership in Energy and Environmental Design (LEED) is a set of rating systems for the design, construction, operation, and maintenance of green buildings which was Developed by the U.S. Green Building Council. Other certificates system that confirms the sustainability of buildings is the British BREEAM (Building Research Establishment Environmental Assessment Method) for buildings and large-scale developments. Currently, World Green Building Council is conducting research on the effects of green buildings on the health and productivity of their users and is working with World Bank to promote Green Buildings in Emerging Markets through EDGE (Excellence in Design for Greater Efficiencies) Market Transformation Program and certification.[4] There are also other tools such as Green Star in Australia and the Green Building Index (GBI) predominantly used in Malaysia.

Although new technologies are constantly being developed to complement current practices in creating greener structures, the common objective of green buildings is to reduce the overall impact of the built environment on human health and the natural environment by:

- Efficiently using energy, water, and other resources
- Protecting occupant health and improving employee productivity
- Reducing waste, pollution and environmental degradation[3]

A similar concept is natural building, which is usually on a smaller scale and tends to focus on the use of natural materials that are available locally.[5] Other related topics include sustainable design and green architecture. Sustainability may be defined as meeting the needs of present generations without compromising the ability of future generations to meet their needs.[6] Although some green building programs don't address the issue of the retrofitting existing homes, others do, especially through public schemes for energy efficient refurbishment. Green construction principles can easily be applied to retrofit work as well as new construction.

A 2009 report by the U.S. General Services Administration found 12 sustainably-designed buildings that cost less to operate and have excellent energy performance. In addition, occupants were overall more satisfied with the building than those in typical commercial buildings. These are eco-friendly buildings.[7]

Contents

Reducing environmental impact

Hanging gardens of One Central Park, Sydney

Globally, buildings are responsible for a huge share of energy, electricity, water and materials consumption. The building sector has the greatest potential to deliver significant cuts in emissions at little or no cost. Buildings account for 18% [8] of global emissions today, or the equivalent of 9 billion tonnes of CO_2 annually. If new technologies in construction are not adopted during this time of rapid growth, emissions could double by 2050, according to the United Nations Environment Program. Green building practices aim to reduce the environmental impact of building. Since construction almost always degrades a building site, not building at all is preferable to green building, in terms of reducing environmental impact. The second rule is that every building should be as small as possible. The third rule is not to contribute to sprawl, even if the most energy-efficient, environmentally sound methods are used in design and construction.

Buildings account for a large amount of land. According to the National Resources Inventory, approximately 107 million acres (430,000 km^2) of land in the United States are developed. The International Energy Agency released a publication that estimated that existing buildings are responsible for more than 40% of the world's total primary energy consumption and for 24% of global carbon dioxide emissions.[9]

[10]

Goals of green building

The concept of sustainable development can be traced to the energy (especially fossil oil) crisis and environmental pollution concerns of the 1960s and 1970s.[11] The Rachel Carson book, "Silent Spring",[12] published in 1962, is considered to be one of the first initial efforts to describe sustainable development as related to green building.[11] The

green building movement in the U.S. originated from the need and desire for more energy efficient and environmentally friendly construction practices. There are a number of motives for building green, including environmental, economic, and social benefits. However, modern sustainability initiatives call for an integrated and synergistic design to both new construction and in the retrofitting of existing structures. Also known as sustainable design, this approach integrates the building life-cycle with each green practice employed with a design-purpose to create a synergy among the practices used.

Blu Homes mkSolaire, a green building designed by Michelle Kaufmann.

Green building brings together a vast array of practices, techniques, and skills to reduce and ultimately eliminate the impacts of buildings on the environment and human health. It often emphasizes taking advantage of renewable resources, e.g., using sunlight through passive solar, active solar, and photovoltaic equipment, and using plants and trees through green roofs, rain gardens, and reduction of rainwater run-off. Many other techniques are used, such as using low-impact building materials or using packed gravel or permeable concrete instead of conventional concrete or asphalt to enhance replenishment of ground water.

Taipei 101, the tallest and largest green building of LEED Platinum certification in the world since 2011.

While the practices or technologies employed in green building are constantly evolving and may differ from region to region, fundamental principles persist from which the method is derived: siting and structure design efficiency, energy efficiency, water efficiency, materials efficiency, indoor environmental quality enhancement, operations and maintenance optimization and waste and toxics reduction.[13][14] The essence of green building is an optimization of one or more of these principles. Also, with the proper synergistic design, individual green building technologies may work together to produce a greater cumulative effect.

On the aesthetic side of green architecture or sustainable design is the philosophy of designing a building that is in harmony with the natural features and resources surrounding the site. There are several key steps in designing sustainable buildings: specify 'green' building materials from local sources, reduce loads, optimize systems, and generate on-site renewable energy.

Life cycle assessment

A life cycle assessment (LCA) can help avoid a narrow outlook on environmental, social and economic concerns[15] by assessing a full range of impacts associated with all cradle-to-grave stages of a process: from extraction of raw materials through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling. Impacts taken into account include (among others) embodied energy, global warming potential, resource use, air pollution, water pollution, and waste.

In terms of green building, the last few years have seen a shift away from a *prescriptive* approach, which assumes that certain prescribed practices are better for the environment, toward the scientific evaluation of actual performance through LCA.

Although LCA is widely recognized as the best way to evaluate the environmental impacts of buildings (ISO 14040 provides a recognized LCA methodology), it is not yet a consistent requirement of green building rating systems and codes, despite the fact that embodied energy and other life cycle impacts are critical to the design of environmentally

responsible buildings.

In North America, LCA is rewarded to some extent in the Green Globes® rating system, and is part of the new American National Standard based on Green Globes, *ANSI/GBI 01-2010: Green Building Protocol for Commercial Buildings*. LCA is also included as a pilot credit in the LEED system, though a decision has not been made as to whether it will be incorporated fully into the next major revision. The state of California also included LCA as a voluntary measure in its 2010 draft *Green Building Standards Code*.

Although LCA is often perceived as overly complex and time consuming for regular use by design professionals, research organizations such as BRE in the UK and the Athena Sustainable Materials Institute in North America are working to make it more accessible.

In the UK, the BRE *Green Guide to Specifications* offers ratings for 1,500 building materials based on LCA.

In North America, the ATHENA® *EcoCalculator for Assemblies* provides LCA results for several hundred common building assembles based on data generated by its more complex parent software, the ATHENA® *Impact Estimator for Buildings*. (The EcoCalculator is available free at www.athenasmi.org.) Athena software tools are especially useful early in the design process when material choices have far-reaching implications for overall environmental impact. They allow designers to experiment with different material mixes to achieve the most effective combination.

Siting and structure design efficiency

The foundation of any construction project is rooted in the concept and design stages. The concept stage, in fact, is one of the major steps in a project life cycle, as it has the largest impact on cost and performance.[16] In designing environmentally optimal buildings, the objective is to minimize the total environmental impact associated with all life-cycle stages of the building project.

However, building as a process is not as streamlined as an industrial process, and varies from one building to the other, never repeating itself identically. In addition, buildings are much more complex products, composed of a multitude of materials and components each constituting various design variables to be decided at the design stage. A variation of every design variable may affect the environment during all the building's relevant life-cycle stages.[17]

Exterior Light Shelves - Green Office Building, Denver Colorado

Energy efficiency

Green buildings often include measures to reduce energy consumption – both the embodied energy required to extract, process, transport and install building materials and operating energy to provide services such as heating and power for equipment.

As high-performance buildings use less operating energy, embodied energy has assumed much greater importance – and may make up as much as 30% of the overall life cycle energy consumption. Studies such as the U.S. LCI Database Project[18] show buildings built primarily with wood will have a lower embodied energy than those built primarily with brick, concrete, or steel.[19]

To reduce operating energy use, designers use details that reduce air leakage through the building envelope (the barrier between conditioned and unconditioned space). They also specify high-performance windows and extra insulation in walls, ceilings, and floors. Another strategy, passive solar building design, is often implemented in low-energy homes. Designers orient windows and walls and place awnings, porches, and trees[20] to shade windows and roofs during the

summer while maximizing solar gain in the winter. In addition, effective window placement (daylighting) can provide more natural light and lessen the need for electric lighting during the day. Solar water heating further reduces energy costs.

Onsite generation of renewable energy through solar power, wind power, hydro power, or biomass can significantly reduce the environmental impact of the building. Power generation is generally the most expensive feature to add to a building.

An eco-house at Findhorn Ecovillage with a turf roof and solar panels

Water efficiency

Reducing water consumption and protecting water quality are key objectives in sustainable building. One critical issue of water consumption is that in many areas, the demands on the supplying aquifer exceed its ability to replenish itself. To the maximum extent feasible, facilities should increase their dependence on water that is collected, used, purified, and reused on-site. The protection and conservation of water throughout the life of a building may be accomplished by designing for dual plumbing that recycles water in toilet flushing or by using water for washing of the cars. Waste-water may be minimized by utilizing water conserving fixtures such as ultra-low flush toilets and low-flow shower heads. Bidets help eliminate the use of toilet paper, reducing sewer traffic and increasing possibilities of re-using water on-site. Point of use water treatment and heating improves both water quality and energy efficiency while reducing the amount of water in circulation. The use of non-sewage and greywater for on-site use such as site-irrigation will minimize demands on the local aquifer.[21]

Large commercial buildings with water and energy efficiency can qualify for an LEED Certification. Philadelphia's Comcast Center is the tallest building in Philadelphia. It's also one of the tallest buildings in the USA that is LEED Certified. Their environmental engineering consists of a hybrid central chilled water system which cools floor-by-floor with steam instead of water. Burn's Mechanical set-up the entire renovation of the 58 story, 1.4 million square foot sky scraper.

Materials efficiency

Building materials typically considered to be 'green' include lumber from forests that have been certified to a third-party forest standard, rapidly renewable plant materials like bamboo and straw, dimension stone, recycled stone, recycled metal *(see: copper sustainability and recyclability)*, and other products that are non-toxic, reusable, renewable, and/or recyclable. For concrete a high performance or Roman self-healing concrete is available.[22][23] The EPA (Environmental Protection Agency) also suggests using recycled industrial goods, such as coal combustion products, foundry sand, and demolition debris in construction projects.[24] Energy efficient building materials and appliances are promoted in the United States through energy rebate programs.

Indoor environmental quality enhancement

The Indoor Environmental Quality (IEQ) category in LEED standards, one of the five environmental categories, was created to provide comfort, well-being, and productivity of occupants. The LEED IEQ category addresses design and construction guidelines especially: indoor air quality (IAQ), thermal quality, and lighting quality.[25][26][27]

Indoor Air Quality seeks to reduce volatile organic compounds, or VOCs, and other air impurities such as microbial contaminants. Buildings rely on a properly designed ventilation system (passively/naturally or mechanically powered) to provide adequate ventilation of cleaner air from outdoors or recirculated, filtered air as well as isolated operations

(kitchens, dry cleaners, etc.) from other occupancies. During the design and construction process choosing construction materials and interior finish products with zero or low VOC emissions will improve IAQ. Most building materials and cleaning/maintenance products emit gases, some of them toxic, such as many VOCs including formaldehyde. These gases can have a detrimental impact on occupants' health, comfort, and productivity. Avoiding these products will increase a building's IEQ. LEED,[28] HQE[29] and Green Star contain specifications on use of low-emitting interior. Draft LEED 2012[30] is about to expand the scope of the involved products. BREEAM[31] limits formaldehyde emissions, no other VOCs. MAS Certified Green is a registered trademark to delineate low VOC-emitting products in the marketplace.[32] The MAS Certified Green Program ensures that any potentially hazardous chemicals released from manufactured products have been thoroughly tested and meet rigorous standards established by independent toxicologists to address recognized long term health concerns. These IAQ standards have been adopted by and incorporated into the following programs: (1) The United States Green Building Council (USGBC) in their LEED rating system[33] (2) The California Department of Public Health (CDPH) in their section 01350 standards[34] (3) The Collaborative for High Performance Schools (CHPS) in their Best Practices Manual[35] and (4) The Business and Institutional Furniture Manufacturers Association (BIFMA) in their level® sustainability standard.[36]

Also important to indoor air quality is the control of moisture accumulation (dampness) leading to mold growth and the presence of bacteria and viruses as well as dust mites and other organisms and microbiological concerns. Water intrusion through a building's envelope or water condensing on cold surfaces on the building's interior can enhance and sustain microbial growth. A well-insulated and tightly sealed envelope will reduce moisture problems but adequate ventilation is also necessary to eliminate moisture from sources indoors including human metabolic processes, cooking, bathing, cleaning, and other activities.

Personal temperature and airflow control over the HVAC system coupled with a properly designed building envelope will also aid in increasing a building's thermal quality. Creating a high performance luminous environment through the careful integration of daylight and electrical light sources will improve on the lighting quality and energy performance of a structure.[21][37]

Solid wood products, particularly flooring, are often specified in environments where occupants are known to have allergies to dust or other particulates. Wood itself is considered to be hypo-allergenic and its smooth surfaces prevent the buildup of particles common in soft finishes like carpet. The Asthma and Allergy Foundation of America recommends hardwood, vinyl, linoleum tile or slate flooring instead of carpet.[38] The use of wood products can also improve air quality by absorbing or releasing moisture in the air to moderate humidity.[39]

Interactions among all the indoor components and the occupants together form the processes that determine the indoor air quality. Extensive investigation of such processes is the subject of indoor air scientific research and is well documented in the journal Indoor Air.[40]

Operations and maintenance optimization

No matter how sustainable a building may have been in its design and construction, it can only remain so if it is operated responsibly and maintained properly. Ensuring operations and maintenance(O&M) personnel are part of the project's planning and development process will help retain the green criteria designed at the onset of the project.[41] Every aspect of green building is integrated into the O&M phase of a building's life. The addition of new green technologies also falls on the O&M staff. Although the goal of waste reduction may be applied during the design, construction and demolition phases of a building's life-cycle, it is in the O&M phase that green practices such as recycling and air quality enhancement take place. O&M staff should aim to establish best practices in energy efficiency, resource conservation, ecologically sensitive products and other sustainable practices. Education of building operators and occupants is key to effective implementation of sustainable strategies in O&M services.[42]

Waste reduction

Green architecture also seeks to reduce waste of energy, water and materials used during construction. For example, in California nearly 60% of the state's waste comes from commercial buildings[43] During the construction phase, one goal should be to reduce the amount of material going to landfills. Well-designed buildings also help reduce the amount of waste generated by the occupants as well, by providing on-site solutions such as compost bins to reduce matter going to landfills.

To reduce the amount of wood that goes to landfill, Neutral Alliance (a coalition of government, NGOs and the forest industry) created the website dontwastewood.com. The site includes a variety of resources for regulators, municipalities, developers, contractors, owner/operators and individuals/homeowners looking for information on wood recycling.

When buildings reach the end of their useful life, they are typically demolished and hauled to landfills. Deconstruction is a method of harvesting what is commonly considered "waste" and reclaiming it into useful building material.[44] Extending the useful life of a structure also reduces waste – building materials such as wood that are light and easy to work with make renovations easier.[45]

To reduce the impact on wells or water treatment plants, several options exist. "Greywater", wastewater from sources such as dishwashing or washing machines, can be used for subsurface irrigation, or if treated, for non-potable purposes, e.g., to flush toilets and wash cars. Rainwater collectors are used for similar purposes.

Centralized wastewater treatment systems can be costly and use a lot of energy. An alternative to this process is converting waste and wastewater into fertilizer, which avoids these costs and shows other benefits. By collecting human waste at the source and running it to a semi-centralized biogas plant with other biological waste, liquid fertilizer can be produced. This concept was demonstrated by a settlement in Lubeck Germany in the late 1990s. Practices like these provide soil with organic nutrients and create carbon sinks that remove carbon dioxide from the atmosphere, offsetting greenhouse gas emission. Producing artificial fertilizer is also more costly in energy than this process.[46]

Reduce impact onto electricity network

Electricity networks are built based on peak demand (another name is peak load). Peak demand is measured in the units of watts (W). It shows how fast electrical energy is consumed. Residential electricity is often charged on electrical energy (kilowatt hour, kWh). Green buildings or sustainable buildings are often capable of saving electrical energy but not necessarily reducing peak demand.

When sustainable building features are designed, constructed and operated efficiently, peak demand can be reduced so that there is less desire for electricity network expansion and there is less impact onto carbon emission and climate change.[47] These sustainable features can be good orientation, sufficient indoor thermal mass, good insulation, photovoltaic panels, thermal or electrical energy storage systems, smart building (home) energy management systems.[48]

Cost and payoff

The most criticized issue about constructing environmentally friendly buildings is the price. Photo-voltaics, new appliances, and modern technologies tend to cost more money. Most green buildings cost a premium of <2%, but yield 10 times as much over the entire life of the building.[49] In regards to the financial benefits of green building, “Over 20 years, the financial payback typically exceeds the additional cost of greening by a factor of 4-6 times. And broader benefits, such as reductions in greenhouse gases (GHGs) and other pollutants have large positive impacts on surrounding communities and on the planet.”[50] The stigma is between the knowledge of up-front cost[51] vs. life-cycle cost. The savings in money

come from more efficient use of utilities which result in decreased energy bills. It is projected that different sectors could save $130 Billion on energy bills.[52] Also, higher worker or student productivity can be factored into savings and cost deductions.

Numerous studies have shown the measurable benefit of green building initiatives on worker productivity. In general it has been found that, "there is a direct correlation between increased productivity and employees who love being in their work space."[53] Specifically, worker productivity can be significantly impacted by certain aspects of green building design such as improved lighting, reduction of pollutants, advanced ventilation systems and the use of non-toxic building materials.[54] In "The Business Case for Green Building (http://www.usgbc.org/articles/business-case-green-building)", the U.S. Green Building Council gives another specific example of how commercial energy retrofits increase worker health and thus productivity, "People in the U.S. spend about 90% of their time indoors. EPA studies indicate indoor levels of pollutants may be up to ten times higher than outdoor levels. LEED-certified buildings are designed to have healthier, cleaner indoor environmental quality, which means health benefits for occupants."[55]

Studies have shown over a 20-year life period, some green buildings have yielded $53 to $71 per square foot back on investment.[56] Confirming the rentability of green building investments, further studies of the commercial real estate market have found that LEED and Energy Star certified buildings achieve significantly higher rents, sale prices and occupancy rates as well as lower capitalization rates potentially reflecting lower investment risk.[57][58][59]

Regulation and operation

As a result of the increased interest in green building concepts and practices, a number of organizations have developed standards, codes and rating systems that let government regulators, building professionals and consumers embrace green building with confidence. In some cases, codes are written so local governments can adopt them as bylaws to reduce the local environmental impact of buildings.

Green building rating systems such as BREEAM (United Kingdom), LEED (United States and Canada), DGNB (Germany), CASBEE (Japan), and VERDE^{GBCe} (Spain) help consumers determine a structure's level of environmental performance. They award credits for optional building features that support green design in categories such as location and maintenance of building site, conservation of water, energy, and building materials, and occupant comfort and health. The number of credits generally determines the level of achievement.[60]

Green building codes and standards, such as the International Code Council's draft International Green Construction Code,[61] are sets of rules created by standards development organizations that establish minimum requirements for elements of green building such as materials or heating and cooling.

Some of the major building environmental assessment tools currently in use include:

- United States: International Green Construction Code (IGCC)

International frameworks and assessment tools

IPCC Fourth Assessment Report

Climate Change 2007, the Fourth Assessment Report (AR4) of the United Nations Intergovernmental Panel on Climate Change (IPCC), is the fourth in a series of such reports. The IPCC was established by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) to assess scientific, technical and socio-economic information concerning climate change, its potential effects and options for adaptation and mitigation.[62]

UNEP and Climate change

United Nations Environment Program UNEP works to facilitate the transition to low-carbon societies, support climate proofing efforts, improve understanding of climate change science, and raise public awareness about this global challenge.

GHG Indicator

The Greenhouse Gas Indicator: UNEP Guidelines for Calculating Greenhouse Gas Emissions for Businesses and Non-Commercial Organizations

Agenda 21

Agenda 21 is a programme run by the United Nations (UN) related to sustainable development. It is a comprehensive blueprint of action to be taken globally, nationally and locally by organizations of the UN, governments, and major groups in every area in which humans impact on the environment. The number 21 refers to the 21st century.

FIDIC's PSM

The International Federation of Consulting Engineers (FIDIC) Project Sustainability Management Guidelines were created in order to assist project engineers and other stakeholders in setting sustainable development goals for their projects that are recognized and accepted by as being in the interests of society as a whole. The process is also intended to allow the alignment of project goals with local conditions and priorities and to assist those involved in managing projects to measure and verify their progress.

The Project Sustainability Management Guidelines are structured with Themes and Sub-Themes under the three main sustainability headings of Social, Environmental and Economic. For each individual Sub-Theme a core project indicator is defined along with guidance as to the relevance of that issue in the context of an individual project.

The Sustainability Reporting Framework provides guidance for organizations to use as the basis for disclosure about their sustainability performance, and also provides stakeholders a universally applicable, comparable framework in which to understand disclosed information.

The Reporting Framework contains the core product of the Sustainability Reporting Guidelines, as well as Protocols and Sector Supplements. The Guidelines are used as the basis for all reporting. They are the foundation upon which all other reporting guidance is based, and outline core content for reporting that is broadly relevant to all organizations regardless of size, sector, or location. The Guidelines contain principles and guidance as well as standard disclosures – including indicators – to outline a disclosure framework that organizations can voluntarily, flexibly, and incrementally, adopt.

Protocols underpin each indicator in the Guidelines and include definitions for key terms in the indicator, compilation methodologies, intended scope of the indicator, and other technical references.

Sector Supplements respond to the limits of a one-size-fits-all approach. Sector Supplements complement the use of the core Guidelines by capturing the unique set of sustainability issues faced by different sectors such as mining, automotive, banking, public agencies and others.

IPD Environment Code

The IPD Environment Code[63] was launched in February 2008. The Code is intended as a good practice global standard for measuring the environmental performance of corporate buildings. Its aim is to accurately measure and manage the environmental impacts of corporate buildings and enable property executives to generate high quality, comparable

performance information about their buildings anywhere in the world. The Code covers a wide range of building types (from offices to airports) and aims to inform and support the following;

- Creating an environmental strategy
- Inputting to real estate strategy
- Communicating a commitment to environmental improvement
- Creating performance targets
- Environmental improvement plans
- Performance assessment and measurement
- Life cycle assessments
- Acquisition and disposal of buildings
- Supplier management
- Information systems and data population
- Compliance with regulations
- Team and personal objectives

IPD estimate that it will take approximately three years to gather significant data to develop a robust set of baseline data that could be used across a typical corporate estate.

ISO 21931

ISO/TS 21931:2006, Sustainability in building construction—Framework for methods of assessment for environmental performance of construction works—Part 1: Buildings, is intended to provide a general framework for improving the quality and comparability of methods for assessing the environmental performance of buildings. It identifies and describes issues to be taken into account when using methods for the assessment of environmental performance for new or existing building properties in the design, construction, operation, refurbishment and deconstruction stages. It is not an assessment system in itself but is intended be used in conjunction with, and following the principles set out in, the ISO 14000 series of standards.

See also

- Natural building
- First EcoHouse
- National Green Building Standard

Green building by country

- Green Building in Bangladesh
- Green building in Germany
- Green building in Israel
- Green building in South Africa
- Green building in the United Kingdom
- Green building in India
- Green building in the United States

General

- Alexander Thomson, a pioneer in sustainable building
- Alternative natural materials
- Andrew Delmar Hopkins
- Arcology — high density ecological structures

- Active solar
- Autonomous building
- Building Codes Assistance Project
- Center for Environmental Innovation in Roofing
- Centre for Interactive Research on Sustainability
- Climate-friendly gardening
- Copper in architecture for sustainability and recyclability
- Copper wire and cable as energy-efficient electrical conductors
- Deconstruction (building)
- Dimension stone
- Domotics
- Earth structure
- Eco hotel
- Energy Conservation Building Code
- Eco-building cluster (in Belgium)
- Ecohouse (disambiguation)
- Environmental planning
- Energy-plus-house
- EnOcean
- Fab Tree Hab
- Federal Roofing Tax Credit for Energy Efficiency (in the US)
- Geo-exchange
- GovEnergy Workshop and Trade Show
- Green architecture
- Green Building Council
- Green Home
- Green library
- Green technology
- Glass in green buildings
- Heat island effect
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- List of low-energy building techniques
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- Mahoney tables
- Nano House
- Natural building
- Photovoltaics
- Rainwater harvesting
- Sustainable city
- Sustainable habitat
- Sustainable House Day
- The Verifier
- Tropical green building
- Whole Building Design Guide
- World Green Building Council
- Zero-energy building

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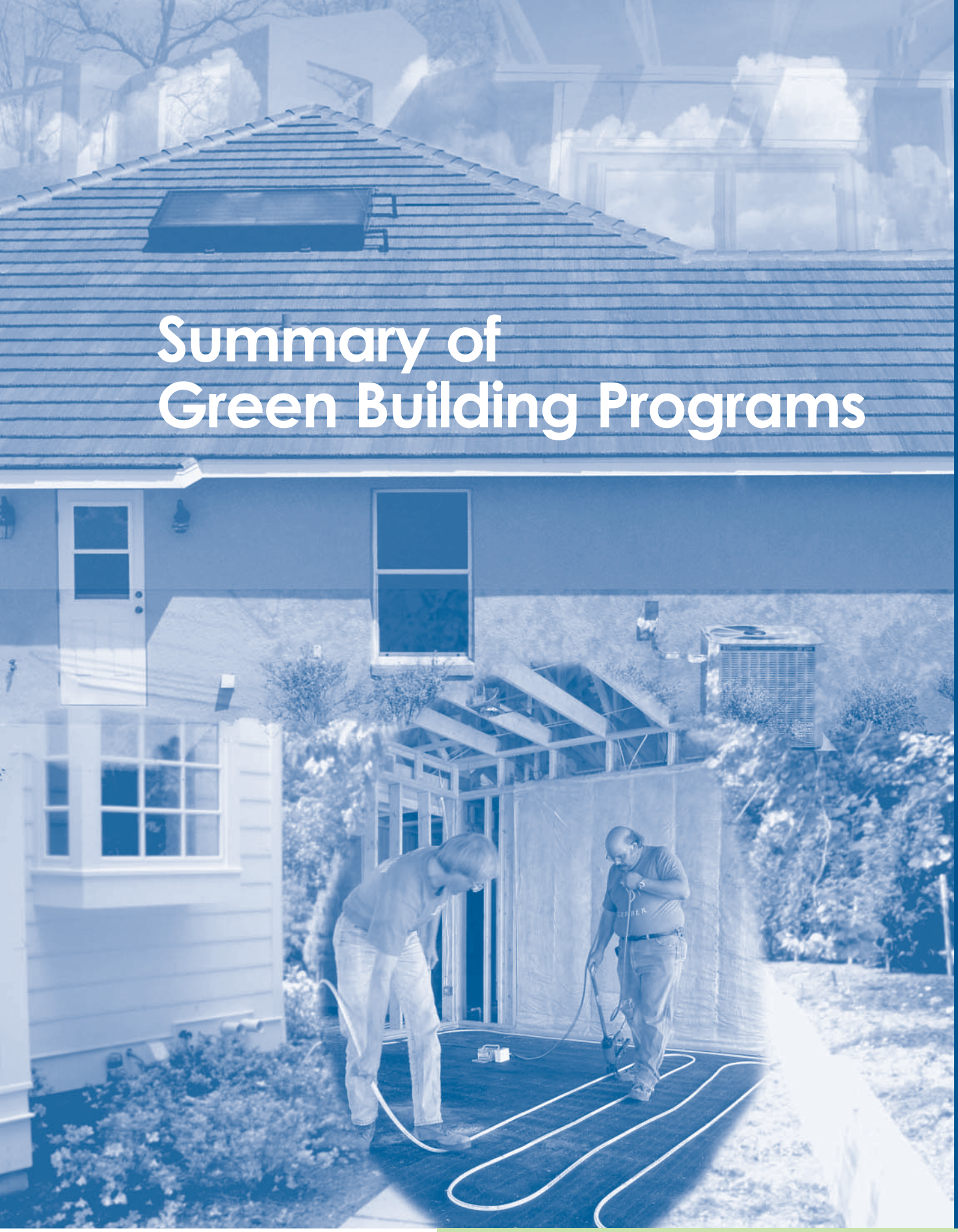
Summary of Green Building Programs



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Summary of Green Building Programs

Prepared for:
National Renewable Energy Laboratory
Golden, Colorado

Prepared by:
National Association of Home Builders (NAHB) Research Center, Inc.
Upper Marlboro, Maryland

Second Edition
August 2002

Foreword

In early 2002, the National Association of Home Builders (NAHB) Research Center completed a census of residential green building programs across the United States to assess differences and similarities among programs. Although the Research Center recognizes that other (e.g., commercial) green building programs exist, the focus of this report is on residential programs. In addition to presenting basic facts about the programs, the information provided catalogs different ways that builders participate in green building programs. This guide assumes that readers have a basic understanding of green building techniques.

Key Findings

Basic Facts

More than 18,000 homes have been built in compliance with the 26 green building programs surveyed in this study. Most of these homes are in Denver, Austin, and Seattle. The Austin and Denver programs have the most builder members; the Austin program has been in existence the longest.

Most Established Programs

Built Green Colorado in Denver and the Austin Energy Green Building Program in Texas are the largest and best established green building programs in the country. Built Green Colorado was established in 1995 and currently has 111 builders participating in the program. More than 9,000 homes have been completed to date in accordance to the program's guidelines. Participation in the Built Green Colorado program is voluntary. Builders receive marketing materials and recognition in the market.

Austin Energy's Green Building Program was established in 1990. This voluntary program currently has 111 builders participating, with more than 2,000 homes completed to date in accordance with the program's guidelines.

Programs with Mandatory Participation

For builders in Boulder, Colorado, and Frisco, Texas, compliance with the local green building program is required to get building permits.

Programs in Development

Green building programs in the early stages of development include Southern Arizona Green Building Alliance, Western North Carolina Green Building Council, Alameda County (California), Chula Vista (California), Hudson Valley Home Builders Association (HBA) Green Building Program (New York), and the Schenectady HBA Green Building Program (New York).

Table of Contents

1. Green Built Home (Wisconsin Environmental Initiative)

Overview:
Checklist with very little weighting—the most points that are allocated to any one practice is four.

Certification method:
For each home, the builder submits a checklist, registration form, and a working set of plans. Green Built Home conducts an initial plan review and conducts random site visits.

Levels of certification:
One

Qualification:
Minimum of 50 points to qualify. Point breakdown is as follows: meet all mandatory requirements (15 points), and include a minimum of 35 additional points from any combination of other categories from the checklist (out of 232 total checklist points).

Year of inception:
1999

Number of builders:
30

Incentives offered to builders to participate:
Logos in homes, yard signs, plaques on certified homes, local press, ribbons and shirts for builders.

Number of homes constructed to date:
202

Contact information:
Green Built Home
Wisconsin Environmental Initiative
John Imes
16 N. Carroll Street, Suite 840
Madison, WI 53703-2726
p. 608-280-0360
f. 608-280-0361
http://www.wi-ei.org/GBH/index.htm
jimes@wi-ei.org

Mandatory Requirements

Category	Points
WI Energy Star home	10 Required
Energy Star appliances	1 Required
Erosion control plan (available in builder guidebook)	1 Required
One recycled material (minimum 50%)	1 Required
No uncertified Lauan or other tropical hardwood plywood, doors, or trim	1 Required
Homeowner handbook (prepared by program)	1 Required

Continued next page

Green Built Home (Wisconsin Environmental Initiative) continued

Checklist Requirements	
Category	**Maximum Possible Points**
Landscape conservation	13
Energy use (general)	7
Water conservation	5
Materials selection	4
Energy use	
Insulation and air sealing	14
Glazing	9
Mechanical systems	17
Indoor air quality	15
Water heating	14
Indoor water conservation	3
Appliances	7
Lighting	11
Integrated climatic design	6
Materials	
Below grade	10
Structural frame	18
Envelope	16
Insulation	5
Roof	3
Subfloor	5
Finish floor	15
Doors, cabinets, and trim	14
Finishes and adhesives	6
Waste management	15
Total Possible Points	**232**

2. Build A Better Kitsap Home Builder Program (Kitsap HBA, Washington)

Overview:
Builders qualify at a one-, two-, or three-star level determined by mandatory criteria, plus points awarded from a checklist. Checklist items are generally weighted from 1 to 3 points.

Certification method:
Self-certification checklist (plus mandatory one-time program orientation)

Levels of certification:
One-, two-, or three-stars (★)

Qualification:
- ★ All mandatory requirements, plus 10 points from Section 2 through 8 of checklist.
- ★★ All mandatory requirements, plus 30 points from Section 2 through 8 of checklist. Earn at least 3 points from each section.
- ★★★ All mandatory requirements, plus 30 points total from Section 2 through 8 of checklist. Attend a workshop within 1 year of certification.

Year of inception:
1997

Number of builders:
27

Incentives offered to builders to participate:
Marketing such as billboards, Internet marketing, print brochures

Number of homes constructed to date:
278

Contact information:
Build a Better Kitsap
Art Castle
5251 Auto Center Way
Bremerton, WA 98312-3319
p. 360-479-5778
f. 360-479-0313
acastle@kitsaphba.com
http://www.kitsaphba.com

Mandatory Requirements	
Category	**Points**
Meet Washington State energy code	Required
Meet Washington State ventilation/indoor air quality code	Required
Meet Washington State water use efficiency standards	Required
Program orientation (one time only)	Required
Provide "Operations and Maintenance Kit"	Required
Checklist Requirements	
Section	**Maximum Possible Points**
Site protection	18
Site design	22
Reduce	20
Reuse	8
Recycle	14
Resource-efficient material selection	31
Maximize energy efficiency	43
Indoor air quality and health	58
Manage hazardous waste	9
Promote responsible operation and maintenance	16
Total Possible Points	**239**

3.

EarthCraft House (Greater Atlanta HBA, Georgia)

Overview:
Places emphasis and value on providing training and technical assistance to builders. Requires energy efficiency, plus other green features. All homes are inspected and blower-door tested by specially trained EarthCraft House inspectors. Checklist is weighted toward features that have the most environmental benefits. Allows bonus points for proximity to mass transit, PV or solar hot water, or other innovations. Includes a workbook for builders to educate about various items on the checklist.

Certification method:
Required third-party inspection, plus self-certification worksheet

Levels of certification:
One

Qualification:
Certification requires 150 points from the checklist out of 489 total possible points

Year of inception:
1999

Number of builders:
89

Incentives offered to builders to participate:
All first inspections are free to the builder, some incentives to homeowners in the form of reduced closing costs and lower interest rate mortgages, other loan assistance programs.

Number of homes constructed to date:
500

Contact information:
EarthCraft House
Greater Atlanta Home Builders Association, Inc.
P.O. Box 450749
Atlanta, GA 31145
p. 770-938-9900
f. 770-934-8363
earthcraft@earthcrafthouse.com
http://www.earthcrafthouse.com

"EarthCraft House renovation is perhaps the most exciting new aspect to our program. We've worked with six of the city's top renovators to outline how the program might work. We're currently in the pilot state, and so far the response just through word of mouth has been amazing. We plan to officially launch this part of the program in mid summer [2002] with a detailed workbook, and special training class."

Jim Hackler
EarthCraft House Greater Atlanta HBA

Checklist Requirements	
Category	**Maximum Possible Points**
Site planning	45
Tree protection and planting measures	15
Energy efficient building envelope and systems	90 (for ENERGY STAR certification)
Energy measures	House must either be ENERGY STAR certified or must get at least 75 points from the following "energy measures" below
Air leakage test	35
Air sealing measures	30
Insulation	50
Windows	32
Heating and cooling equipment	42
Ductwork/air handler	58
Energy efficient lighting/appliances	12
Resource efficient design	26
Resource efficient building materials	
Recycled/natural content materials	10
Advanced products	29
Durability	15
Waste management	
Waste management practices	14
Recycle construction waste	15
Indoor air quality	
Combustion safety	30
Moisture control	13
Ventilation	26
Materials	13
Water—indoor use	19
Water—outdoor use	35
Homebuyer education/opportunities	26
Builder operations	13
Bonus points (mass transit, brownfield development, etc.)	55+
Total Possible Points	**489**

4.

Built Green™ Colorado (HBA of Metro Denver)

Overview:
Comprehensive checklist that requires builders to meet the Energy Efficiency Minimum Requirement and then reach a cumulative point total of 70.

Certification method:
Self-certification checklist; 5% of all residential homes are inspected on random basis by third-party services.

Levels of certification:
One

Qualification:
Builders must have 70 points; the points can come from anywhere in the checklist.

Year of inception:
1995

Number of builders:
111

Incentives offered to builders to participate:
Market distinction, education, TV ads

Number of homes constructed to date:
9,646

Contact information:
Built Green Colorado
HBA of Metro Denver
1400 S. Emerson
Denver, CO 80210
p. 303-778-1400
f. 303-733-9440
info@builtgreen.org
http://www.builtgreen.org

Checklist Requirements	
Category	**Maximum Possible Points**
Energy requirement (Required)	3
Energy efficiency	
Envelope	60
Mechanical systems	158
Water heating	43
Appliances	34
Lighting	16
Materials	
Foundation	33
Structural frame	72
Subfloor	10
Windows	13
Doors	8
Insulation	16
Exterior wall finishes	34
Roof	14
Finish floor	31
Cabinetry and trim	14
Health and safety	
Indoor air quality	95
Resource conservation	
Land use	17
Materials reduction	9
Materials re-use	16
Waste reduction and recycling	7
Water	35
Total Possible Points	**738**

5. BuiltGreen™ (MBA of King and Snohomish Counties, Washington)

Overview:
Comprehensive checklist with weighted items
Certification method:
Self-certification checklist
Levels of certification:
One-, two-, or three-stars (★)
Qualification:
★ Attend program orientation; meet mandatory green codes and regulations; earn 25 points from checklist; prepare and post a jobsite recycling program; and provide an "Operations and Maintenance Kit."
★★ One star requirements, plus 75 additional points (100 points minimum) from checklist with at least 6 points from each section; attend a Built Green workshop within 1 year of certification.
★★★ Meet two-star requirements plus 105 additional points (180 points minimum).
Year of inception:
2000
Number of builders:
9 participating
Incentives offered to builders to participate:
Access to marketing tools
Number of homes constructed to date:
1,600
Contact information:
Built Green
Master Builders Association of King and Snohomish Counties
2155 112th Avenue, NE
Bellevue, WA 98004
p. 425-451-7920
builtgreen@mba-ks.com
http://www.builtgreen.net

Mandatory Requirements	
Category	**Maximum Possible Points**
Meet Washington State water use efficiency standards	Required
Meet stormwater/site development standards	Required
Meet Washington State ventilation/indoor air quality code	Required
Meet Washington State energy code	Required
Provide Homeowner with Operations and Maintenance kit	Required
Checklist Requirements	
Site and water	
Overall	13
Protect sites natural features	22
Protect natural processes on-site	58
Eliminate water pollutants	37
Design alternatives	25

Energy efficiency	
Envelope	128
Heating/cooling	20
Water heating	5
Lighting	6
Efficient design	3
Alternative systems	15
Health and indoor air quality	
Overall	25
Jobsite operations	19
Layout and material selection	50
Moisture control	9
Air distribution and filtration	21
HVAC equipment	30
Materials efficiency	
Overall	40
Jobsite operations	
Reduce	9
Reuse	13
Recycle	40
Design and material selection	
Overall	10
Framing	29
Foundation	4
Subfloor	1
Doors	5
Finish floor	15
Interior walls	2
Exterior walls	8
Windows	2
Cabinetry and trim	12
Roof	7
Insulation	5
Other exterior	10
Promote environmentally friendly homeowner Operation and Mainenance	
Water conservation—outdoor	40
Water conservation—indoor	31
Eliminate water pollutants	5
Energy	
Heating/cooling	9
Water heating	19
Appliances	10
Efficient lighting	9
Health and indoor air quality	3
Recycling	6
Total Possible Points	**830**

6.

Green Home Designation (Florida Green Building Coalition)

"The most valuable aspect of Florida's Green Building Program is the one-on-one assistance available to builders through program Certifying Agents, and the Building America Industrialized Housing Partnership."

Eric Martin
Florida Green Building Coalition

Overview:
Program that features a comprehensive, weighted checklist of efficiency measures. Gives value to meeting Florida energy code, plus additional energy points for HERS rating above 80 and design, appliances, lights, and amenities. Also has categories for water, site, health, materials, and disaster mitigation.

Certification method:
Mix of self-certified and inspector-certified items. Some items require special submittals for verification

Levels of certification:
One level

Qualification:
Builders must achieve a minimum number of points in each category to encourage diversity and to consider the house as a system. However, if there is a deficit in one category, it can be amended if the deficiency is added to the total minimum score of 200. For example, if the home achieves only 10 points in a category with a minimum of 15 required, the builder can still qualify for a Green Building Designation if the total number of points is, at minimum, 205.

Year of inception:
2001

Number of builders:
15

Incentives offered to builders to participate:
Discount on per-home registration fee

Number of homes constructed to date:
2

Contact information:
Green Home Designation
Eric Martin, Research Engineer
Florida Solar Energy Center
1679 Clearlake Road
Cocoa, FL 32922
p. 321-638-1450
f. 321-638-1439
info@floridagreenbuilding.org
http://www.floridagreenbuilding.org

Mandatory Requirements	
Category	**Maximum Possible Points**
Prerequisite 1 (use at least one measure)	
Sanitation system that reduces/eliminates chlorine use (salt water, ionization, etc.)	Required
Pool cover	Required
Solar pool heating system	Required
Efficient pool pumping	Required
No swimming pool or spa	Required
Prerequisite 2 (use at least one measure)	
Use of native aquatic vegetation in shoreline area	Required
Low-maintenance plants placed between lawn and shoreline; no turf adjacent to water	Required
Use of terraces, swales, or berms to slow stormwater movement into water body	Required
Home site does not border natural water body	Required

Checklist Requirements	
Energy (building envelope/systems)	(100 min/150 max)
Codes/Ratings (both inspector-certified)	150
Design	19
Energy (appliances, lights, amenities)	(10 min/25 max)
Energy-efficient appliances/amenities	9
Energy-efficient lighting	19
Water	(15 min/40 max)
Appliances	12
Greywater reuse	4
Rainwater harvesting	4
Installed landscape	25
Installed irrigation	14
Site	(10 min/30 max)
Native tree and plant preservation	15
On-site use of cleared materials	2
Erosion control/topsoil preservation	5
Drainage/retention	10
Health	(10 min/30 max)
Combustion	10
Moisture control	7
Ventilation	20
Source control (materials)	9
Cleanability	4
Universal design	4
Materials	(10 min/45 max)
Structure	14
Sub-assembly	7
Partitions / trim	4
Finishes	4
Durability	6
Waste management	12
Disaster mitigation	(5 min/30 max)
Hurricane (wind, rain, storm surge)	20
Flood (check all 4 to receive 5 points)	5
Wild fire (check all 3 to receive 5 points)	5
Termites (check all 12 to receive 10 points)	10
General	(0 min/50 max)
Small house credit	50
Renewable power generation	20
Reconfigurability	6
Lot choice	10
Other	14
Total Possible Points	**400**

7. City of Boulder Green Points (Colorado)

Overview:
Checklist of features that are weighed.
Certification method:
City- or self-certification checklist (method required is specified for each checklist item).
Levels of certification:
One
Qualification:
Point requirements are based on square footage. Homes smaller than or equal to 1,500 square feet need 50 points. Homes between 1,501 and 2,500 square feet need 65 points. Homes larger than 2,501 square feet need one additional point for each 50 additional square feet up to the maximum allowable points. The program also covers remodeling and additions over 500 square feet.
Year of inception:
1997
Number of builders:
38 have gone through training. All builders in Boulder participate because it is mandatory.
Incentives offered to builders to participate:
Must participate to get building permit.
Number of homes constructed to date:
Approximately 116
Contact information:
Mike Weil
Director, Energy Programs Coordinator
City of Boulder
Office of Environmental Affairs
P.O. Box 791
Boulder, CO 80306
p. 303-441-4191
f. 303-441-4070
weilm@ci.boulder.co.us
http://www.ci.boulder.co.us/environmentalaffairs/green_points/

Checklist Requirements	
Category	**Maximum Possible Points**
Construction/Demolition and Use of recycled materials	29
Land use and Water conservation	25
Framing	30
Energy code measures	113
Plumbing	5
Electrical	10
Insulation	34
HVAC	51
Solar	79
Indoor air quality	48
Innovation	10
Total Possible Points	**Approximately 434**

8. Green Building Program, Austin Energy (Texas)

Overview:
Comprehensive, weighted checklist
Certification method:
Self-certification
Levels of certification:
One-, two-, three-, four-, and five-stars (★)
Qualification:

★	40-59 points
★★	60-89 points
★★★	90-129 points
★★★★	130-179 points (must include blower-door test, duct-blaster test, or ducts located in conditioned space and combustion/ backdraft test)
★★★★★	180 or more points (including requirements listed in four stars)

Year of inception:
1990
Number of builders:
111
Incentives offered to builders to participate:
Training (e.g., monthly seminars), support services, plan reviews, one-on-one consultation, marketing
Number of homes constructed to date:
2,475
Contact information:
Richard Morgan
P.O. Box 1088
Austin, TX 78767
p. 512-505-3709
f. 512-505-3711
Richard.morgan@austinenergy.com
http://www.ci.austin.tx.us/greenbuilder

Mandatory Requirements	
Category	**Maximum Possible Points**
Durable finish (min. 50-year warranty)	Required
One recycled content material (min 50%)	Required
Meet City of Austin Building and Energy Code	Required
Efficient and effective cooling and dehumidification system	Required
Two ceiling fans	Required
Meet City of Austin Building Code requirements	Required
No vapor barrier on inside perimeter wall	Required
One-inch minimum pleated filter on HVAC system	Required
Low-VOC paints on interior	Required
If termite control used, pyrethroid or borate based	Required
Any planting beds mulched to min 2" depth	Required
Rating certificate and homeowner information packet given to homeowner	Required
Rating submitted for all homes in greater Austin Area	Required

Continued next page

Green Building Program, Austin Energy continued

Checklist Requirements	
Section	**Maximum Possible Points**
Energy	
Design	43
Thermal envelope	22
Heating, cooling, water heating	38
Lighting and appliances	13
Materials	
Design, structure	15
Finish materials	16
Excess jobsite resources	10
Water	
Indoor	6
Outdoor	28
Health, Safety	
Molds, mites, fibers	21
Chemical outgassing	18
Combustion gases	7
Electromagnetic fields	2
Integrated pest management	7
Community	28
Total Possible Points	**274**

"After 10 years of promoting Green Building in Austin we now have home buyers asking for 'green' features in the homes they buy. We have achieved this through a long-term effort to educate the consumer about the benefits of green building...Builders [also benefit] from the technical assistance they get from us. This assistance ranges from free monthly seminars for members of our program to individual sessions with our staff to help them achieve a higher level of energy efficiency, comfort, and durability in their homes."

Richard Morgan
Austin Energy Green Building Program

9. City of Scottsdale Green Building Program (Arizona)

Overview:
Weighted rating (checklist) that emphasizes a system's approach by requiring 26 prerequisites. After meeting these requirements, projects get points from various rating categories. Projects qualify as "entry level" (26 points from the rating categories) or "advanced level" (56 points from the rating categories).

Certification method:
Checklist items verified by inspector. Certification and Homeowners Guide provided at completion of project.

Levels of certification:
Entry and advanced

Qualification:
63 points out of 368

Year of inception:
1998

Number of builders:
47

Incentives offered to builders to participate:
Expedited plan review: permitting time reduced by half

Number of homes constructed to date:
129

Contact information:
Anthony Floyd
7506 East Indian School Road
Suite 125
Scottsdale, AZ 85251
p. 480-312-4202
f. 480-312-7314
afloyd@ci.scottsdale.az.us
http://www.ci.scottsdale.az.us/greenbuilding/

Requirements		
Category	**Required Elements**	**Maximum Possible Points**
Site use	1	26
Structural elements	1	23
Building envelope	5	63
Heating, cooling, and ventilation	6	59
Indoor air quality	4	21
Electrical power, lighting, and appliances	3	25
Plumbing system	3	38
Roofing	–	12
Exterior finishes	–	12
Interior finishes	1	10
Interior doors, cabinetry, trim	–	15
Finish floor	1	13
Pools and spas	–	26
Solid waste	1	7
Special options	–	18
Total Possible Points	**26**	**368**

10.

New Mexico Building America Partner Program (HBA of Central New Mexico)

Overview:
Minimum standards for energy conservation (prescriptive or performance-based compliance), indoor air quality, water conservation, building materials conservation, solid waste reduction through recycling, and testing. No check-list or optional items. In addition to addressing Building America objectives of performance-based goals for indoor air quality, energy conservation, and water conservation, this program addresses solid waste reduction and material conservation.

Certification method:
Third-party testing done by HERS raters

Levels:
One

Qualification:
Two technical seminars and two public seminars

Year of Inception:
2001

Number of builders:
15

Incentives offered to builders to participate:
Marketing niche

Number of homes constructed to date:
830

Contact information:
HBA of Central New Mexico
Building America Partner Program
Lindsay Chism
PO Box 1881
Los Lunas, NM 87031
p. 505-866-6479
f. 505-565-8207
ldcconsulting@aol.com
http://www.hbacnm.com/green_builder

11.

County of Santa Barbara Innovative Building Review Program (California)

Overview:
Free program that advises developers on how to make developments more energy efficient. Includes a few green features beyond energy efficiency. Incentives to meeting targets include expedited plan review, 50% reduction in energy plan-check fee, marketing materials, and eligibility for Energy-Efficient Building of the Year.

Certification method:
Plan review (by committee at regularly scheduled meetings) and self-certification checklist.

Levels of certification:
Target 1, 2, or 3

Qualification:
Target 1: 20% better than Title 24 (California Energy Code); 5 points from checklist.
Target 2: 30% better than Title 24; 12 points from checklist.
Target 3: 40% better than Title 24; 30 points from checklist.

Year of inception:
1995

Number of builders:
60

Incentives offered to builders to participate:
Expedited review and reduced fees for checking energy plan.

Number of homes constructed to date:
890

Contact information:
County of Santa Barbara
Innovative Building Review Program
Kathy Pfeifer
30 E. Figueroa Street, 2nd Floor
Santa Barbara, CA 93101-2709
p. 805-568-2507
f. 805-568-2522
kathypm@co.santa-barbara.ca.us
http://www.silcom.com/~sbcplan/ibdrc.html

Mandatory Requirements	
Category	**Maximum Possible Points**
Exceed Title 24 requirements by 20%	Required (Target 1)
Exceed Title 24 requirements by 30%	Required (Target 2)
Exceed Title 24 requirements by 40%	Required (Target 3)
Checklist Requirements	
Category	**Maximum Possible Points**
Energy	51
Siting	4
Summer shading and wind protection	52
Non-energy related building techniques	23
Total Possible Points	**130**

12.

Build a Better Clark (Clark County, Washington HBA)

Overview:
Builders qualify at a one-, two-, or three-star level determined by mandatory criteria, plus points awarded from a checklist. Checklist items are generally weighted from 1 to 3 points.

Certification method:
Self-certification checklist (plus mandatory one-time program orientation)

Levels of certification:
One-, two-, or three-stars (★)

Qualification:

★	All mandatory requirements.
★★	All of one-star requirements, plus earn additional 50 points total. Attend a workshop within past 12 months.
★★★	Two-star requirements, plus an additional 40 points total (for a minimum total of 90 points). Attend a workshop within past 12 months.

Year of inception:
1999

Number of builders:
16

Incentives offered to builders to participate:
In development

Number of homes constructed to date:
26

Contact information:
Build a Better Clark
Attn: Mary Gould
5007 NE St. John's Road
Vancouver, WA 98661
p. 360-694-0933
f. 360-694-1606
joel@cchba.com
http://www.cchba.com/build_a_better_clark_page.htm

Mandatory Requirements	
Category	**Maximum Possible Points**
Meet Washington State energy code	Required
Meet Washington State ventilation/indoor air quality code	Required
Meet Washington State water use efficiency standards	Required
Prepare a job-site recycling plan and post on-site	Required
Use at least one recycled-content building product	Required
Provide a "Homeowner's Kit"	Required
Program orientation (one time only)	Required
Checklist Requirements	
Category	**Maximum Possible Points**
Treat site appropriately	
Site protection	19
Site design	20
Prevent waste	
Reduce	23
Reuse	8
Recycle	12
Resource-efficient material selection	32
Maximize energy efficiency	46
Indoor air quality and health	56
Manage hazardous waste	9
Promote responsible operation and maintenance	16
Total Possible Points	**241**

13.

Earth Advantage™ Program (Portland General Electric, Oregon)

Overview:

Earth Advantage is a utility-run program that provides marketing and technical support to builders. The program starts with a plan review by an Earth Advantage technical specialist. The specialist conducts on-site inspections to check for proper installation of materials. Two diagnostic tests are performed: one in the early stages of building to test the duct air loss and the second–a blower door test–is conducted when the home is complete. A certificate is given that lists the features for the home, the appliance ratings, and the diagnostic test results.

Certification method:

Points worksheet and onsite inspections

Levels of certification:

One

Qualification:

For the house to be certified, the builder must achieve *a minimum of 50 points in each of the four following categories:*

1) Energy Efficiency
2) Healthier Indoor Air
3) Environmental Responsibility
4) Resource Efficiency

House must also pass two performance tests (duct-blast and blower-door). To ensure that the house meets the requirement for performing 15% better than the Oregon energy code, core measures are required in each of the five following categories that include energy-efficiency points:

1) Shell Construction
2) HVAC/Duct Sealing
3) Water Heating
4) Lighting
5) Appliances.

Year of inception:

1999

Number of builders:

33

Incentives offered to builders to participate:

Marketing, advertising, others to be developed

Number of homes constructed to date:

100+

Contact information:

Duane Woik
16280 SW Upper Boones Ferry Road
Portland, OR 97224
p. 503-603-1733
f. 503-603-1710
http://www.earthadvantage.com

Checklist Requirements	Maximum Possible Points			
	Energy and Environmental Categories			
Construction Categories	**Energy Efficiency**	**Healthier Indoor Air**	**Environmental Responsibility**	**Resource Efficiency**
Shell construction	134	56	72	118
HVAC	160	160	20	64
Water heating	69	0	30	32
Lighting	6	0	12	8
Appliances	12	0	8	6
Foundation	0	34	12	26
Siding	0	58	44	68
Roofing	0	22	18	36
Insulation material	0	0	4	10
Interior surfaces	0	4	4	10
Surface coating	0	54	24	28
Cabinets	0	42	28	28
Countertops	0	32	12	16
Casework	0	18	12	8
Stove/fireplace	0	22	4	0
Flooring	0	46	36	42
Finish plumbing	0	0	8	6
Land and water	0	0	144	2
Waste management	0	0	28	16
Total Possible Points	**381**	**548**	**520**	**524**

14.

G/Rated (City of Portland, Oregon)

Overview:
Builders participating in this city-operated program are awarded points from a checklist for certification. Projects are jury-reviewed and are selected for publicity purposes.

Certification method:
Inspection, plus self-certification weighted checklist.

Levels of certification:
One

Qualification:
Case Study

Year of inception:
2001

Number of builders:
Not tracked

Incentives offered to builders to participate:
$3,000 grants for qualified projects that serve as case studies to be shared with the community.

Number of homes constructed to date:
35 (case studies)

Contact information:
Mike O'Brien
City of Portland Office of Sustainable Development
Green Building Specialist
p. 503-823-5494
mobrien@ci.portland.or.us
http://www.green-rated.org

Checklist Requirements	
Category	**Maximum Possible Points**
Sustainable sites	
Alternative transportation	7
Erosion and sediment control	2
Stormwater management	3
Healthy and water-efficient landscaping	14
House design	10
Energy efficiency	
Building envelope	6
Heating and cooling	13
Water heating	5
Appliances and lights	5
Renewable energy	18
Materials and resources	
Building materials	11
Efficient structural systems	20
Waste reduction and management	11
Reducing pollutant sources	13
Ventilation	9
Air cleaning	5
Reduce toxins in yard	4
Innovations	23
Partnerships	9
New technologies	5
Total Possible Points	**193**

15.

Home Builders Association of Greater Kansas City (Missouri)

Overview:
Self-certification worksheets. The individual items are not weighted.

Certification method:
Builders enroll in the Home Builders Association of Greater Kansas City Build Green Council and take an orientation class. Then, the builder can enroll individual homes in one of four possible levels (Platinum, Gold, Silver, or Bronze). Eight hours of classroom instruction per year are required. Each home above the bronze level requires a home energy rating. Only the builder and homebuyer receive and use the guideline, nothing is sent into the HBA.

Levels of certification:
Platinum, Gold, Silver, or Bronze

Qualification:
There are five categories of guidelines: Site, Energy, Materials, Indoor Air Quality, and Recycling. The energy aspect of the guidelines are performance-based, rather than prescriptive (i.e., the guidelines require an energy rating, but the guidelines do not dictate how the builder reaches the appropriate energy rating level). The guidelines offer suggestions that the builder can check off (e.g., sealed combustion, direct vent water heater) and submit to the HBA and also give to the home buyer. The Bronze level does not require a home energy rating. An energy rater does not have to be contacted–the builder can self-certify that the home meets the 1993 MEC.

Year of inception:
2002

Number of builders:
TBA

Incentives offered to builders to participate:
Home tours, use of logo on house listing, other marketing

Number of homes constructed to date:
TBA

Contact information:
Stan Parsons
Staff Coordinator
HBA of Greater Kansas City
600 East 103rd Street
Kansas City, MO 64131
p. 816-942-8800 x231
f. 816-942-8367
stan@kchba.org
http://www.kchba.org

16.

City of Frisco (Texas) Green Building Program

Overview:
This is one of the only programs in the country where all new residential homes (platted after May 23, 2001) must meet or exceed the green building program's criteria (i.e., it is not a voluntary program). The individual items are not weighted in the minimum standards list.

Certification method:
Performance-based program

Levels of certification:
One

Qualification:
There are four categories of guidelines: Energy Efficiency, Water Conservation, Indoor Air Quality, and Waste Recycling. The Energy Efficiency aspect of the standards are performance-based, rather than prescriptive. The standards require that the house meets or exceeds the ENERGY STAR Homes designation, but they do not dictate how the builder reaches the appropriate energy rating level. There are minimum standards for the other three categories.

Year of inception:
2001

Number of builders:
40

Incentives offered to builders to participate:
Mandatory participation

Number of homes constructed to date:
1,600 units are in the queue

Contact information:
Jeff Witt
City of Frisco
6875 Main Street
Frisco, TX 75034
p. 972-335-5540 x145
f. 972-335-5549
jwitt@ci.frisco.tx.us
http://www.ci.frisco.tx.us/planning/greenbuilding_index.htm

17.

Hawaii BuiltGreen™

Overview:
Comprehensive checklist with weighted items
Certification method:
Self-certification checklist
Levels of certification:
One-, two-, and three-stars (★)
Qualification:
★ Attend a one-time program orientation; meet mandatory green codes and regulations; earn at least 35 points for naturally ventilated homes; earn at least 45 points for air-conditioned homes.
★★ One-star requirements, plus 85 additional points (120 or 130 points total, respectively) from Sections 1 through 5 with at least 5 points from each section.
★★★ Meet two-star requirements, plus 95 additional points (215 or 225 points total, respectively); attend green-building-related workshop or conference within past 12 months.
Year of inception:
TBA
Number of builders:
TBA
Incentives offered to builders to participate:
Identified in Parade of Homes directory, serve in speakers' bureau
Number of homes constructed to date:
TBA
Contact information:
Karen Nakamura
Executive Vice President
Building Industry Association of Hawaii
1727 Dillingham Blvd.
Honolulu, HI 96819
p. 808-847-4666 x203
f. 808-842-0129
ktn@bia-hawaii.com
http://www.bia-hawaii.com/builtgreen/

Mandatory Requirements	
Category	**Maximum Possible Points**
No soil exposed during job (protected with mulch)	Required
No fill in sensitive areas	Required
Sensitive areas flagged and protected during construction	Required
Post-cleanup procedures for spills	Required
Hazardous wastes separated and properly disposed of	Required
Sediment traps installed for construction	Required
No adverse impacts on adjoining properties or critical areas during construction	Required
Water quality monitoring during construction	Required
Concrete trucks and pumps washed in designated areas	Required
Low flow shower heads and sinks (2.5 gpm)	Required
Low flow bath faucets (2.0 gpm)	Required
Clothes dryer vented to outdoors	Required
All wood used has approved chemical treatment for termites	Required
All cuts and drill holes in CCA-treated wood field-treated	Required
Homeowner's operations and maintenance manual	Required
Homeowner's outdoor landscaping manual	Required

For Air-Conditioned Homes Only	
House meets Hawaii MEC standards for A/C buildings	Required
A/C system sized for efficient operation (not oversized)	Required
Programmable thermostats provided	Required
Heat-trap installed or 1" pipe insulation on at least first 8 feet of outlet pipe from water heater	Required
Solar heater or heat pump for swimming pool heaters	Required
Checklist Requirements	
Protecting Site	
Design choices	35
Job site operations	15
Outdoor water conservation	9
Bonus points	10
Energy performance and comfort	
Site	15
Shell	24
Openings	43
Interior layout and finishes	10
Mechanical venting and cooling	21
A/C homes only	23
Water Heating – distribution	25
Indoor water conservation (double points if rainwater collection is not required)	12
Electric lighting	16
Appliances	17
Bonus points for custom homes	10
Health and indoor air quality	
Floors	38
Cabinetry and trim	8
Interior walls	8
Mechanical and other controls	14
A/C Homes only	11
Job site operations	10
Durability and Materials Conservation	
Design choices	8
Termite details	19
Framing	24
Foundation	9
Sub-floor	2
Windows and doors	10
Insulation	4
Interior walls	1
Finish floor	19
Cabinetry and trim	17
Roof	5
Exterior finish	8
Outdoor features	12
Job site operations (triple points for custom homes)	21
Bonus points	25
Environmentally friendly homeowner O&M	11
Total Possible Points	**569**

18.

California Green Builder Program

Overview:
The individual items are not weighted in the minimum standards list. However, for each of the four categories of guidelines, the program has established performance-based requirements.

Certification method:
Performance-based program

Levels of certification:
One

Qualification:
There are four categories of guidelines: Energy Efficiency, Air Quality, Waste Recycling, and Water Conservation. Below are the minimum requirements under the program:
Energy Efficiency: Meet EPA/DOE Energy Star Homes efficiency levels; exceed a 15% improvement over California Title 24 Energy Code.
Air Quality: Reduce air emissions by building to Energy Star Homes efficiency level.
Waste Recycling: 50% diversion from land fill job site waste. Where recycling and diversion are not available, builder agrees to adopt the Building Industry Institute Waste Recycling Guidelines and work with local jurisdictions to overcome local market barriers.
Water Conservation: 25% decrease in water use compared to typical 1980s home.

Year of inception:
2001

Number of builders:
TBA

Incentives offered to builders to participate:
Recognition, expedited plancheck, reduced fees, and expedited field check.

Number of homes constructed to date:
TBA

Contact information:
Robert Raymer, P.E.
BII Technical Director
1215 K Street, Suite 1200
Sacramento, CA 95814
p. 916-443-7933
http:www.thebii.org/cgbp.asp

19.

Green Built Program (HBA of Greater Grand Rapids, Michigan)

Overview:
Energy efficiency covered by participation in Energy Star or American Lung Association Health (ALA) House. Checklist for additional points focuses on areas not addressed by Energy Star or ALA programs.

Certification method:
Independent auditor completes application

Levels of certification:
One

Qualification:
Meet Energy Star minimum requirements, plus 40 additional points from checklist

Year of inception:
Spring 2002

Number of builders:
8, plus 6 associate members

Incentives offered to builders to participate:
Use of Green Built logos; inclusion in list of builders distributed to general public inquiring about Green Building; names included in HBA marketing materials

Number of homes constructed to date:
4

Contact information:
Ann Dykema
Home & Building Association of Greater Grand Rapids
2021 44th Street SE
Grand Rapids, MI 49508-5009
p. 616-281-2021
f. 616-281-4500
adykema@hbaggr.com
http://www.hbaggr.com

Mandatory Requirements	
Category	**Maximum Possible Points**
Attendance at training program	Required
Four-Star Energy Star rating	80
Checklist Requirements	
Category	**Maximum Possible Points**
Five-Star Energy Star Rating	1 for every Energy Star point over 80, up to a maximum of 100
American Lung Association Health House®	100 points
Land use	13
Water efficiency	26
Roofing	8
Framing/Decking	19
Foundation	15
Appliances	10
Lighting	8
Design Efficiency/Waste Management	19

20.

Vermont Built Green (in progress)

Overview:
Weighted checklist with minimum requirements. Points are accumulated for a total score.
Certification method:
Combination of self-certification and spot inspections.
Levels of certification:
Either "Vermont Built Green Certified" or "Vermont Built Green Certified with XX points"
Qualification:
TBA
Year of inception:
TBA
Number of builders:
N/A
Incentives offered to builders to participate:
ENERGY STAR certification
Number of homes constructed to date:
N/A
Contact information:
Richard Faesy
Vermont Energy Investment Corporation
255 S. Champlain Street
Burlington, VT 05401
p. 802-658-6060
f. 802-658-1643
rfaesy@veic.org
http://www.sover.net/~michaelh/bsr

Mandatory Requirements (draft)	
Category	**Maximum Possible Points**
Siting and land use	
Location	Required
Minimize damage to environment	Required
Promote community and security	Required
Building design—efficient design	Required
Quality/Durability—choose quality materials	Required
Energy use	
Envelope and systems	Required
Lighting and appliances	Required
Sustainable equipment	Required
Resource impacts	
Resource efficient materials	Required
Reduce, reuse, recycle	Required
Encourage waste reuse and recycling for homeowners	Required
Water efficiency	Required
Occupant health/Indoor air quality	
Minimize sources of pollutants	Required
Provide ventilation to remove generated pollutants	Required
Occupant education and Operations and Maintenance	Required

Continued next page

Checklist Requirements	
Category	**Maximum Possible Points**
Siting and land use	
Location	18
Minimize damage to environment	31
Promote community and security	23
Nature connection	3
Building design	
Efficient design	7
Minimize house size	(multiplication factor for total checklist points. 2,001 ft^2 - 2,500 ft^2 is 1.00; 2,000 ft^2 is 1.05; add 0.05 for each 100 ft^2 less than 2,000 ft^2; subtract 0.05 for each 500 ft^2 over 2,500 ft^2)
Quality/Durability—choose quality materials	39
Energy use	
Envelope and systems	31
Lighting and appliances	18
Sustainable equipment	18 + 0.005 points per peak watt of renewable energy (or 0.01 points per peak watt of Renewable Energy if grid-connected)
Resource impacts	
Resource efficient materials	70
Reduce, reuse, recycle	23
Encourage waste reuse and recycling for homeowners	3
Waste efficiency	18
Occupant health/Indoor air quality	
Minimize sources of pollutants	41
Provide ventilation to remove generated pollutants	12
Occupant education and Operations and Maintenance	9

21. Southern Arizona Green Building Alliance (in progress)

Overview:
Green Building Program is in its infancy and details are still being determined.
Certification method:
TBA
Levels of certification:
One-, two-, or three-armed "saguaro"
Qualification:
TBA
Year of inception:
TBA
Number of builders:
TBA
Incentives offered to builders to participate:
TBA
Number of homes constructed to date:
TBA
Contact information:
Loretta Ishida
The Development Center for Appropriate Technology (DCAT)
PO Box 27513
Tucson, AZ 85726-7513
p. 520-624-6628
f. 520-798-3701
Loretta@dcat.net
http://www.dcat.net

22. Western North Carolina Green Building Council (in progress)

Overview:
No guidelines yet. The statewide program is in a very early stage of development. They are currently looking for funding to move the program to the draft stage. They are tentatively planning on teaming with the North Carolina Solar Center.
Certification method:
TBA
Levels of certification:
TBA
Qualification:
TBA
Year of inception:
TBA
Number of builders:
TBA
Incentives offered to builders to participate:
TBA
Number of homes constructed to date:
TBA
Contact information:
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PO Box 8427
Asheville, NC 28814
p. 828-251-5888
sheltereco@earthlink.net
http://www.main.nc.us/wncgbc

23. Alameda County (California) (in progress)

Overview:
Under Development
Certification method:
TBA
Levels of certification:
TBA
Qualification:
TBA
Year of inception:
TBA
Number of builders:
TBA
Incentives offered to builders to participate:
TBA
Number of homes constructed to date:
TBA
Contact information:
Mari Soll
p. 510-614-1699

24. Chula Vista (California) GreenStar Building Incentive Program (in progress)

Overview:
Under Development
Certification method:
TBA
Levels of certification:
TBA
Qualification:
TBA
Year of inception:
TBA
Number of builders:
TBA
Incentives offered to builders to participate:
TBA
Number of homes constructed to date:
TBA
Contact information:
Mary Venables
p. 619-691-5296

25. Hudson Valley HBA Green Building Program (New York) (in progress)

Overview:
Under Development
Certification method:
TBA
Levels of certification:
TBA
Qualification:
TBA
Year of inception:
TBA
Number of builders:
TBA
Incentives offered to builders to participate:
TBA
Number of homes constructed to date:
TBA
Contact information:
Jean Rowe
Hudson Valley Builders Association
338 Meadow Avenue
Newburgh, NY 12550
p. 845-562-0002
http://www.hvbuilder.com

26. Schenectady HBA Green Building Program (New York) (in progress)

Overview:
Under Development
Certification method:
TBA
Levels of certification:
TBA
Qualification:
TBA
Year of inception:
TBA
Number of builders:
TBA
Incentives offered to builders to participate:
TBA
Number of homes constructed to date:
TBA
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Rita Sickles
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Schenectady, NY 12306
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http://www.schenectadybuilders.com

Conclusion

For more information on Green Building Programs, contact the NAHB Research Center, 400 Prince George's Boulevard, Upper Marlboro, MD 20774-8731, (800) 638-8556, or visit our website at www.toolbase.org.

This document can also be downloaded from www.toolbase.org.


NAHB
RESEARCH
CENTER

NREL

Building
AMERICA

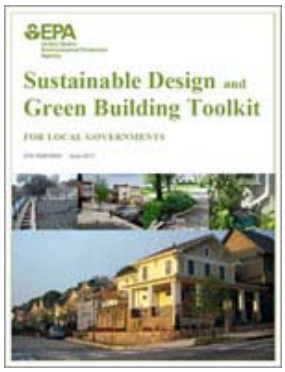
https://archive.epa.gov/greenbuilding/web/html/
Last updated on 2/20/2016

Green Building

The buildings in which we live, work, and play protect us from nature's extremes, yet they also affect our health and environment in countless ways. As the environmental impact of buildings becomes more apparent, a new field called "green building" is gaining momentum.

Green, or sustainable, building is the practice of creating and using healthier and more resource-efficient models of construction, renovation, operation, maintenance and demolition. Read more about green building or use these links to explore topics:

Toolkit



The Sustainable Design and Green Building Toolkit for Local Governments (PDF) (110 pp, 1.12MB, About PDF) helps local governments identify and remove barriers to sustainable design and green building in existing codes and ordinances. The toolkit includes an Assessment Tool in Excel (XLSX) (184K) that local governments can use to evaluate their codes and ordinances; instructions appear on the opening tab.

Green Building Standards

Learn about six major model codes and rating systems that communities can use to develop green building programs and revise building ordinances.

EPA Green Building Publications

EPA Green Building Publications "Catalogue" (PDF) (16 pp, 2MB)

Basic Information

Why Build Green?

Components of Green Building

- Energy Efficiency and Renewable Energy
- Water Efficiency
- Environmentally Preferable Building Materials and Specifications
- Waste Reduction
- Toxics Reduction
- Indoor Air Quality
- Smart Growth and Sustainable Development

Building Types

- Homes
- Schools
- Commercial Buildings
- Laboratories
- Healthcare Facilities

Funding Opportunities

National Programs
State & Local Programs

Frequent Questions

Additional Resources

EPA Regional Websites
Federal Agency Websites
Publications and Tools

THE NATIONAL ACADEMIES PRESS OPENBOOK

Energy-Efficiency Standards and Green Building Certification Systems Used by the Department of Defense for Military Construction and Major Renovations (2013)

Chapter: Summary

Visit **NAP.edu/10766** to get more information about this book, to buy it in print, or to download it as a free PDF.

Summary

Congress has an ongoing interest in ensuring that the 500,000 buildings and other structures owned and operated by the Department of Defense (DOD) are operated effectively in terms of cost and resource use. Section 2830 of the National Defense Authorization Act for fiscal year (FY) 2012 (NDAA 2012) requires the Secretary of Defense to submit a report to the congressional defense committees on the energy-efficiency and sustainability standards used by DOD for military construction and major renovations of buildings. DOD's report must include a cost-benefit analysis, return on investment, and long-term payback for the building standards and green building certification systems identified below:

(A) American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 189.1-2011 for the Design of High-Performance, Green Buildings Except Low-Rise Residential.
(B) ASHRAE Energy Standard 90.1-2010 for Buildings Except Low-Rise Residential.

(C) Leadership in Energy and Environmental Design (LEED) Silver, Gold, and Platinum certification for green buildings, as well as the LEED Volume certification.
(D) Other American National Standards Institute (ANSI)-accredited standards.

DOD's report to the congressional defense committees must also include a copy of DOD policy prescribing a comprehensive strategy for the pursuit of design and building standards across the department that include specific energy-efficiency standards and sustainable design attributes for military construction based on the cost-benefit analysis, return on investment, and demonstrated payback required for the aforementioned building standards and green building certification systems.

THE COMMITTEE'S TASK

To obtain independent, objective advice in developing its response to Section 2830 of NDAA 2012, the Deputy Undersecretary of Defense for Installations and Environment asked the National Research Council (NRC) to establish an ad hoc committee of experts to undertake three related tasks:

1. Conduct a literature review that synthesizes the state-of-the-knowledge about the costs and benefits, return on investment, and long-term payback of specified design standards related to sustainable buildings.
2. Evaluate a consultant-generated methodology and analysis of the cost-benefit, return on investment, and long-term payback for specified building design standards and evaluate the consultant's application of the methodology using empirical data from DOD buildings.
3. Identify potential factors and approaches that the DOD should consider in developing a comprehensive strategy for its entire portfolio of facilities that includes standards for energy efficiency and sustainable design.

The specified design standards to be evaluated are ASHRAE Energy Standard 90.1-2010 for Buildings Except Low-Rise Residential; ASHRAE Standard 189.1-2011 for High-Performance Green Buildings Except Low-Rise Residential; LEED Silver, Gold, Platinum, and Volume certifications; and other ANSI-accredited standards such as Green Globes.

It became evident at the first committee meeting that the wording of task 2 was not clear in regard to the relationship between the NRC, DOD, and the consultant, or the work being undertaken by the consultant. For purposes of clarity, the committee notes that the consultant was hired directly by DOD under a separate contract and the consultant's report is contained in its entirety in Appendix C.

The DOD consultant's report developed an analytical approach that included a traditional benefit-cost analysis to calculate long-term benefits and costs, adjusted rate of return on investment, and payback of ASHRAE Standards 90.1-2010 and 189.1-2011 and of the LEED and Green Globes green building certification systems; sensitivity analyses using a range of scenarios that represented uncertainty in future conditions; and a test of the analytical approach using data from DOD buildings to identify issues that might arise if the approach were to be applied in the DOD operating environment.

The committee evaluated the cost-benefit and sensitivity analyses as outlined in task 2. Regarding the consultant's application of the methodology using empirical data from DOD buildings, it is important to note that the consultant's purpose was not to conduct a cost-benefit analysis for a sample of DOD buildings but to identify issues that might arise if the proposed analytical approach were to be used by DOD. Thus, the committee evaluated the potential application of the consultant's analytical approach to the DOD operating environment.

A clearer description of task 2 would read as follows:

> Evaluate a report developed under a separate contract by a DOD consultant that focuses on a methodology and analysis of the cost-benefit, return on investment, and long-term payback for specified building design standards and evaluate the potential application of the consultant's analytical approach to the DOD operating environment.

HIGH-PERFORMANCE OR GREEN BUILDINGS

The Energy Independence and Security Act of 2007 (EISA 2007) defines the attributes of high-performance buildings, which include reductions of energy, water, material, and fossil fuel use, improved indoor environmental quality for occupants, improved worker productivity, and lower life-cycle costs when compared to baselines for building performance. The terms "green" and "sustainable" are often used interchangeably with high-performance buildings, but there are no standard definitions for those terms. In this report, *high performance* refers to buildings that are specifically called out as meeting the EISA standard. *Green* is a more inclusive term used to indicate buildings that are designed to be highly energy efficient, to meet green building certification systems, or to be otherwise regarded as sustainable. Buildings that are not described as high-performance or green are referred to as conventional buildings.

Building standards and green building certification systems have been developed by nonprofit organizations to provide a framework for the design and operation of high-performance and green buildings. Building standards typically establish minimum requirements for the design of one aspect of a building's performance (for example, energy). Green building certification systems, in contrast, take a "whole building" approach to design by accounting for the interrelationships among building design, materials, mechanical systems, technologies, and operating practices.

LEED, developed by the U.S. Green Building Council (USGBC), and Green Globes, licensed by the Green Building Initiative (GBI), are the green building certification systems most commonly used in the United States. EISA 2007 requires federal agencies to use a green building certification system for new construction and major renovations of buildings.

ECONOMIC PERFORMANCE METHODS AND MEASURES

Several closely related methods and measures are used for determining the economic performance of buildings, building systems, and components. There are salient differences among the methods and measures that bear on their correct application and interpretation for evaluating the cost-effectiveness of DOD construction and renovation projects.

Benefit-cost analysis (BCA) is most often used to determine if a government program or investment can be justified on economic grounds. It entails assigning monetary values to societal benefits from the program/investment, as well as to assessing direct program/investment costs, all over a specified time horizon (e.g., 20 years), and finding the difference between benefits and costs as net present value (NPV) benefits. A positive NPV means that total benefits exceed total costs, and the program or other investment is cost-effective. BCA can also be used to make mutually exclusive choices among building design, systems, and components. The choice with the highest NPV benefits is preferred on economic grounds. Related additional economic performance measures—benefit-cost ratios, internal rates of return on investment, adjusted internal rates of return on investment—can be computed from the time-denominated cash flows of benefits and costs of BCA.

Payback refers to the time period at which initial investment is recovered. Payback measures do not include future savings that may occur after the initial investment is recovered. For that reason, payback measures are not appropriate for comparing the long-term economic effectiveness of buildings or projects, because the alternative with the shortest payback period may not be the alternative with the greatest NPV benefits or the greatest return on investment.

COMPLEXITY OF THE TASK

The committee's completion of its three related tasks was complicated by the following factors:

- *Difficulty of measuring building performance objectively.* The research on high-performance or green buildings inherently incorporates some level of subjectivity because of the unique nature of buildings, diversity in baselines for comparison studies, and the lack of a standard protocol for research on this topic.

All buildings differ in terms of location, materials, design, size, function, technologies, operational practices, and other factors, which influence overall building performance. The diversity in building

design and the multitude of factors that contribute to any building's performance make it difficult to isolate the specific factors that contribute to energy use, water use, or other performance measures.

There are no national baselines from which to measure the performance of multiple factors associated with high-performance or green buildings. Instead, some baselines have been developed to measure individual factors such as energy.

The Commercial Buildings Energy Consumption Survey (CBECS) is the only national data source for detailed characteristics and energy use of U.S. commercial buildings. EISA 2007 establishes the CBECS as a baseline within the definition of high-performance buildings. However, there are well-documented deficiencies in the CBECS database, as detailed in Chapter 3. There are no national databases for water use, operations and maintenance, indoor environmental quality, or worker productivity as it relates to buildings. Baselines for comparing those factors are typically developed differently for individual studies.

There is no standard protocol for conducting research on high-performance or green buildings, although some studies do use similar methodologies or evaluation methods. Together all of these factors hinder objective comparisons across studies and preclude definitive, fully documented findings. The subjectivity inherent in making comparisons across research studies instead requires judgments based on a "preponderance" of evidence.

- *Recent release of ASHRAE Standards 189.1-2011 and 90.1-2010 and the LEED Volume certification program.* Few, if any buildings have been built to the latest versions of the ASHRAE standards. The only information available about the expected performance of buildings constructed to those standards was based on the same design models used in their development. The LEED Volume certification is also a new program for which there is little documented experience thus far.
- *Continuous improvement of building standards and green building certification systems and related factors.* Building standards and green building certification systems are regularly updated to take into account new objectives, techniques, knowledge, and technologies for buildings. As a result, multiple versions of each exist. With a few exceptions, research studies do not identify the specific versions of the standards and certification systems under which the buildings studied were constructed.

Instead, the research typically compares a sample of buildings that are defined as green to a sample of conventional buildings. Studies related to LEED-certified buildings typically include buildings constructed under different versions of LEED that meet a range of certification levels, so even these have great variability. All of those factors and the incorporation by reference of building standards such as ASHRAE 90.1 into green building certification systems create confounding factors for research studies, which hinder the attribution of specific benefits and costs to specific standards or certification systems.

- *Quantity and quality of the literature.* Although there are hundreds of publications related to high-performance or green buildings, relatively few are well-designed empirical studies. Of these, several focused specifically on LEED-certified buildings; none focused on Green Globes-certified buildings. The only data available on the actual performance of Green Globes-certified buildings were individual case studies.

Other factors that made the task more complex included issues related to qualitative and quantitative measurements of building performance, measured data versus modeled data for energy and water use, and the inclusion of a mix of building types in most empirical studies.

THE COMMITTEE'S APPROACH

The committee focused on the main purposes of the statement of task but did not have time to conduct extensive additional investigations. Thus, the committee's report does not evaluate building standards or certification systems that were not specified, describe the various debates about the use of green building certification systems, or acknowledge the full array of initiatives that are underway at DOD. Such initiatives include approaches for reducing greenhouse gas emissions, and for net-zero-energy buildings.

For its evaluation of the research literature, the committee determined it would focus on studies that met the following criteria:

- *Time frame.* The committee relied on studies published in 2004 or later because the first studies evaluating the incremental costs of LEED-certified buildings were published in 2004. The first evaluations of a sample of at least six high-performance or green buildings in the United States were published in 2006.
- *Robustness.* The committee focused on studies with clearly stated objectives, a clearly defined methodology, findings based on empirical data, and a sample size of at least six buildings. Individual case studies were not evaluated because of the prevalence of bias, error, and chance.
- *Relevancy to the DOD operating environment.* DOD typically owns and operates buildings for 30 years or longer. Although the committee identified a number of robust, timely studies related to the market value, rental rates, vacancy rates, and appraised value of green buildings compared to conventional buildings, the committee did not evaluate those studies in detail because market factors typically are not relevant to the DOD operating environment.

Based on those criteria, the committee identified 25 studies that served as the basis for its findings. The studies are summarized in Chapters 2 and 4 and Appendix D.

In regard to the DOD consultant's report, the committee discussed the proposed methodology with the DOD consultant and representatives of ASHRAE, the USGBC, and GBI on June 28-29, 2012. The committee suggested changes to the methodology for the consultant's consideration. In September 2012, the committee received the consultant's final report, *Cost-Effectiveness Study of Various Sustainable Building Standards in Response to NDAA 2012 Section 2830 Requirements* for an in-depth evaluation (Slaughter, 2012; see Chapter 3 and Appendix C).

FINDINGS

The committee's findings are based on the literature review, the evaluation of the DOD consultant's study, and the experience and expertise of its members. The findings are presented below with a brief explanation of the committee's rationale. Chapter 5 contains more detailed explanations of the rationale for the committee's findings and recommended approaches.

Finding 1: The committee did not identify any research studies that conducted a traditional benefit-cost analysis to determine the long-term net present value savings, return on investment, or long-term payback related to the use of ASHRAE Standard 90.1-2010, ASHRAE Standard 189.1-2011, and the LEED or Green Globes green building certification systems.

Of the 25 studies that met the committee's criteria for time frame, robustness, and relevancy to the DOD operating environment, only two (Turner, 2006; Kats, 2010) provided some analyses of NPV benefits, return on investment, or payback associated with high-performance or green buildings. Those studies, however, did not evaluate the cost-effectiveness of the specific building standards or green building certification systems. Instead they looked at the cost-effectiveness of green buildings compared to conventional buildings.

Finding 2: There is some limited evidence to indicate that provisions within ASHRAE Standard 189.1-2011 may need to be selectively adopted if use of this standard is to be cost-effective in the DOD operating environment.

ASHRAE Standard 189.1-2011 contains mandatory requirements that limit the ability of DOD to adapt the standard to its operating environment. The foreword to ASHRAE 189.1-2011 states that "new provisions within the standard were not uniformly subjected to economic assessment" and that cost-benefit assessment was not a necessary criterion for acceptance of any given proposed change to the standard from the 2009 version. The study *Incremental Costs of Meeting ASHRAE Standard 189.1 at Air Force Facilities: An Evaluation of Four AF MILCON Projects* (LMI, 2011) and the committee's review of ASHRAE Standard 189.1-2011 identified some mandatory requirements that may not be cost effective or feasible in the DOD operating environment.

Finding 3. Research studies indicate that the incremental costs to design and construct high-performance or green buildings typically range from 0 to 8 percent higher than the costs to design and construct conventional buildings, depending on the methodology used

in the study and the type of building analyzed. The additional incremental costs to design and construct high-performance or green buildings are relatively small when compared to total life-cycle costs.

Several studies focused on the incremental costs to design and construct high-performance or green buildings when compared to conventional buildings. Those studies used different methodologies to calculate the additional costs of design and construction and applied them to different types of buildings. The studies indicated that the additional first costs for high-performance or green buildings would typically range from 0 to 8 percent higher than the costs to design and construct conventional buildings, although the costs ranged up to 18 percent higher in a few instances. The study with the largest sample size indicated that, on average, the incremental first costs of green buildings were within 2 percent of the costs of conventional buildings,

Over the life cycle of a building, design and construction costs typically range from 5 to 10 percent of total costs, while operations and maintenance costs account for 60 to 80 percent of total costs. Thus, the additional incremental costs to design and construct high-performance or green buildings are relatively small when considered as part of total life-cycle costs.

Finding 4: The analytical approach proposed by the DOD consultant has merit as a decision support tool in the DOD operating environment if appropriate and verifiable data are available for conducting benefit-cost and sensitivity analyses.

The DOD consultant conducted a traditional benefit-cost analysis to calculate NPV benefits and adjusted rate of return on investment to determine the cost-effectiveness of the two ASHRAE Standards and the two green building certification systems. The consultant also conducted a payback analysis as required by NDAA 2012. The consultant's proposed analytical approach expanded on the traditional BCA to incorporate factors related to geographic location, climate conditions, and local factors for utility costs. Sensitivity analyses were also incorporated to test a range of scenarios that represented uncertain future conditions related to discount rates, water prices, and energy prices. To the committee's knowledge, those factors are not required by DOD or by other federal regulations. The

committee believes that the consultant's analytical approach has merit as one of an array of decision support tools to be used by DOD for evaluating investments in new construction or major renovations.

However, the committee has significant concerns about the sources of data available and the application of those data in the consultant's analysis, including estimates of the incremental costs to design and construct high-performance or green buildings; those concerns are detailed in Chapters 3 and 5. As a consequence, the committee cannot support the consultant's findings related to the absolute NPV benefits calculated for the ASHRAE standards, LEED, or Green Globes.

Finding 5: The evidence from the literature search indicates that high-performance or green buildings can result in significant reductions in energy use and water use. The cost savings associated with the reductions in energy and water use will vary by geographic region, by climate zone, and by building type.

Thirteen of the 25 studies evaluated by the committee focused on measured actual energy use in buildings based on utility bills. All thirteen found that high-performance or green buildings, on average (i.e., over a group of buildings), used 5 to 30 percent less site energy than similar conventional buildings.

The six studies that provided some evaluation of water use found that high-performance or green buildings on average used 8 to 11 percent less water than conventional buildings.

Seven studies provided some analysis of the performance of buildings certified at different levels of LEED. They indicated that the majority of LEED-Silver and LEED-Gold and Platinum buildings studied used significantly less energy and less water than conventional buildings.

The long-term cost savings that can be achieved through reductions in energy and water use over the life cycle of buildings will depend, in part, on local utility prices and on heating and cooling loads related to climate zones. During the 30 or more years a DOD building is in use, those differences could be significant. Across a portfolio of facilities, local price factors may be an important consideration for DOD in determining which

investments in military construction or major renovations will be the most cost-effective over the long term.

Finding 6: Not every individual high-performance or green building achieved energy or water savings when compared to similar conventional buildings.

Although high-performance or green buildings saved energy and water, on average, within a sample of green buildings, some individual buildings had significantly greater reductions than the average, and some did not perform as well as conventional buildings. Similarly, there were LEED-Silver and LEED-Gold-certified buildings that used more energy and more water than conventional buildings. The research studies speculated about reasons why this was so, but they did not provide sufficient evidence to draw generalizations regarding why some high-performance or green buildings significantly outperformed conventional buildings and why others did not, although building type was clearly a factor.

Finding 7: In general, the quantities of energy and water used by a building once it is in operation are greater than the quantities of energy and water predicted by building design models, if these models are specifically created for compliance with LEED, Green Globes, or ASHRAE standards.

All building standards and green building certification systems require that a building design meet or surpass an energy efficiency standard. In the case of LEED, Green Globes, and ASHRAE 189.1, this standard is ASHRAE/Illuminating Engineering Society of North America (IESNA) 90.1. An energy model created to be compared with the ASHRAE/IESNA 90.1 standard necessarily underestimates the

energy use and the energy cost of the building once constructed and in operation. This is because (1) such models assume perfection in manufacturing, installation, and operation of buildings and their systems; and (2) such models do not include certain heat losses because they are too difficult to calculate.

Energy and water use should be predicted with an “actual use” model that takes into account factors not considered by the LEED, GBI, or

ASHRAE design models. An "actual use" model starts with the model created for compliance with LEED, Green Globes, or with ASHRAE 189.1, and then incorporates real-life assumptions of manufacturing, installation, and operation. It also incorporates the three-dimensional heat losses.

An "actual use" model created during design can be significantly improved in its predictive value if it is updated with as-built/as-operated conditions. Imperfections during construction can be observed and incorporated in the model, change orders can be modeled as well, and variations in occupancy captured (e.g., different plug loads). An "actual use/as-built model" is best suited for use as a benchmark to assess whether the building performs as it should and to correct deficiencies in operation.

The difference between modeled energy or water use and actual energy or water use is important for facilities managers and other decision makers when communicating with other stakeholders. Using data from LEED, GBI, or ASHRAE design models in decision making or in communications can set unrealistically high expectations that cannot be met. Using data from an as-built model will provide more realistic performance data. However, conveying information based on measured energy or water use will provide the most realistic data for decision-making and will improve the credibility of facilities managers and decision makers with other stakeholders.

Finding 8. DOD has the opportunity to continue to take a leadership role in improving the knowledge base about high-performance buildings, improving decision-support tools, and improving building models by collecting data on measured energy, water, and other resource use for its portfolio of buildings and by collaborating with others.

The data currently available to support decision-making about investments in military construction and major renovation projects is inadequate. Under the Energy Performance Act of 2005, all federal buildings are required to be metered by FY 2012. Metered data for energy and water use can be used to improve decision support tools and processes, to establish baselines for conventional buildings, and to measure the performance of high-performance or green buildings against those baselines. DOD could work with the Department of Energy and others to improve the available knowledge and databases related to high-

performance buildings, to the benefit of the federal government and society.

Finding 9. Effective operation of high-performance buildings requires well-trained facilities managers.

High-performance or green buildings incorporate new building design processes, new technologies, and new materials. Effective operation of high-performance buildings requires well-trained facilities managers who understand the interrelationships among building technologies, occupant behavior, and overall building performance, as recognized through the enactment of the Federal Buildings Personnel Training Act of 2010.

RECOMMENDED APPROACHES FOR DOD'S CONSIDERATION

Decisions about investments related to new construction and major renovations of buildings at DOD installations are not reducible to a single decision rule (such as benefit-cost maximization), nor are facilities managers responsible to a single stakeholder. In fact, facilities managers must assess the relative merits of facilities improvement projects against performance with respect to multiple decision criteria and justify recommendations to stakeholder groups and governing bodies that hold different and sometimes conflicting priorities. Trade-offs are required for most building projects, including design and construction costs (i.e., first costs) versus operating and maintenance and deconstruction costs, resilience and flexibility factors versus worker productivity, and so forth.

Based on its findings and on its own expertise and experience with building standards and green building certification systems, the committee recommends that DOD consider the following approaches as it develops a comprehensive strategy for its entire portfolio of facilities to include standards for energy efficiency and sustainable design.

Recommended Approach 1. Continue to require that new buildings or major renovations be designed to achieve a LEED-Silver or equivalent

rating in order to meet the multiple objectives embedded in laws and mandates related to high-performance buildings.

The preponderance of available evidence indicates that green building certification systems and their referenced building standards offer frameworks for reducing energy and water use in buildings, compared to design approaches and practices used for conventional buildings. They may also result in improved indoor environmental quality, improved worker productivity, and lower operations and maintenance costs, although the evidence is very limited. Green building certification systems can also help to establish explicit and traceable objectives for future building performance and a feedback loop to determine if the objectives were met.

The incremental costs to design and construct high-performance or green-certified buildings compared to conventional buildings is minimal compared to the total costs of a building over its life cycle. Over the 30 years or more that high-performance or green buildings are in use, the cost savings attributable to reduced energy use and reduced water use may be significantly greater than the incremental first costs of design and construction.

The limited evidence available indicates that the majority of LEED-Silver-certified buildings studied used significantly less energy and water than conventional buildings, although some LEED-Silver-certified buildings did not outperform conventional buildings. Based on the evidence and committee members' own experience with green building certification systems, the committee believes the most prudent course for DOD is to continue its current policy. At the same time, DOD should establish practices to evaluate the performance of its high-performance or green buildings to ensure that performance objectives are being met, to continuously improve performance, and to ensure that the measures required to reduce levels of energy and water use are cost-effective.

Because DOD has developed standard designs for the types of buildings it constructs most often, using the LEED-Volume certification program may be cost-effective, although as yet there is little experience with or documented evidence about the program. DOD should consider a pilot study to determine whether volume certifications will in fact be cost-effective.

Recommended Approach 2. Retain flexibility to modify building standards and the application of green building certification systems in ways that are appropriate to the Department of Defense operating environment and mission.

ASHRAE Standard 189.1-2011 contains many mandatory provisions that have not yet been evaluated for their cost-effectiveness. The committee recommends that DOD conduct pilot studies on specific provisions of the standard to determine their cost-effectiveness and their practicality in the DOD operating environment before adopting ASHRAE 189.1-2011 in its entirety. As experience with the various provisions emerges, DOD can determine which provisions of the standard are cost-effective and support DOD's mission and incorporate those provisions into DOD guidance documents when appropriate.

Recommended Approach 3. Put policies and resources in place to measure the actual performance of the Department of Defense's high-performance, green, and conventional buildings to meet multiple objectives.

Not every individual high-performance or green building will have significant energy and water savings even if it is certified at a LEED-Silver or equivalent rating. The committee recommends for all new construction and major renovations that DOD measure actual performance for 3 years or longer after initial occupancy and use the resulting information and lessons learned to further modify its policies if appropriate. This can be done because DOD meters all of its buildings. Data for conventional buildings should also be gathered to establish baselines for performance measurement.

It will be necessary to continue to use building models in the design stage to support decision making among alternatives. Building models can be improved over time such that predicted results are more closely aligned with actual results, as detailed in Chapter 5. As DOD's buildings are metered, DOD should gather data on the use of energy, water, and wastewater to establish baselines for conventional buildings and to determine how well high-performance or green buildings are performing

in comparison to baselines and in comparison to predictions associated with design models.

DOD can continue to take a leadership role in improving the performance of all federal facilities, as well as all U.S. buildings, by collaborating with the Department of Energy, other federal agencies, nonprofit organizations, and others to improve national databases related to buildings and their performance and to improve the knowledge base related to the design, construction, and operation of high-performance facilities.

Recommended Approach 4. Use investment approaches that analyze the total cost of ownership, a full range of benefits and costs, and uncertain future conditions as part of the decision-making process.

The analytical approach developed by the DOD consultant could potentially be used by DOD to improve the basis for decisions about which investments will be most cost-effective across its portfolio of facilities. The proposed approach accounts for life-cycle costs, variations in geographic conditions, climate, type of building, and local cost factors. It also helps define upper and lower ranges of uncertainty for specific factors that are inherent with decision making about buildings that will be used for 30 years or longer. To use such an approach effectively, however, DOD will need to ensure that the data available for analysis are accurate and reliable.

Recommended Approach 5: Specify and fund training appropriate for facilities managers to ensure the effective operation of high-performance buildings.

Effective use of new technologies and new processes associated with high-performance buildings requires a workforce that is adequately trained to make decisions and implement them to maximum benefit. Facilities managers should have the skills and training necessary to understand the interaction of complex building systems and how to operate them effectively. Implementation of the Federal Building Personnel Training Act of 2010 should help to ensure that DOD facilities managers are certified in the required competencies and skills.

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A Green Building Overview

Minimize the residential sector's toll on the environment with these 10 practices.

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Green building, also called sustainable design and development, is the practice of using healthier and more resource-efficient land planning, construction, renovation, operation, maintenance and demolition. Today, it's much more than the original understanding of simply incorporating recycled materials into a home. Green building focuses on five key areas: sustainable site development, water savings, energy efficiency, materials selection and indoor environmental quality.

It's important to build green to minimize the huge impact that the construction, operation and maintenance of homes has on the environment. Building green can ease the residential sector's water use, energy consumption and emission of carbon dioxide by requiring less resource consumption throughout the home's life cycle. In addition to environmental benefits, green building has potential economic and social benefits, such as reduced operating costs, improved occupant productivity, minimized strain on local infrastructure and improved overall quality of life.

All homebuilding-industry professionals—from site planners to architects to general contractors—have the ability to increase the use of green-building practices as they select locations, design buildings and specify materials and construction methods. Additionally, home buyers can drive green building by requesting or requiring green building practices. It's important for industry professionals to inform home buyers about the benefits of green building and make green options available to them.

As a builder, educating yourself on green building practices is an important first step in building green. The U.S. Environmental Protection Agency (EPA) offers extensive programs and information on green building and can serve as a gateway to additional resources. Incorporating all the practices of green building into every construction project, however, may rarely be possible, because of time, money or

home-buyer constraints, so it's more practical to focus on the practices with the most positive environmental impact for a given project. Consider the following priorities:

1. To design and build energy-efficient homes.
2. To reuse existing homes and infrastructure instead of developing open space.
3. To design communities that foster a sense of community and reduce dependence on cars.
4. To optimize designs to use smaller spaces and to use materials more efficiently.
5. To preserve or restore local ecosystems and biodiversity.
6. To specify materials that are resource-efficient and have low environmental impact.
7. To design for durability and adaptability.
8. To design water-efficient homes and landscapes.
9. To provide a safe and comfortable indoor environment.
10. To return, reuse and recycle job-site waste.

Green building practices can be integrated at any stage of a home, but beginning the home with an integrated design-and-construction approach to green building yields the most significant benefits.

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Successful green building means more than using green materials. Another key to successful green building is the performance of the home: How much energy does the home use? How comfortable and healthy is the indoor environment for the homeowners?

Energy-efficient homes are comfortable, healthy homes. Energy efficiency in a home is affected by the thermal enclosure, including insulation and air sealing, as well as by HVAC size, design and type of installation. Certainly, an overriding majority of homes have all these components, but to achieve maximum energy efficiency for the home as an integrated system, it's critical to optimize material and design choices and install all components correctly.

Thermal Enclosure

The thermal enclosure includes the components of the home that isolate it from heat gain and loss and from air leaks. They include the structure, insulation, exterior finishes, sheathing, drywall, doors and windows. A properly installed thermal enclosure not only can reduce energy consumption but can also alleviate customer complaints about drafts or uneven temperatures. The HVAC system can't be expected to work efficiently if the thermal enclosure is inadequate. Deficiencies in the thermal enclosure—uncontrolled air leakage, improperly installed or missing insulation, minimum efficiency windows—contribute to uncomfortable conditions in the home. In most cases, oversizing the HVAC system won't make up for these problems.

Insulation

Installing insulation incorrectly reduces the effective R-value of the wall systems and can lead to "hot spots" or "cold spots" in the home. This requires the HVAC equipment to work harder, leading to higher energy

bills and variable temperatures throughout the home. Here's a breakdown

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ASSESSING GREEN BUILDINGS FOR SUSTAINABLE CITIES

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Keywords: assessment, method, green, building, sustainable, development, urban, environment

Summary

Within the shift from building environmental assessment to sustainability assessment, this paper presents one possible approach from the perspective of developing countries. This approach considers that besides the global environmental assessment, the economic and social performance of a building can only be assessed if we relate it to a city that is the system to which that building belongs. Therefore, one way of assessing buildings for sustainability, is by measuring the contribution of a building to local/urban sustainability. At the same time, this paper suggests that, although direct transfer and application of assessment methods from developed nations to developing ones should not be prescribed, it is in the best interest of developing nations to use foreign tools based on international environmental building standards and adapt them to the local context in which those tools will be used.

As an example of the stated above, an analysis of the LEED® NC and the possible ways of adapting it to assess buildings' contribution to local sustainability in Cordoba, Argentina is presented. It indicates that it is possible to use internationally renowned assessment methods as a basis for buildings-for-local-sustainability assessment methods, provided each of the credits of that system is redirected to the new target to be assessed and its relative value be re pondered.

1. Introduction

The environmental awareness and concern that have fostered the green building movement in the industrialized countries are also in place in the developing countries, but the tools and techniques developed during the past decade in the industrialized world to systematically and reliably assess the buildings' environmental performance is missing in the developing world.

In highly urbanized countries of the developing world, like Argentina, which is here to be used as the subject of analysis, the development of building assessment methods is becoming necessary to diagnose the building-stock's performance and to encourage the building industry to get onto sustainable track. Faced with the need for the evaluation of buildings, some questions arise on adequately defining what is to be assessed and what kind of assessment method to be used.

This work is in its early stages of development. It is intended to stimulate the discussion of building assessment methods in the developing world as well as preparing for the design and implementation of a building assessment method that would help transform Cordoba in a sustainable city.

1.1 Developed nations' approach vs. developing nations' approach to sustainability and buildings

Given the fact that there are assessment methods already in place in diverse markets of the developed world, it is tempting to "borrow" one of those few, good assessment and rating tools and use it to assess buildings in Cordoba. The American LEED® or the British BREEAM™, are examples of building environmental assessment methods that are carefully developed, widely accepted in their home markets and that are fostering the transformation of those markets towards sustainability, at least as understood in the so called "developed market economies".

However, as UNEP affirms in "Energy and cities" (UNEP, 2003), "sustainable construction adopts different approaches and is accorded different priorities in different countries. It is not surprising that there are widely divergent views and interpretations between countries with developed market economies and those with developing economies. Countries with mature economies are in the position of being able to devote greater attention to creating more sustainable buildings by upgrading the existing building stock through the application of new developments or the invention and use of innovative technologies for energy and material savings, while developing countries are more likely to focus on social equality and economic sustainability". These differences suggest that, the direct transfer of assessment tools from developed countries to developing ones should not be prescribed.

Nevertheless, at the same time, the truth is developing countries lack the economic resources necessary to launch an assessment method from scratch, and they have even fewer resources to keep such a tool in place dynamically. There is the need for sincerity about the realities of the state of development if developing nations want to create tools that will help them overcome some of those development shortcomings. In doing so, developing nations could benefit from the knowledge and experiences accumulated in the North during the past 15 years and apply some of those assessment methods critically. Go to the essence of the creation of the tools, generate their own framework –one in accordance to their social and market realities-, and be able to adapt those tools to these realities. In addition, a common language can be shared, one that keeps the possibility of comparing advances in different parts of the world and thus fostering growth in a truly global market economy.

1.2 From environmental assessment to sustainability assessment

For the past 10 to 15 years, the emphasis of the environmental assessment methods released in some developed countries has been on the technical issues that indicated how much of the increasingly limited natural resources –including energy- a building consumed and how it performed in terms of its impact on the natural environment. More recently, an appreciation of the significance of non-technical issues has grown. It is now recognized that economic viability and social equality are important aspects of a society that are also affected by the built environment. This latter reflects more of a sustainability approach to buildings, one in which the environmental, the social and the economic aspects of a project are not weighed in isolation but in relationship to each other in the context of the built environment.

Argentina, as well as in other nations of the developing world, cannot afford to be looking at environmental performance only. The social and economic problems are at the top of our countries' agendas. Environmental degradation is often an effect of under development as much as it is of development. The impact of the construction industry on the environment is not dissociated from the economic and social realities of our countries.

2. from green buildings to Sustainable Cities

All the stated so far is well known by the building research community. The need to focus efforts on sustainability assessment. Sustainability assessment includes the environmental, the social and the economical impacts of our buildings on present and future generations as well as the synergies between these three spheres.

Now the question is how to define sustainable, sustainable construction, sustainable buildings...in the context of this paper? What is the framework of this assessment method? What I to be assessed?

Buildings are not sustainable. A "sustainable building" is an oxymoron. There is no such thing as a building that can sustain itself in time. Buildings are consumers of goods and only produce intangible value (shelter, comfort, quality of life..) Buildings need the interaction with infrastructure (transportation, water systems, sewage systems, power supply, etc.) and are part of a greater system of the built environment of a city or a region. The term "sustainable buildings" is used not to refer to self-sustaining buildings but to refer to buildings that contribute positively to sustainable development.

Sustainable development's great goal is to ensure the quality of life of present and future generations. Its great spatial delimitation is Mother Earth and its time frame is infinite. Now, operatively, sustainable development is defined by the scale of application, the scale of work. In general terms, there is the global sustainable development and there is the local sustainable development (urban, regional, and/or national). And there is the so called "glocal".

Buildings interact with their immediate surroundings in a direct and sometimes un-mediated way. Most of their impact is local. Building design determines public space in cities, buildings influence the urban systems contributing to the burden on infrastructure and metabolic systems; they redirect wind, cast shadows, produce garbage, etc. All impacts directly related to urban quality of life. Although we cannot forget that all local actions have impact on global systems, it can be said that most measurable impacts of buildings are on the local scale. Besides the environmental impacts, the economic and social performance of buildings can only be assessed if we relate them to a city that is the system to which those buildings belong. As stated in the Agenda 21 on Sustainable Construction (CIB 1999) "it is clear that the whole construction industry has a significant impact, both directly and indirectly, on achieving Sustainable Development in the *urban* environment".

Having said so, one way of defining a sustainable building is by its contribution to local sustainability, that is to say when a building reduces its negative impacts on the natural environment while enhancing the synergies that produce social and economic development. It can even be hoped for buildings to help mitigate local environmental problems.

At this point, it can be said that one way of assessing "how sustainable" a building is, is by measuring the building's contribution to local sustainability.

Local sustainability should be defined in terms of a specific city, or in terms of cities with similar development patterns. It could be said that some Latin American cities, for example, share development patterns. Most of them are the result of a colonial grid imposed on the natural environment –most of the time with little consideration for natural flows and environmental risks-. They have suffered migration waves without being able to absorb the immigrants and consequently generating slums. They suffer from political and economical instability and construction technologies are similar. Etc. These characteristics could make for a common profile on the construction industry and sustainable development. From there, we could build an assessment methodology that could be shared among Latin American cities, and that could then be tailored to specific goals a particular city may have; In a way, to generate a common and understandable language that will help us share advances towards the sustainability of the region, and that at the same time would give every city the freedom for customizing the tool.

This doesn't simplify the way to a building assessment method!. Quite on the contrary, it complicates it!

3. Buildings-for-local-sustainability Assessment method

3.1 Beginning the process

For the reasons described in the introduction, this paper proposes to begin the process of designing this new assessment method by analyzing the possibility of adapting another methodology that has already been tested elsewhere to assess environmental performance in buildings, and evaluate its ability to be modified to assess buildings' contribution to local sustainability in Cordoba, Argentina. Cordoba, is a 1.3 million inhabitant city located in the geographical center of Argentina, 700 km. away from Buenos Aires. It is the capital of the province also called Cordoba.

The method chosen for the first test is the LEED®. The LEED®, USGBC's Leadership in Energy and Environmental Design, is being widely used in the US as green building rating system. It's mission, as stated in its website is to "encourage and accelerate global adoption of sustainable green building and development practices through the creation and implementation of universally understood and accepted standards, tools and performance criteria". Other assessment methods taken from different market conditions will also follow in future stages of this research: the regional versions of the GBC, the BREEAM™, etc., LEED® should be the first in a series of methods to be analyzed.

3.2 Using the LEED® -NC as the basis for a new buildings-for-local-sustainability assessment method

Only LEED® *for new construction is being used for analysis in this paper. It is not the intention of this paper to analyze and/or criticize the* LEED® *itself for what it has been conceived but rather to borrow its excellent content and reorganize it for an exercise on assessing building's local sustainable performance.*

The questions that will guide this adaptation test will be: How to refocus the indicators from the global issues to the local scale? How to add the social and economic impacts to the already stated environmental impacts of buildings? How to assess complexity and Synergy? (if at the same time we want to simplify the method to improve the possibilities of replicating the assessment?).

3.2.1 Adjust and re ponder each credit group's relative importance

The importance given to each of the 6 credit groups in LEED® has to be revised to the priorities of Cordoba. They would have to be redirected to Cordoba's sustainable development goals and re pondered to assess a building's contribution to that sustainable development. Few Examples are:

- The credit group that weighs the most in LEED® is "energy and atmosphere", taking 17 possible points - 25% of the possible points available- awarded to 6 credits and adding another 3 prerequisites for certification: "fundamental commissioning of the building energy systems", "minimum energy performance" and "CFC reduction in HVAC&R equipment". Only 4 of those 17 points are awarded to renewable energy and green power. Reducing energy *consumption* is not "the" priority in a city like Cordoba, in a country like Argentina. Like some other countries in the developing world, Argentina will have to increase its energy consumption to get into sustainability track, to be able to increase its production and balance its economic and social inequalities. At the same time, Argentina has a fair amount of energy resources, both from petroleum-based and renewable sources. The Province of Cordoba itself is an exporter of electricity. It produces electricity from fuel (50%), hydro-powered plans (40%) and one nuclear plan (10%). There are still additional hydro resources available for the production of more electricity to be harvested if needed (ICS 2004 pg 15). Argentina would need to take its extra share of energy, needed to pump up development, from clean sources instead of petroleum-based sources. Hypothetically, a building that only consumes energy from clean renewable sources (wind, solar, bio, etc.) could "waste" as much as wanted! In conclusion, the credits that encourage the use of renewable energy resources have to be given more relative value against the credits that encourage energy savings. In the reality of the actual Argentinean energy market, this would mean giving credits to solar and micro-wind produced energy until large commercial wind energy plants are in place (several projects have been analyzed by the National government none of which have been

realized). Credits that encourage savings will still be required but will be given a relative lesser value than credits that encourage the use of clean renewable energy.

- Water efficiency, builds up for 7 % of the credit points available in LEED® (5 out of 69). In a city like Cordoba, water is no minor issue. It has dry winters and hot summers that begin before the rains come. Cordoba relies on two sources of water only, for all the water the city consumes (lake San Roque and Los Molinos). Underground water sources are vastly contaminated (ICS, 2004 pg 32), mostly because of faulted septic systems and the city sewage system was designed to treat half of the system's current flow (ICS, 2004). Therefore, water efficiency and wastewater treatment deserves better consideration in Cordoba. To encourage action towards better water management, more points should be assigned to credits related to water use, treatment and reuse.

3.2.2 Stress the synergies

Some credit-awarded actions have more than one effect on urban sustainability. Stressing the synergies, or giving points for each of the positive effects such actions may have would encourage system thinking and complexity understanding. For example:

- Sustainable Sites credit 2: Development Density & Community Connectivity is awarded 1 point in LEED®. Whereas the intent stated in LEED® is to "channel development to urban areas with existing infrastructure, protect greenfields and preserve habitat and natural resources", this action has a variety of beneficial environmental, social and economical effects at the local scale. This action strengthens community ties, which at the same time makes for safer neighborhoods, and promotes the creation of neighborhood organizations that can obtain local political power and influence the city government on local political agendas, which at the same time induces concrete actions towards the improvement of the quality of life of local citizens, etc. Community connectivity also has impact on transportation, with beneficial effects on the reduction of car travel distances and time, which at the same time reduces the consumption of fossil fuels, the production of green house gases and provides time for alternative, more productive, use of that time (I include here leisure as a productive way to use one's time). Applied to the city here analyzed, some areas of Cordoba could greatly benefit from increased density whereas others would have infrastructure problems. In this case, justification of the benefits of increasing density in the proposed area would have to be submitted for credits to be awarded.

3.3 Pros and cons of buildings-for-local-sustainability assessment methods

Shifting the debate from assessing the environmental performance of a building to assessing its contribution to urban sustainability requires more social commitment. It is almost a debate on ethics and professional responsibility; on the civic duties of the design and construction industries. But it may be a tool for having the results there, in our cities where we can see them and replicate them. And the improvements will be shared by all citizens.

An assessment method that weighs the way a building contributes to a city's development would be an important tool to foster transformation of the built environment towards urban sustainability. However, one major problem local assessment methods can face is the lack of recognition within the construction industry. A local assessment tool will have trouble becoming a certification tool unless a prestigious national or international certification label homologates it. The scale of local recognition is small for some construction firms who would not want to invest what it takes to upgrade their construction methods to certify their buildings only in the local market. This problem could be overcome if a national or international certification entity homologates the local one.

4. Conclusion

This paper has presented a few analyses on the adaptation of foreign environmental assessment methods to buildings-for-local-sustainability assessment methods. It has justified the reasons why building assessment should also be considered in the local urban scale. So far, this paper has made a point for local sustainability assessment of buildings and sketched a methodology of work that has to be deepened and developed.

This work is at an early stage of development. Further research in the same direction is expected to take place during the next months.

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What is a green building?

JULY 1, 2016 RINKESH KUKREJA (HTTP://BUSINESSFEED.SUNPOWER.COM/AUTHORS/RINKESH-KUKREJA)

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This day and age, you hear everyone talking about going green (http://www.conserve-energy-future.com/various-ways-to-go-green.php). Whether you want to admit it or not, at some point everyone will have to follow with the green movement. This is because at the rate we are going, the earth is simply not sustainable. That means that over the years, we will begin to run out of certain natural resources that are needed in order for us to survive. That is alarming to some people, which is why there are so many people that focus on green building. But, what exactly is green building? Lets take a closer look at what it is, why you should consider it, and what the goals of a green building are. You are sure to find that it is something that you should take part in.

Defining a green building

First, we will take a look at what a green building is. Some people may think of a green, or sustainable building as just a building that doesn't really have as bad of an impact on the environment (http://www.conserve-energy-future.com/current-environmental-issues.php) as another 'average' building. Other people may find it to be the type of building, and the actual surroundings of the building.

The ideal green building would be a building project that would allow you to preserve most of the natural environment around the project site, while still being able to produce a building that is going to serve a purpose.The construction and operation will promote a healthy environment for all involved, and it will not disrupt the land, water, resources and energy in and around the building. This is the actual definition of a green building.

The U.S. EPA says "Green building is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction. This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort. Green building is also known as a sustainable or high performance building."

Why go green?

Now, let us take a look at why it is so important to go green. Most people will find when going green that they are able to reduce their carbon footprint and actually lend a helping hand to the environment. You can go green in a variety of different ways, but builders and construction workers must do their part as well. If you haven't begun going green, then you will find that there are a variety of different things that you can do to help you get started. You don't have to jump in head first, and you can actually take some baby steps along the way. Green buildings are designed in such a way to reduce overall impact on environment and human health by:

1. Reducing trash, pollution and degradation of environment.
2. Efficiently using energy, water and other resources.
3. Protecting occupant health and improving productivity.

Does going green really cost more?

Some people feel that they just can't go green because it will cost them more money, but that is really a common misconception. While it may cost you a bit more to get started when you are going green, because green materials and products can be more costly, you really have to consider the type of savings that you will be able to reap. You will be able to save on energy costs,

because going green also means conserving energy. You should really look at the green building as more of an investment than anything else. An investment that will be able to save you money, as well as an investment that will be able to help the environment! It is a win-win situation for everyone!

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Benefits of green building

With new technologies constantly being developed to complement current practices in creating greener structures, the benefits of green building can range from environmental to economic to social. By adopting greener practices, we can take maximum advantage of environmental and economic performance. Green construction methods when integrated while design and construction provide most significant benefits. Benefits of green building include:

Environmental benefits:

- Reduce wastage of water (http://www.conserve-energy-future.com/various-ways-to-conserve-water.php)
- Conserve natural resources
- Improve air and water quality
- Protect biodiversity (http://www.conserve-energy-future.com/what-is-biodiversity.php) and ecosystems

Economic benefits:

- Reduce operating costs
- Improve occupant productivity
- Create market for green product and services

Social benefits:

- Improve quality of life
- Minimize strain on local infrastructure
- Improve occupant health and comfort

The goals of green building

Now, we should consider the goals of green building. Of course, one of the main goals is to make the earth more sustainable, but it really does go deeper than that. When you decide to go green, your goal will be to actually help to sustain the environment without disrupting the natural habitats around it. When you start a building project, and you disrupt the natural habitats around it, you can actually make an impact in the wildlife and environment that will be much like a butterfly effect. Even the smallest changes that you can make will help to promote a better planet earth, and a better place for us all to live- not just us humans, but also the plants and wildlife that take up their residence here on earth as well.

As you can see, green building is something that everyone should really jump on to. If you don't plan to rebuild your home, then you may just want to make a few green changes within your home to ensure that you are able to get the goals that you want out of it. You can cut down on your energy usage, save money, and make a big impact on the environment. You will find that it isn't as hard as people make it out to be, and you will feel better about yourself when you go green too!

ABOUT THIS ARTICLE

Written by Rinkesh Kukreja from conserve-energy-future.com (http://conserve-energy-future.com/).

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GREEN BUILDING STANDARDS AND CERTIFICATION SYSTEMS

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INTRODUCTION

Buildings have extensive direct and indirect impacts on the environment. During their construction, occupancy, renovation, repurposing, and demolition, buildings use energy, water, and raw materials, generate waste, and emit potentially harmful atmospheric emissions. These facts have prompted the creation of green building standards, certifications, and rating systems aimed at mitigating the impact of buildings on the natural environment through sustainable (/design-objectives/sustainable) design.

WITHIN THIS PAGE

The push toward sustainable design increased in the 1990s with the creation of Building Research Establishment's Environmental Assessment Method (BREEAM (http://www.breeam.com/)), the first green building rating system in the U.K. In 2000, the U.S. Green Building Council (USGBC (http://www.usgbc.org/)) followed suit and developed and released criteria also aimed at improving the environmental performance of buildings through its Leadership in Energy and Environmental Design (LEED (http://www.usgbc.org/leed#rating)) rating system for new construction. Since that first release, LEED has continued to grow in prominence and to include rating systems for existing buildings and entire neighborhoods. Others also responded to the growing interest and demand for sustainable design including the Green Building Initiative (GBI), which was created to assist the National Association of Homebuilders (NAHB) in promoting its Green Building Guidelines for Residential Structures. Although originally developed for Canada, GBI helped to make Green Globes available for use in the U.S. in 2005. Additional rating systems have been developed that were influenced by these early programs but are tailored to their own national priorities and requirements or seek to go beyond the limits of current policy and building practices to address broader issues of sustainability or evolving concepts such as net zero energy (/resources/net-zero-energy-buildings), and living and restorative building concepts (/resources/living-regenerative-and-adaptive-buildings) that improve the natural environment, or those that model nature's processes (/resources/biomimicry-designing-model-nature).

Green product standards also began to appear in the marketplace in the 1980s and increased in the 1990s. Initially, many green product standards were developed in response to growing concerns for product toxicity and its impact on children's health and indoor environmental quality (IEQ (/design-objectives/sustainable/enhance-indoor-environmental-quality)). In the 21st century, when growing concerns over global warming and resource depletion became more prominent and supported by research, the number and type of green product standards and certifications grew. The focus also expanded to include a broader range of environmental issues and the impacts of products during their manufacture, use, and reuse. While there is still no universal definition of a green product, these products are intended to meet claims that they offer environmental benefits and adhere to certain standards. (See also Use Greener Materials (/design-objectives/sustainable/optimize-building-space-material-use))

There is now a proliferation of standards, rating, and certification programs in the marketplace to help guide, demonstrate, and document efforts to deliver sustainable, high-performance buildings. It is estimated that there are nearly 600 green product certifications in the world with nearly 100 in use in the U.S., and the numbers continue to grow (Source: BuildingGreen (http://www.buildinggreen.com)). There are also green building rating programs in use around the world and they vary in their approach with some outlining prerequisites and optional credits, while others take a prescriptive approach, and still others suggest performance-based requirements that can be met in different ways for different products and project types. As a result, it can be challenging and time consuming determining which standards, certifications, and rating programs are most credible and applicable to a particular project. This page will provide an introduction to some commonly used terms and an overview of the most widely recognized green building product standards, and building rating and certification programs currently in use with an emphasis on how they vary and some of the issues to consider when selecting them.

DESCRIPTION

A. BUILDING STANDARDS

A **standard** is a set of guidelines and criteria against which a product can be judged. Common standards related to building practices are created through consensus processes by organizations such as ANSI (http://www.ansi.org/), ASTM (http://www.astm.org/), or ASHRAE (http://www.ashrae.org/). Supporting the governance of standards and certifications is the International Standards Organization (ISO (http://www.iso.org/iso/home.html)), which defines and develops worldwide standards that frequently become law or form the basis of industry norms. ISO defines a standard as: "a document, established by consensus, approved by a recognized body that provides for common and repeated use as rules, guidelines, or characteristics for activities or their results."

Requirements found in standards may either be prescriptive (identifying methods of achievement) or performance based (stating expectations of end results). Consensus based standards, those developed through a formal, voluntary consensus process that is exemplified by an open and due process have immediate buy-in, government support, and international influence. According to the National Technology Transfer and Advancement Act (https://www.nist.gov/standardsgov/national-technology-transfer-and-advancement-act-1995) (NTTAA) federal agencies are required by law to adopt existing private-sector voluntary consensus standards instead of creating proprietary, non-consensus standards. Standards frequently serve as incentives for improved performance. Many of the green product standards available today are proprietary or regulatory standards that have been developed outside of the formal ANSI and ISO consensus process. These types of standards may be more or less stringent than consensus standards and can include some level of transparency and public comment. However, many of these types of standards are trusted because they are associated with a group that has strong environmental credentials.

The ANSI/ASHRAE/USGBC/IES Standard 189.1, *Standard for the Design of High Performance Green Buildings except Low-Rise Residential Buildings* provides minimum requirements for site, design, construction and operations in mandatory, code-enforceable language. This standard is comprehensive and includes chapters for site, water, energy efficiency, indoor environmental quality, and materials. For a detailed description on many other building codes and standards that address sustainability goals and requirements, see the Relevant Codes and Standards section below and Energy Codes and Standards (/resources/energy-codes-and-standards).

B. GREEN CODES

Green building codes continue to be developed and adopted in the U.S. and abroad that seek to push the standard of building design and construction to new levels of sustainability and performance. Codes come in two basic formats: *prescriptive* and *performance*, with *outcome-based* becoming a developing third option. A **Prescriptive** path is a fast, definitive, and conservative approach to code compliance. Materials and equipment must meet a certain levels of stringency, which are quantified in tables. **Performance-based codes** are designed to achieve particular results, rather than meeting prescribed requirements for individual building components. **Outcome-based codes** for example, establish a target energy use level and provide for measurement and reporting of energy use to assure that the completed building performs at the established level. (See also: Outcome-Based Pathways for Achieving Energy Performance Goals (/resources/outcome-based-pathways-achieving-energy-performance-goals).)

The unique difference between codes and building rating systems is that codes are mandatory. If green codes become adopted on a wide spread basis, their impact can change the building environment rapidly and extensively. When undertaking a project, whether it is new construction or a renovation, check to see if there is a state or local green code that will dictate the direction and scope your project must take.

The *International Green Construction Code* (IgCC) (http://www.iccsafe.org/codes-tech-support/codes/2015-i-codes/IgCC/) provides a comprehensive set of requirements intended to reduce the negative impact of buildings on the natural environment. It is a document which can be readily used by manufacturers, design professionals and contractors; but what sets it apart in the world of green building is that it was created with the intent to be administered by code officials and adopted by governmental units at any level as a tool to drive green building beyond the market segment that has been transformed by *voluntary* rating systems.

It was developed by the International Code Council (ICC) in association with cooperating sponsors ASTM International (ASTM) and the American Institute of Architects (AIA). Other organizations indicating their support include the U.S. Green Building Council (USGBC), and The Green Building Initiative (The GBI), producers of the Green Globes rating system. The IgCC was developed with the intent to be consistent and coordinated with the ICC family of Codes & Standards: the I-Codes. It is applicable to the construction of high performance commercial buildings, structures, and systems, including existing buildings subject to alterations and additions, utilizing both traditional and innovative construction practices. Residential occupancies are covered by reference to the ICC 700 National Green Building Standard (NGBS). High-rise residential buildings, however, may conform to either the IgCC or ICC 700. The IgCC also allows jurisdictions to choose ANSI/ASHRAE/USGBC IES Standard 189.1 as jurisdictional compliance option. ASHRAE Standard 189.1, *Standard for High-Performance Green Buildings Except Low-Rise Residential Buildings*, is an American National Standards Institute (ANSI) standard developed by the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) in association with the Illuminating Engineering Society (IES) and the U.S. Green Building Council (USGBC). Because it was written in *mandatory* language, the IgCC is poised to produce environmental benefits on a massive scale: a scale impossible to attain with purely *voluntary* green building programs and rating systems.

The California Green Building Standards Code (CALGreen Code) is Part 11 of the California Building Standards Code (https://en.wikipedia.org/wiki/California_Building_Standards_Code) and was the first statewide "green" building code in the US. CAL Green is designed to save water and promote environmentally responsible, cost-effective, healthier places to live and work. The purpose of CALGreen is to improve public health, safety and general welfare by enhancing the design and construction of buildings through the use of building concepts having a reduced negative impact or positive environmental impact and encouraging sustainable construction practices in the following categories:

- Planning and design
- Energy efficiency
- Water efficiency and conservation
- Material conservation and resource efficiency
- Environmental quality

C. GREEN PRODUCT CERTIFICATIONS

A **certification** is a confirmation that a product meets defined criteria of a standard. ISO defines certification as: "any activity concerned with determining directly or indirectly that relevant requirements are fulfilled."

Green product certifications are intended to outline and confirm that a product meets a particular standard and offers an environmental benefit. Many product labels and certification programs certify products based on life-cycle parameters, making them *multi-attribute* programs. These parameters include energy use, recycled content, and air and water emissions from manufacturing, disposal, and use. Others focus on a *single attribute*, such as water, energy, or chemical emissions that directly impact IEQ.

A green product certification is considered most respected when an independent third party is responsible for conducting the product testing and awarding the certification. Third-party means they are independent of the product manufacturer, contractor, designer, and specifier. Third-party labels and green product certification programs can be helpful in evaluating the attributes of green products because they validate that the product meets certain industry-independent standards. They can also offer greater assurance to consumers, designers, specifiers, and others that a product's marketing claims accurately reflect its green attributes. Many product certifications are also recognized within comprehensive green building rating systems such as LEED, Green Globes, and the National Green

Building Standard. As a result, green product certifications are on the rise as market conditions change and the demand for greener products continues to increase. It is important to note that greenwashing, which is defined as the use of green claims that are not true or are unverifiable but used to sell products or a corporate image, has become commonplace as companies try to stay competitive in the green marketplace.

To fully understand what a green certification represents and the quality of information it provides, the details of its requirements need to be reviewed carefully. The ISO defines different types of labels that can be used for products. Below is an outline of the ISO-defined labels and what is being claimed. Product certifications available in the U.S. are mostly Type I and Type II labels while Type III labels are now required in France and becoming more common in Europe and for those U.S. manufacturers with an international focus.

ISO-DEFINED TYPES OF GREEN PRODUCT CERTIFICATION LABELS

TYPE	ISO NUMBER	WHAT THE LABEL DOES
Type I	ISO 14024	Seal of approval for multi-attribute requirements
Type II	ISO 14021	Verifiable single-attribute environmental claims for issues such as energy consumption, emissions, or recycled content. Can be first-party, self-declared manufacturer claims. However many manufacturers are beginning to seek third-party verification of those claims in response to industry demand.
Type III	ISO >14025	Comprehensive environmental product disclosure and detailed product information. Similar to an Environmental Product Declaration (EPD)

SUMMARY OF GREEN PRODUCT CERTIFICATIONS

The following table, and the expanded information directly below it, outlines some of the most commonly used and respected green product certifications in the marketplace. Please see the Additional Resources section for more information on other programs not included in this page.

PRODUCT CERTIFICATION	SINGLE- OR MULTI-ATTRIBUTE	TYPE OF STANDARD OR CERTIFICATION	MANAGING ORGANIZATION	ISSUE OF FOCUS
Energy Star (http://www.energystar.gov/)	Single-Attribute	Government certification relying on manufacturer-provided data or third-party testing	U.S. EPA and U.S. DOE	Energy consuming products
WaterSense (https://www3.epa.gov/watersense/)	Single-Attribute	Government label based on third-party testing	U.S. EPA	Showerheads, toilets, faucets, urinals, and valves
Forest Stewardship Council (https://us.fsc.org/)	Single-Attribute	Third-party certification	Forest Stewardship Council (FSC)	Forests and forestry products
SCS Global Services (http://www.scsglobalservices.com/certified-green-products-guide?scscertified=1)	Multi-Attribute	Third-party certification	SCS Global Services	Wide range of products (i.e. carpets, textiles, wood products, insulation, and more)
Green Seal (http://www.greenseal.org/)	Multi-Attribute	Third-party ISO Type 1 certification	Green Seal	Wide range of sectors (paints, adhesives, lamps, electric chillers, windows, window films, occupancy sensors)
Cradle to Cradle (http://www.mbdc.com)	Multi-Attribute	Third-party certification, Cradle to Cradle Certified^{CM} Product Standard is managed and updated by the Institute's Certification Standards Board	Cradle to Cradle Products Innovation Institute C2CPII	Building materials, interior design products, textiles and fabrics, paper and packaging, and personal and homecare products
GREENGUARD (http://www.greenguard.org/)	Multi-attribute	Third party certification	UL Environment	Indoor air quality, children and schools focus
Green Squared (http://www.greensquaredcertified.com)	Multi-attribute	Third-party ISO Type 1 environmental labeling and declaration requirements (ISO 14024)	TCNA	Tiles and tile installations

SINGLE-ATTRIBUTE PRODUCT CERTIFICATIONS

ENERGY STAR (http://www.energystar.gov)—First established in 1992 as a voluntary labeling program, Energy Star is a widely recognized government-run product certification label for energy efficient products. It is a joint program of the U.S. EPA and DOE. Energy Star-certified products include appliances, heating and cooling equipment, lighting, home electronics, commercial roofing, and office equipment. Energy Star standards are generally updated and made more stringent every two

years. (See also Single-Attribute Building Rating System below.)

The Energy Policy Act of 2005 (EPACT) (/ffc/fed/congressional-acts/energy-policy-act-2005) requires federal agencies to buy either Energy Star products or products designated as energy efficient by the Federal Energy Management Program (FEMP), for which the requirements are included in the Federal Acquisition Regulation (FAR) Subpart 23.203 (https://www.acquisition.gov/sites/default/files/current/far/html/Subpart%2023_2.html#wp1080577). Executive Order 13423 (/ffc/fed/executive-orders/eo-13423) requires federal agencies to activate Energy Star "sleep" features on computers and monitors and mandates that federal agencies buy EPEAT* (http://www.epeat.net/) registered products. (For more information addressing federal requirements for Energy Star, click here (http://www.energystar.gov/index.cfm?c=fed_agencies.fed_ag_index))

WaterSense (https://www3.epa.gov/watersense/)—a partnership program by the U.S. EPA, WaterSense seeks to protect the future of our nation's water supply by offering people a simple way to use less water with water-efficient products, new homes, and services. Established in 2006 for water-efficient products, the program seeks to help consumers make smart water choices that save money and maintain high environmental standards without compromising performance. WaterSense products and services that have earned the label must be at least 20 percent more efficient without sacrificing performance. Look for the "WaterSense: Meets EPA Criteria" label, not just "WaterSense Partner". The "partner" label indicates that an organization or manufacturer has signed an agreement with EPA to promote water efficiency but does not address performance of a specific product.

Executive Order 13423 requires federal agencies (/ffc/fed/executive-orders/eo-13423) to implement water-efficiency measures, including the purchase, installation, and implementation of water-efficient products and practices. Beginning in fiscal year 2008, agencies must reduce water consumption intensity, relative to their fiscal year 2007 baseline, through cost-effective life-cycle measures by 2 percent annually (or 16 percent total) by the end of fiscal year 2015.

Forest Stewardship Council (FSC) (https://us.fsc.org/)—is a third-party certification program established in 1993 with the goal of promoting responsible forestry and certifying the resulting wood products. The standard is managed by the FSC while certification is awarded by third parties such as the Rainforest Alliance and Scientific Certification Systems. There are different standards for different forest products (FSC pure, FSC mixed, and FSC recycled) and different regions. The FSC chain of custody is a requirement of certification that follows the path of the wood product from forest to consumer. The FSC program uses a specific, prescriptive approach and provides assurance of good environmental and social stewardship of forests.

SCS Global Services (http://www.scsglobalservices.com/certified-green-products-guide?scscertified=1)—is a third-party certification of claims for recycled content, biodegradable liquid products, and no-added formaldehyde products. SCS Global Services is a long-respected certifier that backs its certifications with vigorous and transparent standards. A number of products with this certification meet indoor air quality, recycled content, and FSC chain-of-custody requirements within green building rating systems such as LEED.

MULTI-ATTRIBUTE PRODUCT CERTIFICATIONS

Green Seal (http://www.greenseal.org)—is a third-party certification and labeling program that covers a wide range of products with sector-specific requirements, particularly consumable items for building operations. Green Seal has been certifying products since 1992 and is an ISO 14024 Type I program. Green Seal considers the impacts of a product over its entire life cycle when developing a standard. Building products covered include paints, adhesives, lamps, electric chillers, windows, window films, and occupancy sensors. Green Seal is referenced in several LEED rating systems, and cleaning products for industrial and institutional use are referenced in LEED for Existing Buildings in Operations and Maintenance.

The Cradle to Cradle Certified^{CM} (http://www.mbdc.com) program is a third party, multi-attribute eco-label administered by the Cradle to Cradle Products Innovation Institute that assesses a product's safety to humans and the environment and design for future life cycles. The program provides guidelines to help businesses implement the Cradle to Cradle framework, which focuses on using safe materials that can be disassembled and recycled as technical nutrients or composted as biological nutrients. Unlike single-attribute eco-labels, the Cradle to Cradle Certified program takes a comprehensive approach to evaluating the design of a product and the practices employed in manufacturing the product. The materials and manufacturing practices of each product are assessed in five categories: Material Health, Material Reutilization, Renewable Energy Use, Water Stewardship, and Social Responsibility.

GREENGUARD (http://www.greenguard.org)—is a third-party certification and label established in 2001. GREENGUARD Children and Schools certification complies with California Section 01350 (http://www.calrecycle.ca.gov/greenbuilding/specs/section01350/), calling for emissions at half of California's more stringent thresholds. GREENGUARD certifies that a product meets thresholds for formaldehyde, total aldehydes, total volatile organic compounds (VOCs), and one-tenth of the threshold limit value (a regulatory benchmark) for many other compounds. The GREENGUARD Environmental Institute certifies products that comply with their rigorous formaldehyde, emissions, and chemical testing requirements.

Green Squared (http://www.greensquaredcertified.com)—Certification was developed by TCNA, and involves one industry, one standard, and one mark and covers products used in a tile installation. As the first multi-attribute sustainability standard developed for tiles and tile installation materials, Green Squared uses the transparency and consensus of the ANSI process combined with third party certification to evaluate, validate, and communicate products which have a positive impact on the environment and society. Green Squared covers product characteristics, manufacturing, end of product life management, progressive corporate governance, and innovation in an effort to establish sustainability criteria for products throughout their full life cycle. Green Squared acknowledges products which have been verified to be in conformance with ANSI A138.1. The easily-recognizable Green Squared mark helps architects, designers, and end users choose products and assured that the products they are choosing meet the industry's broad range of sustainability criteria.

A new category and approach to identifying and declaring the manufacturing, production, ingredients and make up of a product is rapidly emerging. Whether it is an **Environmental Product Declaration (EPD)**, a **Health Product Declaration (HPD)**, a **Declare Label**, or the **Living Product Challenge**, there is a growing movement to seek full disclosure of a product within a life cycle framework and create a world of products that do no harm and improve the environment. Additionally, the **JUST Label** seeks to address social responsibility through transparency. These labels are starting to be accepted or required within the various green building rating systems, although labels do not yet exist for all products. For example, in LEED there is an option within the Materials and Resources category to achieve a credit for transparency about the environmental impact of a product by utilizing an EPD. The Declare label is in use within the Living Building Challenge to meet the stringent materials requirements.

An **Environmental Product Declaration (EPD)** is an independently verified and registered document that communicates transparent and comparable information about the life-cycle environmental impact of products. The International EPD System is a global program for environmental declarations based on ISO 14025 and EN 15804. Their database currently contains more than 500 EPDs registered by 150 companies in 27 countries. Having an EPD for a product does not imply that the declared product is environmentally superior to alternatives. It is simply a transparent declaration of the life-cycle environmental impact. The relevant standard for Environmental Product Declarations is ISO 14025, where they are referred to as "type III environmental declarations". A type III environmental declaration is created and registered in the framework of a program, such as the International EPD System. An EPD may be used for many different applications, including green public procurement (GPP) and building assessment schemes. See: environdec.com (http://www.environdec.com/en/What-is-an-EPD/) for more information.

Designers, specifiers, and owners are increasingly seeking transparent information on the ingredients in building products, and their associated health hazards. **Health Product Declarations (HPD)** provide a full disclosure of the potential chemicals of concern in products by comparing product ingredients to a wide variety of "hazard" lists published by government authorities and scientific associations. To achieve third party verification, the HPD must have 100% disclosure of known ingredients and/or 100% disclosure of known hazards down to 1000 ppm. The Health Product Declaration (HPD) Open Standard consists of a defined Format and Instructions for reporting about the contents of building products along with the associated health and other related information. The Standard is maintained and sponsored by the Health Product Declaration Collaborative. Version 2.0 of the HPD Open Standard was released in September 2015. In April 2016, the US Green Building Council issued an interpretation (http://www.usgbc.org/node/10149113) of the LEED v4 Building Product Disclosure and Optimization—Material Ingredients, Option 1 that includes clarification of how the Health Product Declaration 2.0 can be used to meet the requirements of the credit. For more information see the The Health Product Declaration® Collaborative (HPDC) (http://hpdcollaborative.org/).

Human and environmental health considerations have emerged as a crucial factor in material selection. **Declare** is a platform for manufacturers of ecologically sound products to demonstrate market leadership and secure a competitive advantage. Declare takes complex chemical analysis and raw material source location information and provides it to consumers in an elegant, easy to use 'nutrition label'. Declare gives manufacturers an expanded point of entry into the most groundbreaking restorative projects in the world. Project teams pursuing the Living Building Challenge can use the Declare product database and label to select products that meet the Living Building Challenge's stringent materials requirements, streamlining the materials specification and certification process. Declare also meets the requirements of the proposed LEED v4 materials inventory and toxic chemical avoidance credit. The Declare label is valid for a 12-month period. After this period manufacturers must renew by paying a renewal fee and either confirming that the information contained within the Product Declaration Form has not changed or submitting a new form. See: Living Future— Declare (https://living-future.org/declare/) for more information.

According to the International Living Future Institute, "**The Living Product Challenge** is a philosophy first, an advocacy tool second and a certification program third. It is intended to guide the manufacturing of thousands of things people are surrounded by on a daily basis, and to give direction and support to those who make the goods that are used. Within the larger Living Future Challenge framework that covers the creation of Living Buildings, Communities and Food Systems, the Living Product Challenge focuses on manufactured goods. It is a unified tool for transformative thought, allowing a future to be envisioned that is Socially Just, Culturally Rich and Ecologically Restorative. The Living Product Challenge is comprised of seven performance categories, or "Petals": *Place, Water, Energy, Health and Happiness, Materials, Equity and Beauty*. Petals are subdivided into a total of 20 Imperatives, each of which focuses on a specific sphere of influence. This compilation of Imperatives can be applied to almost every conceivable product, of any size, manufactured in any location—be it a new innovation or a reinvention of an existing item." For more information see: Living Product Challenge (http://www.living-future.org/lpc).

The International Living Future Institute's **JUST** program is a voluntary disclosure program and tool for all types and sizes of organizations. JUST is a call to social justice action. It is not a verification or certification program. Rather, the program provides an innovative transparency platform for organizations to reveal much about their operations, including how they treat their employees and where they make financial and community investments. In a similar fashion to the Living Building Challenge's Declare Program, the JUST Program acts somewhat as a "nutrition label" for socially just and equitable organizations. This approach requires reporting on a range of organization-and employee-related indicators. Each of the indicator metrics asks for simple yet specific and measurable accountabilities in order for the organization to be recognized at a One, Two, or Three Star Level, which is then summarized elegantly on a label. Organizations can use the label on their website or marketing to demonstrate their commitments to these issues. JUST marks the beginning of a new era of corporate transparency. See: About JUST (http://justorganizations.com/content/about) for more information.

D. GREEN BUILDING RATING AND CERTIFICATION SYSTEMS

Both standards and product certifications will play a role in determining the level of sustainability or performance of a product. However, each must be considered as part of a larger process of integrating (/design-objectives/aesthetics/engage-integrated-design-process) them into the overall project goals to ensure the entire project is sustainable.

Green building rating or certification systems broaden the focus beyond the product to consider the project as a whole. Rating systems are a type of building certification system that rates or rewards relative levels of compliance or performance with specific environmental goals and requirements. Rating systems and certification systems are frequently used interchangeably.

Green building rating and certification systems require an integrated design process (/design-objectives/aesthetics/engage-integrated-design-process) to create projects that are environmentally responsible and resource-efficient throughout a building's life-cycle: from siting to design, construction, operation, maintenance (/facilities-operations-maintenance), renovation, and demolition. A few of these programs are *single-attribute*, focusing solely on water or energy, while others are *multi-attribute* addressing emissions, toxicity, and overall environmental performance in addition to water and energy. While the philosophy, approach, and certification method vary across these the systems, a common objective is that projects awarded or certified within these programs are designed to reduce the overall impact of the built environment on human health and the natural environment.

Green building rating systems exist to address every project type from single-family houses and commercial buildings to entire neighborhoods. There are rating systems available for new construction, which focus on decisions made in the planning and design process and actions taken through construction, as well as for existing buildings, which focus on operations and maintenance throughout the life of the building. A primary reason for the creation of rating systems is the need to more clearly define, implement, and measure green. Federal, state, and municipal agencies across the country such as the General Services Administration (/ffc/gsa) (GSA), Department of Energy (/ffc/doe), Department of Health and Human Services (/ffc/hhs), and the Environmental Protection Agency (/ffc/epa), have taken an early lead in incorporating energy efficiency and sustainability by following green building guidelines in the design, construction, and renovation of Federal facilities. Most states and many major cities have also incorporated green into their internal building requirements for new construction.

To determine which standard, certification, or rating system should be used, ask the following:

- Who the organization is that is making the assessment?
- Is it being done by a first-party, second-party, or third-party?

A first-party assessment is one that comes directly from an organization that is associated with the entity making the claim or who may benefit from the claim. A second-party assessment is performed by an interested party such as a trade association. A third-party assessment is conducted by an independent party that has no financial interest or ties to the outcome of the assessment.

According to RSMeans (https://www.rsmeans.com/products/reference-books/green/green-building-project-planning-cost-estimating.aspx) there are four principles that should be considered when evaluating a building rating or certification system:

- Science-based — Results and decisions must be reproducible by others using the same standard.
- Transparent — Standards and process for awarding the certification should be transparent and open for examination.
- Objective — Certification body should be free of conflict.
- Progressive — Standards should advance industry practices, not simply reward business as usual.

WHY PURSUE A GREEN BUILDING RATING OR CERTIFICATION?

The reasons for pursuing a green building certification for a project are varied. Certification through any rating system provides verification of the green nature of the project, and can be a valuable educational and marketing tool for owners and design and construction teams through the process of creating a more sustainable building. Green building certification can also be a way to provide an incentive for clients, owners, designers, and users to develop and promote highly sustainable construction practices. It is important to note that a building does not have to be certified to be sustainable and well-built.

The guidelines within rating systems also help to clarify a market filled with "green" options. Rating systems also clearly outline what green standards need to be followed and what types of green products should be included in construction specifications.

Ultimately, the type of certification system pursued for a project depends upon that singular project; none of these certification systems are one-size-fits all. The dynamic nature of projects might prohibit one system but favor another. The choice is dependent upon the uniqueness of each project and the project needs and requirements such as the project location, size, budget, and overall project goals. Also comparing essential issues such as cost, ease of use, and building performance will help determine which building rating system is applicable and which certification level is possible.

Building rating and certification systems are in a state of change and evolution and continue to be refined to reflect new standards and goals for achieving ever higher levels of sustainability. So it is essential to investigate the most current versions of these programs to gain an understanding of particular requirements that must be met in order to achieve the best results.

BENEFITS OF USING GREEN BUILDING STANDARDS AND CERTIFICATION SYSTEMS

There are a wide range of economic and environmental benefits to sustainable design, often achieved through the use of standards, rating, and certification systems. According to a study of LEED certified buildings, the USGBC (http://www.usgbc.org/) has found that energy, carbon, water, and waste can be reduced, resulting in savings of 30 to 97% respectively. Operating costs of green buildings can also be reduced by 8-9% while increasing in value up to 7.5%. Many sustainable buildings have also seen increases of up to 6.6% on return on investment, 3.5% increases in occupancy, and rent increases of 3%. Other benefits of green buildings, such as higher productivity and increased occupant health, have been attributed to better indoor environmental quality, increases in natural daylighting (/resources/daylighting), and healthier materials and products within green buildings.

In a similar study by the GSA (http://www.gsa.gov/graphics/pbs/GSA_Assessing_Green_Full_Report.pdf), 12 sustainable buildings that were analyzed from a whole building perspective cost less to operate, have excellent energy performance, and have occupants that are more satisfied with the overall building than the occupants in typical commercial buildings. The 12 GSA buildings were compared to industry standard performance of energy, water, maintenance and operations, waste, recycling, transportation, and occupant satisfaction metrics.

While these benefits are possible, it is important to note that they are dependent upon factors such as climate, topography, timing, credit synergies, and local building standards.

SUMMARY OF GREEN BUILDING RATING AND CERTIFICATION SYSTEMS

The following table and the expanded information directly below it outlines several of the most commonly used and respected green building rating and certification systems in the marketplace.

BUILDING RATING OR CERTIFICATION SYSTEM	SINGLE- OR MULTI-ATTRIBUTE	TYPE OF STANDARD OR CERTIFICATION	MANAGING ORGANIZATION	ISSUES / AREAS OF FOCUS
Energy Star (http://www.energystar.gov)	Single-Attribute	Government certification using a benchmarking method	U.S. EPA and U.S. DOE	Building energy and water use

BUILDING RATING OR CERTIFICATION SYSTEM	SINGLE- OR MULTI-ATTRIBUTE	TYPE OF STANDARD OR CERTIFICATION	MANAGING ORGANIZATION	ISSUES / AREAS OF FOCUS
Leadership in Energy and Environmental Design (LEED) (http://www.usgbc.org/leed)	Multi-Attribute	Green building rating and certification system through independent third-party verification for: • New Construction (NC) • Existing Buildings, Operations & Maintenance (EB O&M) • Commercial Interiors (CI) • Core & Shell (CS) • Schools (SCH) • Retail • Healthcare (HC) • Homes • Neighborhood Development (ND)	U.S. Green Building Council	Performance in: • Sustainable Sites • Water Efficiency • Energy & Atmosphere • Materials & Resources • Indoor Environmental Quality • Locations & Linkages • Awareness & Education • Innovation in Design • Regional Priority through a set of prerequisites and credits
Green Globes (http://www.thegbi.org/green-globes-certification/)	Multi-Attribute	Green building guidance and assessment program for: • Existing buildings • New construction	Green Building Initiative in the U.S. BOMA Canada	Environmental assessment areas to earn credits in: • Energy • Indoor Environment • Site • Water • Resources • Emissions • Project/Environmental Management No prerequisites
Living Building Challenge (http://living-future.org/lbc)	Multi-Attribute	Performance-based standard, and certification program for: • Landscape and infrastructure projects • Partial renovations and complete building renewals • New building construction • Neighborhood, campus and community design	International Living Future Institute	Performance areas include: • Site • Water • Energy • Materials • Health • Equity • Beauty All areas are requirements.

BUILDING RATING OR CERTIFICATION SYSTEM	SINGLE- OR MULTI-ATTRIBUTE	TYPE OF STANDARD OR CERTIFICATION	MANAGING ORGANIZATION	ISSUES / AREAS OF FOCUS
NZEB (http://living-future.org/netzero)	Multi-Attribute	Certification program using the structure of the Living Building Challenge which can be applied to any building type.	International Living Future Institute	One hundred percent of the project's energy needs must be supplied by on-site renewable energy on a net annual basis, without the use of on-site combustion. NZEB certified buildings must also meet the following requirements of the Living Building Challenge: • the first half of Imperative One, Limits to Growth, dealing with appropriate siting of buildings • Imperative 19, Beauty and Spirit • Imperative 20, Inspiration and Education
Passive House Institute US (http://www.phius.org/home-page)	Multi-Attribute	Performance based passive building standard • Third-party RESNET approved quality assurance/quality control • Earns U.S. DOE Zero Energy Ready Home status • Includes HERS rating	Passive House Institute US	Any type of building. New focus areas include: • air tightness requirement • source energy limit • space conditioning criteria
SITES (http://www.sustainablesites.org)	Multi-Attribute	Third party verified rating system for development projects located on sites with or without buildings.	Administered by GBCI	Performance criteria in the areas of: • Water • Wildlife Habitat • Energy • Air Quality • Human Health • Outdoor recreation opportunities
WELL Building Standard (http://www.wellcertified.com/well)	Multi-Attribute	Performance based standard and certification program for • New and Existing Buildings • New and Existing Interiors • Core and Shell Retail • Education Facilities • Restaurant • Commercial Kitchen • Multifamily Residential	Administered by the International WELL Building Institute™ (IWBI)	Measures attributes of buildings that impact occupant health by looking at seven factors: Air, Water, Nourishment, Light, Fitness, Comfort, Mind
INTERNATIONAL PROGRAMS				

BUILDING RATING OR CERTIFICATION SYSTEM	SINGLE- OR MULTI-ATTRIBUTE	TYPE OF STANDARD OR CERTIFICATION	MANAGING ORGANIZATION	ISSUES / AREAS OF FOCUS
BCA Green Mark Scheme (https://www.bca.gov.sg/GreenMark/green_mark_buildings.html) (Singapore)	Multi-Attribute	Benchmarking scheme that aims to achieve a sustainable built environment by incorporating best practices in environmental design and construction, and the adoption of green building technologies.	Building and Construction Authority (BCA)	Rates buildings according to five key criteria: • Energy efficiency • Water efficiency • Environmental protection • Indoor environmental quality, and • Other green and innovative features that contribute to better building performance.
Beam (http://www.beamsociety.org.hk/en_index.php) (Hong Kong)	Multi-Attribute	Comprehensive standard and supporting process covering all building types, including mixed use complexes, both new and existing to assess, improve, certify, and label the environmental performance of buildings	Business Environment Council	Performance and assessment in: • Site aspects • Material aspects • Water use • Energy use • Indoor environmental quality • Innovations and additions
BREEAM (http://www.breeam.com/) (UK, EU, EFTA member states, EU candidates, as well as the Persian Gulf)	Multi-Attribute	Certification system is a multi-tiered process with pre-assessment, third-party consultant guidance through an assessment organization for: • New Construction • Communities • In Use Buildings and • EcoHomes	BRE Global	Assessment uses recognized measures of performance, which are set against established benchmarks in: • Energy and water use • Internal environment (health and well-being) • Pollution • Transport • Materials • Waste • Ecology and • Management processes
CASBEE (http://www.ibec.or.jp/CASBEE/english/overviewE.htm) (Japan)	Multi-Attribute	Building assessment tools for • Pre-design • New Construction • Existing Building and • Renovation	JSBC (Japan Sustainable Building Consortium) and its affiliated sub-committees	Assessment areas include: • Energy efficiency • Resource efficiency • Local environment, and • Indoor environment
EDGE (https://www.edgebuildings.com/)	Multi-Attribute	A universal standard and a certification system for residential and commercial structures.	International Finance Corporation (IFC), a member of the World Bank Group	Assessment areas include: • Energy • Water • Materials

BUILDING RATING OR CERTIFICATION SYSTEM	SINGLE- OR MULTI-ATTRIBUTE	TYPE OF STANDARD OR CERTIFICATION	MANAGING ORGANIZATION	ISSUES / AREAS OF FOCUS
Green Star SA (http://www.gbcsa.org.za/home.php) (South Africa)	Multi-Attribute	Green building rating system for: • Office • Retail • Multi-unit residential	Green Building Council of South Africa administers program Independent assessors to assess and score projects	Categories assessed in: • Management • Indoor Environmental Quality • Energy • Transport • Water • Materials • Land Use & Ecology • Emissions • Innovation
Pearl Rating System for Estidama (http://estidama.upc.gov.ae/pearl-rating-system-v10/pearl-building-rating-system.aspx) (UAE)	Multi-Attribute	Green building rating system for: • Community • Buildings • Villas • Temporary Villas and Buildings	Abu Dhabi Urban Planning Council	Assessment of performance in: • Integrated Development Process • Natural Systems • Livable Communities • Precious Water • Resourceful Energy • Stewarding Materials • Innovating Practice

SINGLE-ATTRIBUTE GREEN BUILDING RATING SYSTEMS

Energy Star Rating System (http://www.energystar.gov)—is a rating system created by the U.S. EPA and DOE that uses a benchmarking method to assess a building's energy and water use. (Please note that Energy Star also has a product certification program. (See also Single-Attribute Product Certification above.)

As stated on the ENERGY STAR website, "statistically representative models are used to compare your building against similar buildings from a national survey conducted by the Department of Energy's Energy Information Administration. This national survey, known as the *Commercial Building Energy Consumption Survey (CBECS)*, is conducted every four years, and gathers data on building characteristics and energy use from thousands of buildings across the United States. Your *building's peer group of comparison* are those buildings in the CBECS survey that have similar building and operating characteristics. A rating of 50 indicates that the building, from an energy consumption standpoint, performs better than 50% of all similar buildings nationwide, while a rating of 75 indicates that the building performs better than 75% of all similar buildings nationwide."

To receive an Energy Star rating, a project's energy usage must be tracked with the online Portfolio Manager (https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager) and receive a score of 75 or more.

MULTI-ATTRIBUTE GREEN BUILDING RATING SYSTEMS

Outlined below are the building rating systems most commonly in use within the U.S. in the private and public sectors. Additionally, international programs are included to provide a reference point for those developing projects outside the U.S.

Leadership in Energy and Environmental Design (LEED) (http://www.usgbc.org/leed)—was created in 2000 by the U.S. Green Building Council (http://www.usgbc.org/) (USGBC), for rating design and construction practices that would define a green building in the United States. LEED is used throughout North America as well as in more than 30 countries with over 6,300 projects currently certified across the globe and over 21,000 projects registered. As of September 2010, over 35 state governments, 380 cities and towns, and 58 counties (http://www.usgbc.org/Docs/Archive/General/Docs7924.pdf) have enacted sustainable legislation, ordinances, or policies, many of which specifically call for LEED certification.

LEED consists of credits which earn points in 7 categories: *Site Selection*, *Water Efficiency*, *Energy and Atmosphere*, *Materials and Resources*, *Indoor Environmental Quality*, *Regional Priority, and Innovation in Design*. One hundred points are available across these categories with mandatory prerequisites such as minimum energy and water-use reduction, recycling collection, and tobacco smoke control. Within each category are credits that pertain to specific strategies for sustainability, such as the use of low-emitting products, reduced water consumption (/resources/water-conservation), energy efficiency (/design-objectives/sustainable/optimize-energy-use), access to public transportation, recycled content (/design-objectives/sustainable/optimize-building-space-material-use), renewable energy (/resources/alternative-energy), and daylighting (/resources/daylighting). Since its inception, LEED standards have become more stringent as the market has changed and expanded to include distinct rating systems (http://www.usgbc.org/leed#rating) that address different building types: New Construction, Existing Buildings, Commercial Interiors, Core & Shell, Schools, Retail, Healthcare, Homes, and Neighborhood Development.

The LEED certification process takes place at LEED Online (https://www.usgbc.org/leedonline/). Project teams are required to compile documentation to show compliance with LEED requirements and upload this documentation to the LEED Online website. The documentation is then reviewed by the Green Building Certification Institute (GBCI); a LEED certification is earned if all prerequisites and a sufficient number of credits are earned. There are four levels of LEED

certification: Certified, Silver, Gold, and Platinum. There are no on-site visits required and certification can occur upon completion of construction.

Green Globes (http://www.thegbi.org/green-globes-certification/)—originated in Canada and was brought to the U.S. by the Green Building Initiative (GBI) in 2004. It is now cited in many Federal, State, and Municipal mandates.

Buildings are rated on a 1,000 point scale spread across seven categories: *Energy, Indoor Environment, Site, Water, Resources, Emissions, and Project/Environmental Management*. Users can indicate that certain credits may not be applicable to a project, a feature unique to Green Globes. It also does not have prerequisites. A Green Globes rating (http://www.greenglobes.com/) requires a Green Globes Assessor to perform an onsite assessment of the building. This ensures that the self-reported claims made in the online documentation are verified. Both new construction and existing buildings can be evaluated using Green Globes; commercial or multifamily.

The first step toward a Green Globes certification is completing a self-reported online assessment survey, which is required at various stages throughout design and construction. At the construction documents phase and after substantial completion, a Green Globes Assessor will perform a site visit to verify the claims made in the survey. A Green Globes (http://www.greenglobes.com) certification of one through four globes can then be earned once verification is confirmed.

Living Building Challenge (LBC) (http://living-future.org/lbc)—is a performance-based system initially launched by the Cascadia Green Building Council. In April 2011, the International Living Future Institute became the umbrella organization for both the Cascadia Green Building Council and the Living Building Challenge.

The LBC makes stringent demands such as 100% net zero energy (/resources/net-zero-energy-buildings), 100% net zero water, on-site renewable energy, and 100% recycling or diversion of construction waste. It examines site, water, energy, materials, health, equity, and beauty. All of its tenets are mandatory making it the most rigorous green building certification system in the market today. An on-site audit must occur by a member of the International Living Future Institute (http://living-future.org/) (ILFI)

After online registration, projects must join the living building community where discussions concerning compliance are held, and documentation occurs. Certification occurs twelve months after project completion, with an on-site audit to ensure compliance.

NZEB (http://living-future.org/netzero)—The International Living Future Institute (ILFI) provides a certification option for a Net Zero Energy Building (NZEB) under its umbrella of the Living Building Challenge certification. These buildings have 100% of their energy needs supplied by on-site renewable energy on a net annual basis. The NZEB designation verifies that a building is truly operating as claimed, harnessing energy from the sun, wind, or earth to exceed net annual demand. To earn this certification, a building must meet five requirements of the LBC:

- Limits of Growth
- Net Zero Energy
- Rights to Nature
- Beauty and Spirit
- Inspiration and Education.

According to ILFI, nearly any building can become NZEB-certified: new or operational, anywhere in the world.

Passive House Institute US (PHIUS) (http://www.phius.org/home-page)—administers a climate-specific passive building standard and certification system that was developed under a DOE/Building America grant specifically to address complex US climates. Buildings designed and built to the PHIUS+ 2015 Passive Building Standard consume 86% less energy for heating and 46% less energy for cooling (depending on climate zone and building type) when compared to a code-compliant building. PHIUS+ 2015 is the first and only passive building standard based upon climate-specific comfort and performance criteria aimed at presenting a cost-optimized solution to achieving the most durable, resilient, and energy-efficient building possible for a specific location. The PHIUS+2015 Passive Building Standard is applicable internationally. There are certified projects in South Korea and Japan, and projects are certifying most recently in China and Israel. In North America, PHIUS is the leading educational institute with most certified passive building professionals trained in North America. PHIUS is also the leading certifier of passive houses and buildings with 95% of all passive construction currently underway. The German Institute is also active in the US and has certified under their program to date about 5% of all passive building construction.

SITES (http://www.sustainablesites.org)—Administered by Green Business Certification Inc. (GBCI), the Sustainable Sites Initiative (SITES) offers a comprehensive rating system designed to distinguish sustainable landscapes, measure their performance and elevate their value. SITES certification is for development projects located on sites with or without buildings—ranging from national parks to corporate campuses, streetscapes to homes, and more. SITES is used by landscape architects, designers, engineers, architects, developers, policy-makers and others to align land development and management with innovative sustainable design. Land is a crucial component of the built environment and can be planned, designed, developed and maintained to protect and enhance the benefits we derive from healthy functioning landscapes. SITES helps create ecologically resilient communities and benefits the environment, property owners, and local and regional communities and economies.

WELL (http://www.wellcertified.com/well)—is a performance-based system for measuring, certifying, and monitoring features of the built environment that impact human health and well-being by looking at seven factors, or Concepts. They include: *Air, Water, Nourishment, Light, Fitness, Comfort, and Mind*.

WELL is grounded in a body of medical research that explores the connection between the buildings where people spend more than 90 percent of their time, and the health and wellness impacts on occupants. WELL Certified spaces and WELL Core and Shell Compliant developments can help create a built environment that improves the nutrition, fitness, mood, sleep patterns and performance of its occupants. WELL is composed of over 100 Features that are applied to each building project, and each WELL feature is designed to address issues that impact the health, comfort, or knowledge of occupants. Many WELL Features intended to improve health are supported by existing government standards or other standards-setting organizations. WELL Features are categorized as either *Preconditions*—necessary for baseline WELL Certification or Compliance, or *Optimizations*—optional enhancements, which together determine the level of certification above baseline certification. The Features of WELL can be applied across many real estate sectors, and the current WELL v1 is optimized for commercial and institutional office buildings. WELL is further organized into Project Typologies which take into account the specific set of considerations that are unique to a particular building type or phase of construction. For WELL v1, three project typologies are: New and Existing Buildings, New and Existing Interiors, and Core and Shell.

INTERNATIONAL GREEN BUILDING RATING SYSTEMS

There are many international green building design systems that also set up their criteria through a nationalistic focus, keeping local standards and codes in mind. They include:

BCA Green Mark Scheme (https://www.bca.gov.sg/GreenMark/green_mark_buildings.html)—Based in Singapore, Green Mark was launched by the Building and Construction Authority (BCA) in January 2005 to promote environmental awareness in the construction and real estate sectors. The BCA Green Mark Scheme rates buildings according to five key criteria including: energy efficiency, water efficiency, environmental protection, indoor environmental quality, and other green and innovative features that contribute to better building performance. The program outlines a six step scheme that also offers cash incentives to developers, especially focused on addressing improvements to existing construction in areas such as energy use reduction and materials conservation.

BEAM (http://www.beamsociety.org.hk/en_index.php)—Based in Hong Kong, BEAM is a comprehensive standard and supporting process covering all building types, including existing and newly constructed mixed use complexes. BEAM is an initiative that assesses, improves, certifies, and labels the environmental performance of buildings. It is a voluntary program developed in partnership with, and adopted by the industry. BEAM is intended to: stimulate demand for more sustainable buildings in Hong Kong and other regions, giving recognition for improved performance and minimizing false claims; provide a common set of performance standards that can be pursued by developers, designers, architects, engineers, contractors and operators; reduce the environmental impacts of buildings throughout the planning, design, construction, management and demolition life cycle; and increase awareness in the building community, and ensure that environmental considerations are integrated at the beginning of a project.

BEAM assessments are currently undertaken by the Business Environment Council (BEC), an independent, nonprofit, environmental information center, under the guidance of the BEAM Society Executive Committee. Certification can only be issued upon building completion due to a significant number of credits being based on actions taken during construction and upon completion.

Building Research Establishment Environmental Assessment Method (BREEAM (http://www.breeam.com/))—has served as the basis for many of the green building certification systems. It was the first building rating system to be established and has been in use since 1990 throughout the UK, EU, EFTA member states, EU candidates, as well as the Persian Gulf. Due to its longevity, its use is widespread and its certification highly recognized. BREEAM ratings are required for many governmental organizations throughout these countries and there are currently over 100,000 BREEAM-rated buildings. BREEAM is a multi-attribute rating system that awards credits for categories such as management, energy, transport, material and waste, and pollution.

The BREEAM application and certification system is a multi-tiered process with pre-assessment, third-party consultant guidance through an assessment organization, of which there are over 1,000 in the UK alone, and the approval process. BREEAM has stipulated that projects must be certified within five years of registration.

CASBEE (http://www.ibec.or.jp/CASBEE/english/overviewE.htm)—in Japan is composed of four assessment tools corresponding to the building life cycle. "CASBEE Family" is the collective name for these four tools and the expanded tools for specific purposes. The CASBEE assessment tools are CASBEE for Pre-design, CASBEE for New Construction, CASBEE for Existing Building and CASBEE for Renovation, to serve at each stage of the design process. Each tool is intended for a separate purpose and target user, and is designed to accommodate a wide range of uses (offices, schools, apartments, etc.) in the evaluated buildings.

CASBEE covers the assessment fields of energy efficiency, resource efficiency, local environment, and indoor environment. Both indoor and outdoor spaces are considered as part of the assessment but are assessed separately.

EDGE (http://www.edgebuildings.com/) (Excellence in Design for Greater Efficiencies)—is a green building certification system for new residential and commercial buildings in 125 emerging markets. The program, which engages financiers, developers, regulators, and homeowners, shows property developers how fast and affordable it is to construct resource-efficient buildings, enabling them to pass value directly to building owners and tenants. EDGE enables design teams and project owners to assess the most cost-effective ways to incorporate energy and water-saving options into their buildings. An innovation of the International Finance Corporation (IFC) (http://en.wikipedia.org/wiki/International_Finance_Corporation), a member of the World Bank Group (http://en.wikipedia.org/wiki/World_Bank) that focuses on private sector development, EDGE consists of a web-based software application, a universal standard and a certification system.

Green Star SA (http://www.gbcsa.org.za/home.php)—was developed by The Green Building Council of South Africa, and is based on the Australian Green Building Council tools to provide the property industry with an objective measurement for green buildings and to recognize and reward environmental leadership in the property industry. Each rating tool reflects a different market sector (office, retail, multi-unit residential, etc.). The objectives of the Green Star SA rating tools are to: establish a common language and standard of measurement for green buildings, promote integrated, whole building design, raise awareness of green building benefits, recognize environmental leadership, and reduce the environmental impact of development.

Green Star SA Certification is a formal process which involves a project using a Green Star SA rating tool to guide the design or construction process during which a documentation-based submission must be submitted as proof of the achievement. A "Design" certification can be submitted for and awarded at the end of the design phase of the project. At the end of construction, a project can submit for and be awarded "As Built" certification, certifying that all green building strategies were in fact incorporated into the final building. The Certified Rating can be achieved prior to practical completion, but must be achieved no later than 24 months after practical completion. As Built submissions must be submitted after practical completion, and the Certified Rating must be achieved no later than 24 months after practical completion.

Pearl Rating System for Estidama (http://estidama.upc.gov.ae/pearl-rating-system-v10/pearl-building-rating-system.aspx)—Estidama, which means 'sustainability' in Arabic, is intended to be the initiative which will transform Abu Dhabi into a model of sustainable urbanization. Its aim is to create more sustainable communities, cities, and global enterprises and to balance the four pillars of Estidama: environmental, economic, cultural, and social. The Pearl Rating System for Estidama aims to address the sustainability of a given development throughout its life cycle from design through construction to operation. Accordingly, three rating stages have been established: Design, Construction, and Operational.

Within each section there are both mandatory and optional credits and credit points are awarded for each optional credit achieved. To achieve a 1 Pearl rating, all the mandatory credit requirements must be met. To achieve a higher Pearl rating, all the mandatory credit requirements must be met along with a minimum number of credit points.

EMERGING ISSUES

New green technologies and materials are always being developed and entering into the marketplace to complement current practices in creating greener environments. Many of these technologies and materials have not been tested long enough in the built environment in order to fully verify their performance. Seek extensive testing and performance data before incorporating new technologies and materials into a project. Also, test beyond the product's green performance for safety, durability, and fire resistance standards from UL (http://gma.ul.com/about/) and ETL (http://www.intertek.com/).

New and more stringent requirements will continue to be introduced to the standards and certifications process. Because of the toxicity of some pesticides and fire retardants, and additional means of exposure, testing and certifying beyond product emissions to product content is a trend that will likely increase.

Over the last several years there has also been a shift away from a prescriptive approach to sustainable design toward the scientific evaluation of actual performance through Life Cycle Assessments (LCA). While LCAs are not yet a consistent requirement of green building rating systems and codes, there is a trend toward requiring LCAs and improving the methods for conducting them.

RELEVANT CODES AND STANDARDS

FEDERAL MANDATES, ACTS, AND EXECUTIVE ORDERS

- Energy Independence and Security Act of 2007 (/ffc/fed/congressional-acts/energy-independence-security-act-2007)
- Executive Order 13693, "Planning for Federal Sustainability in the Next Decade" (/ffc/fed/executive-orders/eo-13693)
- Energy Policy Act of 2005 (EPACT) (/ffc/fed/congressional-acts/energy-policy-act-2005)

INTERNATIONAL CODE COUNCIL

- International Green Construction Code (IgCC (http://www.iccsafe.org/codes-tech-support/codes/2015-i-codes/igcc/)). The IgCC is intended to be used as a jurisdictional and municipal building code for new construction and major renovations. The IgCC is a comprehensive code document; it sets standards for energy conservation, water efficiency, and commissioning, and also includes enforcement procedures and guidelines for existing building renovations.
- ICC 700 National Green Building Standard (http://shop.iccsafe.org/2012-national-green-building-standard-icc-700-2012.html). The standard defines green building for single-family and multi-family homes, residential remodeling, and site development projects while allowing enough flexibility to incorporate regionally appropriate best green practices.

ASHRAE STANDARDS

- ANSI/ASHRAE/USGBC/IES Standard 189.1, *Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings* (https://www.ashrae.org/resources--publications/bookstore/standard-189-1) this standard provides minimum requirements for site, design, construction and operations in mandatory, code-enforceable language. A collaborative effort by ASHRAE, IES and USGBC, this standard is comprehensive and includes chapters for site, water, energy efficiency, indoor environmental quality, and materials. ASHRAE 189.1 can be used as a jurisdictional compliance path for the IgCC.
- ASHRAE Standard 55, *Thermal Environmental Conditions for Human Occupancy* (https://www.ashrae.org/resources--publications/bookstore/standard-55-and-user-s-manual)
- ASHRAE Standard 62.1, *Ventilation for Acceptable Indoor Air Quality* (https://www.ashrae.org/resources--publications/bookstore/standards-62-1--62-2)
- ASHRAE Standard 90.1, *Energy Standard for Buildings Except Low-Rise Residential Buildings* (https://www.ashrae.org/resources--publications/bookstore/standard-90-1)

WATER-RELATED LEGISLATION AND CODES

- Energy Independence and Security Act (EISA) (/ffc/fed/congressional-acts/energy-independence-security-act-2007) Section 438 (stormwater)
- Energy Policy Act of 1992 (http://www.afdc.energy.gov/laws/key_legislation#epact92)
- Energy Policy Act of 2005 (EPACT) (/ffc/fed/congressional-acts/energy-policy-act-2005) Section 109 (process water)
- *International Plumbing Code* (IPC) (http://shop.iccsafe.org/2015-international-plumbing-coder.html), (ICC)
- Uniform Plumbing Code 2006 (http://codes.iapmo.org/home.aspx?code=UPC), (IAMPO)

MATERIAL-RELATED LEGISLATION

- Farm Security and Rural Investment Act of 2002 (FSRIA) (https://www.congress.gov/bill/107th-congress/house-bill/2646)
- Resource Conservation and Recovery Act (RCRA) (https://www.epa.gov/rcra)

MUNICIPAL STANDARDS

Many cities, states, and U.S. Territories have also implemented green standards for public buildings (http://programs.dsireusa.org/system/program?type=64&). Every city's, state's, and U.S. Territory's energy goals and requirements are listed, highlighting LEED, Green Globes, and carbon emission reduction goals. New York City and California are two examples of governments that have implemented green standards for public buildings.

CALIFORNIA

California has implemented green building standards for all major renovations and new construction of public buildings. Executive Order S-3-05 (http://gov.ca.gov/news.php?id=1861) calls to reduce greenhouse gas emissions (/resources/greenhouse-gas-emissions-federal-buildings) 80% below 1990 levels by 2050. To accomplish this goal, Executive Order S-20-04 (http://www.climatechange.ca.gov/state/executive_orders.html) requires all state buildings to reduce energy usage by 20% and achieve a minimum of a Silver LEED rating.

- Assembly Bill 32: California Global Warming Solutions Act (http://www.arb.ca.gov/cc/ab32/ab32.htm)

- California Green Building Strategy (http://www.arb.ca.gov/cc/greenbuildings/greenbuildings.htm)
- California Eexecutive Order S-3-05 (http://gov.ca.gov/news.php?id=1861)
- CalGREEN code (http://www.documents.dgs.ca.gov/bsc/CALGreen/2010_CA_Green_Bldg.pdf)

NEW YORK CITY

New York City's Local Law 86 (http://www.nyc.gov/html/oec/html/green/ll86_basics.shtml) requires LEED certification for public buildings with construction costs exceeding $2 million. The NYC Greener, Greater Buildings Plan (http://www.nyc.gov/html/gbee/html/plan/plan.shtml) is another example of NYC's commitment to sustainability. It requires a combination of benchmarking, energy audits, retro-commissioning, lighting upgrades and sub-metering for the city's largest buildings.

- New York City's Greener Greater Buildings Plan—Local Laws 84, 85, 87, 88 (http://www.nyc.gov/html/gbee/html/plan/plan.shtml)
- New York City's Local Law 86 Diagram of Criteria and Requirements (http://www.nyc.gov/html/oec/downloads/pdf/green_building/2010_gb_ll86_criteria_and_requirements_diagram.pdf)
- New York City Mayor's Office of Environment Coordination (http://www.nyc.gov/html/oec/html/home/home.shtml)

ADDITIONAL RESOURCES

WBDG

BUILDING TYPES / SPACE TYPES

Applicable to all Building Types (/building-types) and Space Types (/space-types)

DESIGN OBJECTIVES

Aesthetics (/design-objectives/aesthetics), Cost-Effective (/design-objectives/cost-effective), Sustainable (/design-objectives/sustainable)

GUIDES & SPECIFICATIONS

BUILDING ENVELOPE DESIGN GUIDE

Sustainability of the Building Envelope (/resources/sustainability-building-envelope)

BUILDING COMMISSIONING

Building Commissioning (/building-commissioning)

ORGANIZATIONS

- BioPreferred (http://www.biopreferred.gov) (USDA)
- Crosswalk of Sustainability Goals and Targets in Executive Orders and Statutes (http://www.fs.fed.us/sustainableoperations/documents/crosswalk-sus-goals-eo.pdf) by DOE and FEMP
- Energy Star's Portfolio Manager (https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager)
- Pharos Project (http://www.pharosproject.net/)
- WaterSense (https://www3.epa.gov/watersense/index.html)
    - WaterSense Product Database (https://www.epa.gov/watersense/product-search)
    - WaterSense Rebate Finder (https://www.epa.gov/watersense/rebate-finder)

PUBLICATIONS

- A comparative study of building energy performance assessment between LEED, BREEAM, and Green Star Schemes (https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwiUhv2bmNvPAhVHFj4KHTC_C7MQFggjMAA&url=http%3A%2F%2Fwww.iesve.com%2Fcontent%2F by Roderick, Y et al. Integrated Environmental Solutions Limited, Kelvin Campus, West of Scotland Science Park, Glasgow, G20 0SP, U.K.
- *Guide to Green Building Rating Systems: Understanding LEED, Green Globes, Energy Star, the National Green Building Standard, and More (http://www.wiley.com/WileyCDA/WileyTitle/productCd-047040194X.html)* by Reeder, L. Hoboken, NJ: John Wiley & Sons, Inc., 2010.
- *Sustainable Building Rating Systems Summary (/ffc/gsa/criteria/sustainable-building-rating-systems-summary)* by K.M. Fowler and E.M. Rauch. Completed by the Pacific Northwest National Laboratory, July 2006.

LEED Cost Analysis Summary

LEED (Leadership in Energy and Environmental Design) represents the efforts of a coalition including the US Green Building Council (GBC) to establish a nationwide standard for constructing so-called “green” buildings. Obtaining LEED certification requires compliance with a minimum number of criteria affecting many aspects of a project, from site selection to the recycled content of building materials. While participation in the LEED program has been mostly voluntary, some government entities require that publicly funded projects apply for LEED certification and other states and communities are considering this.

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Cost of Obtaining LEED Certification

LEED (Leadership in Energy and Environmental Design) represents the efforts of a coalition including the US Green Building Council (GBC) to establish a nationwide standard for constructing so-called "green" buildings. Obtaining LEED certification requires compliance with a minimum number of criteria affecting many aspects of a project, from site selection to the recycled content of building materials. While participation in the LEED program has been mostly voluntary, some government entities require that publicly funded projects apply for LEED certification and other states and communities are considering this.

LEED Certification is Expensive

- LEED adds between 4% and 11% to construction costs. Estimates for some projects range as high as 30%.

- Based on the fraction of public buildings already registered, LEED costs are adding between $900 million and $2.2 billion to the cost of public construction projects each year.

- If all public building projects were required to comply with LEED, public construction costs would rise an additional $4.3 billion to $11 billion per year.

Many of These Costs Provide No Environmental Benefit

- The LEED process imposes an administrative "tax" on the design and construction team.

- These "soft costs" include incremental costs for design, documenting compliance, administrative fees, and verifying compliance through the commissioning process. They account for approximately 30% of the costs attributable to LEED.

- Resources that pay for these soft costs could be used to make the project "greener" instead: additional spending on alternative systems, practices, and materials could provide greater environmental benefit.

Both Cost and Benefit Estimates are Marked by Uncertainty

- LEED imposes costs at the beginning of a project, but experience shows that the cost impact on a particular project can vary from a few percent of construction costs to more than 30%. LEED costs would increase if future versions of the criteria are more stringent.

- Benefit estimates are far less certain. Energy savings may offset upfront costs in just a few years, but many other benefits ascribed to LEED offer uncertain payoffs well into the future.

- Given the uncertainty, it may not be prudent to mandate spending more public funds today for the sake of uncertain future benefits.

WHAT IS A "GREEN" BUILDING ACCORDING TO DIFFERENT ASSESSMENT TOOLS?

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Key words: green building, sustainable building, environmental assessment, environmental indicator, weighting, environmental management, building design, assessment tool

Summary

Environmental assessment tools for buildings are rapidly developing in many countries. All of them claim that they measure "greenness" or "sustainability" of buildings, i.e. if maximum scores are awarded a building is sustainable in some respect. But so far there is no consensus on the interpretation of "green" or "sustainable" in terms of criteria and indicators.

This article explores if different tools point in different directions regarding "green" building design. It also investigates characteristics of assessment tools and consequences of different approaches.

Three distinctly different assessment tools, LEED-NC, Code for Sustainable Homes (CSH) and EcoEffect have been selected. They have three core assessment areas in common, namely Energy, Indoor Environment and Materials & Waste. The content however is different.

The tools have been compared with respect to aim, content and aggregation. They have been tested on a new multi storey residential building. Assessments within the core areas were compared. Measures to improve the overall judgement were explored. The diverging result raises the question how to design environmentally relevant and practically useful assessment tools for buildings.

1. Introduction

Building environmental assessment tools, have emerged to provide an objective evaluation of resource use, ecological loadings and indoor environmental quality (Cole, 2005). Much work has been done to develop a tool that predicts, calculates and estimates one or more environmental performance characteristics of a building (Sundkvist et al, 2006). These tools present different ways to define criteria for "green" building" They bring together a large number of environmental issues and aggregate them into overall judgments. What issues the tools address and give priority to indirect or direct might influence environmental building policies, design and building practices. Assessment methodologies play multiple roles; understanding the impact of buildings on natural systems, marketing "green" buildings, addressing sustainability (Cole, 2005), help decision makers and politicians, and being tools for environmental management primarily in architectural projects. What picture the tools mediate to their users influences "green" building designs. This may contribute to setting the agenda in a similar way as trade magazines and mass media (Gluch and Stenberg, 2006).

Environmental assessment tools consist of a number of indicators and criteria. Some also include life-cycle assessment (LCA) methodology (Assefa et al, 2007). Important for the outcome of the assessment are choice of indicators, measurement scales, aggregation and classification criteria. However the basis for these choices, which always are a balance between theoretical and practical aspects, is seldom presented in tool descriptions (Malmqvist, Glaumann, 2006). A lack of theoretic and systematic approach and a mix of different kinds of indicators make tool comparisons difficult as well as understanding what a final award means in terms of environmental impact.

2. Objective and delimitation

The objective with this paper is to compare different methodologies for environmental assessment of buildings and to explore in which direction they push new "green" building designs.

3. Methodology

Three completely different environmental assessments tools have been select to illustrate fundamental differences. These tools have been compared with respect to a limited number of aspects, namely; *aim, content* and *aggregation.* At last they have been applied on a new multi storey residential building to illustrate the differences between the tools.

The tools chosen for comparison are LEED®-NC, Leadership in Energy and Environmental Design for New Construction version 2.2, (USBC, 2005), Code for Sustainable Homes (DCLG, 2007) and EcoEffect (Assefa et al, 2007). The tools differ, in a number of ways, for example regarding where they are developed, for home they are developed, the methodology they use and the way they are used. The two first tools are internationally well-known and well documented. Besides being different EcoEffect is chosen because it is the one that we have the greatest experience from.

4. Method comparison

4.1 Different Aims

LEED is developed by U.S. Green Building Council (USGBC) committees with the aim to promote "green" design. It is argued that "Green design not only makes a positive impact on public health and the environment, it also reduces operating costs, enhances building and organizational marketability, potentially increases occupant productivity, and helps create a sustainable community" (USGBC, 2005). USGBC (2005) claims that LEED is "consensus-based, market-driven, based on accepted energy and environmental principles, balancing between established practices and emerging concepts."

Code for Sustainable Homes (CSH) is the first tool in the process of becoming a code (DCLG, 2008). It is a further development of the BRE's EcoHomes© scheme. "Adoption of the Code is intended to encourage continuous improvement in sustainable home building." The driving force behind establishing a code for sustainable building seems to be the wish of the British Government to act on climate change in combination with the fact that BRE (Building Research Establishment), has extensive experience with voluntary schemes in this field.

EcoEffect is an assessment tool developed by a group of researchers in Sweden. The task was to develop an holistic environmental evaluation method not a national classification system: The formulated objective was twofold: "1) to quantitatively describe environmental and health impact from real estate and the built environment 2) to provide a basis for comparison and decision making that can lead to reduced environmental impact. The method primarily target decision makers within the planning, designing and management of the built environment". (Sundkvist et al, 2006; Glaumann, Malmqvist, 2004)

LEED is voluntary and very market oriented. CHS involves the authorities and intends to integrate environmental assessment into the building code. EcoEffect is neither commercial as LEED, nor institutionalised as CSH. Focus is on methodology and understanding the significance of different types of environmental impacts.

4.2 Different content

All the tools have the areas Energy, Materials and Indoor Environment in common, but the content still vary a lot. Besides assessing issues related to these core areas LEED gives credits related to the issues: Water, Design Innovation and Site. CSH also specifically assess Water, Waste, Management and Ecology. EcoEffect includes Site assessment and calculation of Life Cycle Costs. The tools also measures issues differently. To be able to compare them we have ranged similar criteria and indicators under common areas (Table 1.). Only the issues within the core areas are presented in this paper.

4.2.1 Energy

About ¼ of the assessments in all the tools are devoted to energy. LEED (Table 1.) assesses energy performance, green power and management. CSH assesses CO_2 emissions for energy use and specific energy saving technical solutions. EcoEffect takes only the detrimental side of energy use into account assessing its associated negative emissions and depletion of resources. EcoEffect then uses a linear scale without a defined endpoint, which cannot be easily transferred to scores. Another difference between the tools is that CSH also assess the energy performance of white goods.

Table 1. Addressed issues and available scores or scale within the three areas; Energy, Indoor Environment and Material & Waste.

AREA		ASSESSED ISSUE	ASSESSMENT METHOD		
			LEED	CSH	EcoEffect
ENERGY	Energy use	Minimum Energy Performance	Mandatory		
		Optimize Energy Performance/ Energy cost savings	10		
	Kind of energy	On-Site Renewable Energy	3		
		Green Electrical Power	1		
		Resource depletion			Calculated
	Emissions	Low or Zero Carbon Technologies		2	
		Dwelling emission rate (CO_2)		15 /Mand.	
		Life cycle emissions from energy use			Calculated
	Technical solutions	Internal lighting		2	
		Drying space		1	
		Energy labelled white goods		2	
		External lighting		2	
		Home Office		1	
		Building fabric (Heat Loss Parameter)		2	
		Cycle storage		2	
	Management	Commissioning of the Building Energy Systems	1/ Mand		
		Measurement and verification	1		
		Available scores for this area	**16**	**29**	-
		Fraction of totally available scores	**23%**	**25%**	-
INDOOR ENVIRONMENT	Air quality	Air quality in general			0-3
		Minimum IAQ Performance	Mandatory		
		Environmental Tobacco Smoke (ETS) Control	Mandatory		
		Outdoor Air Delivery Monitoring	1		
		Increased Ventilation	1		
		Low-Emitting Materials	4		
		Radon			Assessed
	Thermal comfort	Design & Verification	2		
		Thermal Comfort in general			0-3
	Noise	Sound Insulation / Noise		4	0-3
	Daylight	Daylighting, views and sunlight	2	3	0-3
	Else	Electric environment			0-3
		Private space		1	
		Lifetime Homes		4	
		Legionaires diseas			Assessed
	Management & control	Construction IAQ Management Plan	2		
		Controllability of Systems, Lighting/Thermal comfort	2		
		Indoor Chemical & Pollutant Source Control	1		
		Home user guide		3	
		Available scores in this area	**15**	**15**	**0-15**
		Fraction of totally available scores	**22%**	**16%**	**-**
MATERIAL & WASTE	Recycling of materials	Building Reuse	3		
		Materials Reuse	2		
		Recycled Content	2		
	Household waste	Household Waste Storage & Collection of Recyclables	Mandatory	4 /Mand.	
		Composting		1	
	Construction waste	Site Waste Management		2 /Mand.	
		Construction Activity Pollution Prevention	Mandatory		
		Waste Management	2		
	Environmental Impacts	Environmental Impact of materials		15 /Mand.	
		Global Warming Potential - GWP of insulants		1	
		Emissions from material production			Calculated
		Resource depletions from mater. prod.			Calculated
		NOx emissions		3	
		Fundamental Refrigerant Management	Mandatory		
		Enhanced Refrigerant Management	1		
	Sourcing of materials	Certified Wood	1		
		Responsible sourcing of materials		9	
	Other	Regional Materials	2		
		Rapidly Renewable Materials	1		
		Available scores in this area	**14**	**35**	**-**
		Fraction of totally available scores	**20%**	**34%**	**-**

4.2.2 Indoor Environment

LEED covers Air Quality, Thermal Comfort, Daylight and Management of Indoor Air Quality but surprisingly not Noise. CSH addresses Noise, Daylight and the three features; Privacy, “Lifetime homes” and “Home user guide” measured in terms of accessibility, adaptability and information. EcoEffect assesses; Air Quality, Thermal Comfort, Noise, Solar Access and Daylight, Radon Legionella and Electric and Magnetic fields. EcoEffect has an inverted scale, i.e. high scores here mean risk for inconvenience.

4.2.3 Material and waste

LEED is very much focused on reuse and recycling. Typically credits are given for reuse and recycling without taking into account that the reduction of environmental impact vary with material, (for example between recovery of aluminium and wood). Other LEED issues are; Household Waste, Local Materials and Rapidly Renewable Materials.

CSH is concentrated to environmental impact from production of building materials and responsible sourcing but do also cover household waste. Material is about 1/3 of all assessed issues in CSH, compared to 1/5 in LEED. Concerning material EcoEffect evaluate negative environmental impacts from the production phase of used building materials. Reuse and recycling is rewarded by decreased emission, from processing, and material depletion.

Hazardous Substances is not addressed in LEED. In CSH and EcoEffect primarily toxic emissions from the materials and their production are covered by the LCA of the materials. Thus none of the tools assess the issue embedded hazardous substances. Even though hazardous substances are one of the most prominent sub-themes of "environmental impact" according to the building sector in Sweden (e.g. Swedish Environmental Advisory Council, 2000; The Ecocycle Council, 2007). The Swedish focus on hazardous substances has also been observed in other studies (e.g. Stenberg and Räisänen, 2004).

4.3 Differences in weighting and aggregation

All environmental assessment tools weight and aggregate results differently. According to Lee et al. (2002) weighting is the heart of all assessment schemes since it will dominate the final valuation of an assessed building. However, according to Grace K.C. Ding, (2008) there is at present neither a consensus-based approach nor a satisfactory method to guide the assignment of weightings. There are a number of techniques to set weights in a systematic way (Andresen, 1999).

Within LEED 69 points are available within 58 assessed issues organized in six assessment categories. Some indicator are of a *procedural nature***,** rewarding procedures and behaviour, like following a certain control plan, in contrast to *performance indicators*, which directly measure performance like amount of energy used for heating. Often there are optional ways to receive a point. Normally one point is available per issue except for two energy indicators, where more points can be gained (10 for "Optimization of Energy Performance" and 3 for "On Site Renewable Energy", Table 1). This means that the points have the same "environmental" value and are tradable, with the exception of a few mandatory aspects. The awarded points are added and the total score tells which of four final rewards the building get (certified, silver, gold, platinum). The basis for assigning a certain number of points to an issue is not described. This aggregation system is simple and easily understood, but the environmental meaning of the final score is hazy (Humbert, 2007).

In CHS 104 credits can be awarded within 9 categories (Table 1). A total of 34 issues are assessed and the value of each issue varies between 1-15 credits (per issue), some mandatory while most tradable. Most assessed issues gives at maximum 1-4 credits, except the issues Dwelling Emission Rate and Environmental Impact of Materials, which can give up to 15 credits (Table 1). Each category has a weighting factor, which emanates from a survey among international "experts" and a consultation with industry representatives. Energy has a category weight of 1,26 while Materials only have 0, 33, which in reality says that the environmental value of energy scores are almost four times larger than those for materials. The sum of the credits results in a character represented by 1-6 stars. Since the aggregation is done by varying the credits per issue and by weighting the categories the meaning of the result is difficult to perceive. Special for CSH is that it evaluates dwellings and not buildings. A rating of a building is composed of the ratings for its dwellings. The final rating is achieved when the building has been erected and used to make sure that the performance complies with the intentions and the points received at the design stage.

The final rating in EcoEffect consists of results regarding external impacts and internal impacts. External impacts include energy and materials use. The basis is a life-cycle approach and equivalents for seven impact categories are calculated mainly using internationally well-known calculation algorithms. The external impact is measured per designed number of building users and divided by the corresponding value per capita in the country, i.e. in the end showing a percentage. This favours efficient space use, which is important from an environmental point of view (Wilson and Boehland, 2005). For each impact category weights have been established by estimating the potential harm the endpoint problems within each category might cause people. (Assefa et al, 2007). The assessment is based on the total amount of energy and materials used per resident or user.

Internal impacts cover indoor and outdoor problems on the property. Targets are categorized in 5 categories and assessed through risk assessment at the design stage considering 54 issues. The final assessment is completed at earliest one year after building completion. It is then based on a couple of measurements in the building along with a user questionnaire. A scale with four steps (0-3) is applied, punishing poor measure-

ment results and discomfort. Originally there was an expert weighting system in three levels which is now being exchanged to disability/discomfort scale developed as an extension of the DALY (Disability Adjusted Life Years) system (Malmqvist, Glaumann, 2006).

EcoEffect is quite comprehensive and the aggregated values, although systematically applied, may be difficult to understand for a layman.

5. Case study

To illustrate differences in practical use and assessment result the three tools have been tested on a new residential building under construction, Gronskar, Stockholm, i.e. complete drawings and descriptions are available but no real performance data. No environmental assessment tools were used during the design. The results in the areas; Energy, Indoor environment and Material & Waste are presented. The EcoEffect results, which not are received in points or credits, are shown in relation to a reference building, built in 1990 in the same region. LEED and CSH scores are presented in relation to the maximum possible score.

> General information about the test building, GRONSKAR,
> *Gross area: 2893 m^2, 32 apartments, 8 storeys, Energy use for heating and hot water 80 kWh/m^2,yr. Energy supply: District heating and a heat pump on exhaust air.*
> *Structure: Prefabricated concrete elements with an insulation of polystyrene.*
> *Average U-value is 0,46 W/m^2,K, (window U-value is 1,3 W/m^2,K)*

5.1 Energy use

With LEED Gronskar receive 9 of 16 points on energy (i.e. corresponding to 56%). 6 of 10 available points are gained for energy optimization. Primarily due to the heat pump on exhaust air since the envelope is not exceptionally well insulated. No points are gained for on site renewable energy which corresponds to ~20% of the available points. Measures needed to gain all the 10 available points correspond to about 150m^2 solar collectors for 50% of the hot water or lowering the average U-value by ~20%, i.e. from 0,46 to 0, 37 W/m^3K. The first option also gives maximal points for renewables. Since LEED uses *cost indicators* for energy the solar collectors don't give any credits since they are more expensive than district heating for hot water. The option left is to lower the U-value, which would influence the construction of the building.

In CSH 16 credits are given out of 29 for energy, (i.e. corresponding to 55%). The CO_2 emissions per year are compared with emissions from a reference dwelling which has the same size, fixed U-values and is heated by gas. Gronskar uses 80 kWh/m^2,yr. while the reference building uses 146 kWh/m^2,yr mainly because it lacks the heat pump. Gronskar emits about twenty times less CO_2 compared to the reference building because district heating fed by bio fuel emits very little CO_2.

The remaining 3 points Gronskar gained for energy saving fittings and "home office" which implies certain space and support of electricity and telecommunication. More energy points are available for improved envelope, labelled white goods, drying space, bicycle storage etc. The last two and "home office" can be called *potential indicators* since they award possibilities to reduce the environmental impact, which may not happen. Energy saving technical solutions are credited at the same time as low overall energy use, which might lead to *double counting*, i.e. crediting both energy saving measures and overall energy use. Normally Gronskar could also receive two additional points for the heat pump which is considered as a low carbon energy technology. But in this case the heat pump gives no CO_2, reduction according to our calculations, because the Swedish electricity mix emits much more CO_2 than the district heat. To improve the scores it would be better to exchange the heat pump with district heating and receiving more scores for low CO_2 emissions.

In EcoEffect, energy use is evaluated by measuring resource depletion and emissions influencing a number of effect categories. Although Gronskar uses 70% more electricity pr m^2 (the heat pump) than the reference building the overall energy use is 40% less than for the reference building which is also heated with district heating. The result is that the impact from emissions is only slightly larger for Gronskar. The largest impacts come from nutrification and radioactivity (nuclear waste from nuclear power). Contribution to nutrification origins to 70% from Swedish electricity mix and to 30% from the Stockholm district heating. Changing the heat pump here would only give a small reduction of environmental impact so the signal from EcoEffect is primarily to reduce the heat losses, i.e. improve insulation of the building envelop.

5.2 Indoor environment

Gronskar receives 12 out of 15 points (corresponding to 80%) in LEED, 6 credits out of 12 credits (corresponding to 71%) in CSH and is 30% better than reference values in EcoEffect, i.e. is good on indoor environment in all methods. The indoor indicators are different in all methods except from daylight, which still is calculated differently.

In LEED ventilation is the most dominant issue with 6 of the 15 points and two mandatory requirements: Air Quality in general and Minimum IAQ Performance. To receive a higher score Gronskar would have to meet

the criteria for emissions from adhesives, sealants, paints and coatings. Low content of hazardous substances in building materials has been an important goal in the design, but emissions have not been measured. LEED is the only method, which uses indicators for management and control systems. Here Gronskar receives 4 out of 5 points because of the used management and control system. More documentation of specific measures and procedures would be needed to be able to gain the fifth point.

Air quality, ventilation and thermal comfort are not included in CSH. The tool uses a wider definition of sustainable building and includes social issues like "Private Space" and "Lifetime Home". Lifetime Home contains a number of criteria, which all have to be met. Gronskar misses 4 lifetime home points because the buildings electric sockets are not placed at the right height. CSH also gives 3 credits for a "home user guide", which is a specific document that is missing. Further more sound insulation is included in the assessment. To get the 4 available credits better sound insulation would be necessary.

EcoEffect addresses Air Quality, Ventilation, Thermal Comfort and Sound Environment. In EcoEffect Gronskar gets a rather high score in all these areas. The indoor environmental issues that are linked to comfort and health are included in the indoor environment area and Electric environment and Legionnaires disease are also included here. The scores for solar access and daylight are low because many dwellings face north. Directing balconies and some rooms in other directions would be needed to attain better scores.

5.3 Material and waste

Gronskar receives low scores in all the tools. In the category Material and Waste there was a wide variation in the type of indicators and criteria used. With LEED Gronskar received 4 out of 14 points (39%), with CSH it was estimated that it would receive 18 out of 35 credits (54%). The latest version of "Green Guide" and the Mat 1 and Mat 2 calculator tool, all necessary for the rating, were not available to other than approved CHS and BREEAM assessors.

With LEED the project doesn't earn many credits because the lack of reused or recycled content. 7 points out of 14 can be gained in this category. There are also three mandatory criteria - Storage & Collection of Recyclables, Construction Activity Pollution Prevention and Fundamental Refrigerant Management. Using FSC, (Forest Stewardship Council) certified wood and local and rapidly renewable materials would also be needed to get the maximum scores.

The main targets in CSH are using materials with low environmental impact that are responsibly sourced.The low score with CSH primarily depends on the estimated high environmental impact from the used materials. The criteria for the indicator "Responsible Sourcing" was not met exactly as the method demanded EMS Certification and a third party control. Moreover the wood used was not FSC certified. For Household Waste Storage and Construction Waste Gronskar received high scores. The industrialized building processes applied minimize construction waste.

With EcoEffect the indicator for emissions from production of building materials was eight times higher than for the reference building and the indicator for resource use was twice as large as for the reference building. These high values are explained by the comparatively high use of concrete, steel and polystyrene, which demands a lot of energy for production and thus giving emissions. EcoEffect doesn't assess means to recover household waste during operation as in LEED and CSH.

6. Concluding discussion

A "green" building according to LEED has a commissioned and cost optimized energy system and on site renewable energy. Low-emitting materials are used and management and control systems applied to secure a good indoor environment. Building materials are preferably reused, recycled and regional. Schemes for waste and pollution prevention are used.

CSH's "green" building has low CO_2 emissions from energy use and specific technical solutions to reduce the households energy use. The walls and slabs are sound insulated and rooms daylit. The building is adopted for disabled and home office. Responsibly sourced building materials with low environmental impact are used and constructions and household waste is taken care of.

"Green" building according to EcoEffect has low energy use produced with low environmental impact. The indoor environment is designed to have good air quality, thermal comfort, daylight, sunlight and sound isolation and to prevent, electromagnetic fields, radon and legionnaires' disease. Building materials with low environmental impact from production and transport are used and measures are taken for simplifying future recovery. The layout plan is designed for efficient use of space.

Further characteristics of the tools are summarised in Table 2. The differences in aim may influence the market penetration, Table 2. Official back up probably will become a strong incentive to use CHS for residential buildings, LEED is used by "green" forerunners and EcoEffect is mostly used for educational purposes. The dissemination is not a consequence of the content of the tools or their applicability but rather which forces push them into the market.

Table 2. Summary of significant characteristics of the tools

		LEED	CSH	EcoEffect
Aim	*Practical use*	Commercial tool	Policy tool	Analytical tool
	Environmental focus	Environmental sustainability	Climate change, (CO2)	Decreased emissions and depletion.
Content	*Energy*	Quantity and cost of energy use. Technical solutions	Quantity and quality of energy use. Technical solutions	Quantity and quality of energy use.
	Materials and waste	Quality and cost of materials use Recycling	Quality of materials used. Waste management	Quantity and quality of materials used
	Indoor environment	Air quality, Thermal comfort Daylight. Management	Noise, Daylight Management	Air quality, Noise, Daylight, Thermal comfort.,
Assessment & Aggregation	*Energy & materials*	Indicators, criteria	Indicators, criteria	Calculations
	Indoor environment	Indicators, criteria	Indicators, criteria	Indicators, criteria
	Within categories	Scores added	Scores added	Calculated equivalents for energy and materials, Indoor environment weighted
	Between categories	Scores added	Weighted	Weighted and added
	No of assessed issues	58	34	18
	No of final scores	1	1	2

The tools use different methods for measuring and different methodology for aggregating. For example regarding indoor environment both LEED and CSH awards good management for the building in operation while EcoEffect for this purpose relies on questionnaires. The basis for assigning scores for different issues and setting weights seems quite arbitrary in all three tools apart from the damage based weights in EcoEffect. The more issues involved in the weighting procedure the less influence is given to each indicator. A higher weight of one indicator means a lower of another. Finally, adding scores and weighting categories makes the meaning of the result difficult to understand. In this respect LEED, which is purely additive, is easier to understand.

The case study of Gronskar shows that the tools push the design of "green building" in different directions. CSH signals that the heat pump should be exchanged for district heating, since the tool concentrates on CO_2 emissions. Bicycle sheds and laundry lines and other technical solutions could be used to gain more scores for Energy in CSH. In LEED use of local and renewable energy sources are awarded, but since energy cost is decisive in this case solar collectors would probably mean too expensive scores. EcoEffect advocates better U-values and low emission fuels for heating, like the district heating in Stockholm. The huge quantity of concrete and expanded polystyrene insulation would have been avoided with EcoEffect and CSH. Applying LEED it would have been more important to use recycled concrete and insulation. Being a commercial tool may be the reason why LEED puts relatively more weight on the indoor environment and consequently might have produced a better indoor environment than CSH. EcoEffect would have influenced the architect to orientate the north facing balconies to a sunny direction. This exemplifies cultural and geographic differences between the places where the methods have been developed.

It is obvious that a technique encouraged by one tool is not always the best way to reduce environmental impacts according to another. A complete environmental assessment of a building ought to consider the whole life cycle, just like environmental assessments of products or services (Finnveden, 2000). The result of this comparison shows that the concept of "green building" is far from universal. The diverging result raises the question how to design environmentally relevant and practically useful assessment tools for buildings.

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