Sustainable design

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Sustainable design (also called environmental design, environmentally sustainable design, environmentally conscious design, etc.) is the philosophy of designing physical objects, the built environment, and services to comply with the principles of social, economic, and ecological sustainability.[1]

Chair grown by tree shaper John Krubsack in Wisconsin, United States in 1919

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Theory

The intention of sustainable design is to "eliminate negative environmental impact completely through skillful, sensitive design".[1] Manifestations of sustainable design require no non-renewable resources, impact the environment minimally, and connect people with the natural environment.

Beyond the "elimination of negative environmental impact", sustainable design must create projects that are meaningful innovations that can shift behaviour. A dynamic balance between economy and society, intended to generate long-term relationships between user and object/service and finally to be respectful and mindful of the environmental and social differences.[2]

Conceptual problems

Diminishing returns

The principle that all directions of progress run out, ending with diminishing returns, is evident in the typical 'S' curve of the technology life cycle and in the useful life of any system as discussed in industrial ecology and life cycle assessment. Diminishing returns are the result of reaching natural limits. Common business management practice is to read diminishing returns in any direction of effort as an indication of diminishing opportunity, the potential for accelerating decline and a signal to seek new opportunities elsewhere. (see also: law of diminishing returns, marginal utility and Jevons paradox.)

Unsustainable Investment

A problem arises when the limits of a resource are hard to see, so increasing investment in response to diminishing returns may seem profitable as in the Tragedy of the Commons, but may lead to a collapse. This problem of increasing investment in diminishing resources has also been studied in relation to the causes of civilization collapse by Joseph Tainter among others.[3] This natural error in investment policy contributed to the collapse of both the Roman and Mayan, among others. Relieving over-stressed resources requires reducing pressure on them, not continually increasing it whether more efficiently or not[4]

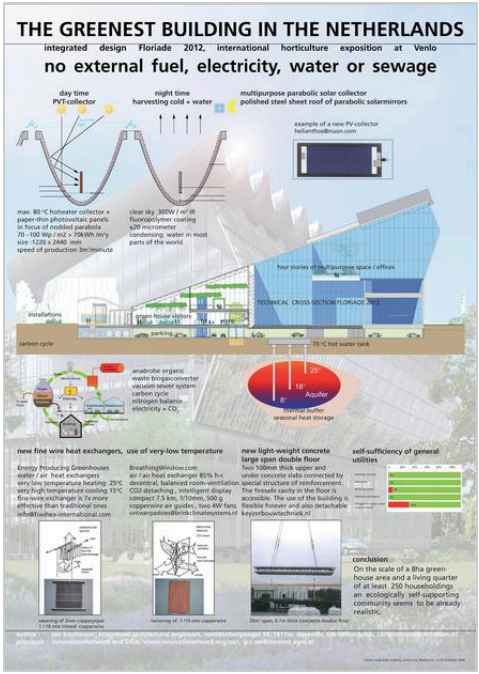
Waste prevention

Negative Effects of Waste

About 80 million tonnes of waste in total are generated in the U.K. alone, for example, each year.[5] And with reference to only household waste, between 1991/92 and 2007/08, each person in England generated an average of 1.35 pounds of waste per day.[6]

Experience has now shown that there is no completely safe method of waste disposal. All forms of disposal have negative impacts on the environment, public health, and local economies. Landfills have contaminated drinking water. Garbage burned in incinerators has poisoned air, soil, and water. The majority of water treatment systems change the local ecology. Attempts to control or manage wastes after they are produced fail to eliminate environmental impacts.

The toxic components of household products pose serious health risks and aggravate the trash problem. In the U.S., about eight pounds in every ton of household garbage contains toxic materials, such as heavy metals like nickel, lead, cadmium, and mercury from batteries, and organic compounds found in pesticides and consumer products, such as air freshener sprays, nail polish, cleaners, and other products.[7] When burned or buried, toxic materials also pose a serious threat to public health and the environment.



Plans for Floriade 2012 in Venlo, the Netherlands: "The Greenest Building in the Netherlands - no external fuel, electricity, water or sewage."

The only way to avoid environmental harm from waste is to prevent its generation. Pollution prevention means changing the way activities are conducted and eliminating the source of the problem. It does not mean doing without, but doing differently. For example, preventing waste pollution from litter caused by disposable beverage containers does not mean doing without beverages; it just means using refillable bottles.

Waste prevention strategies In planning for facilities, a comprehensive design strategy is needed for preventing generation of solid waste. A good garbage prevention strategy would require that everything brought into a facility be recycled for reuse or recycled back into the environment through biodegradation. This would mean a greater reliance on natural materials or products that are compatible with the environment.

Any resource-related development is going to have two basic sources of solid waste — materials purchased and used by the facility and those brought into the facility by visitors. The following waste prevention strategies apply to both, although different approaches will be needed for implementation:[8]

- use products that minimize waste and are nontoxic
- compost or anaerobically digest biodegradable wastes
- reuse materials onsite or collect suitable materials for offsite recycling

Sustainable design principles

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While the practical application varies among disciplines, some common principles are as follows:

- Low-impact materials: choose non-toxic, sustainably produced or recycled materials which require little energy to process

- Energy efficiency: use manufacturing processes and produce products which require less energy
- Emotionally durable design: reducing consumption and waste of resources by increasing the durability of relationships between people and products, through design
- Design for reuse and recycling: "Products, processes, and systems should be designed for performance in a commercial 'afterlife'."[9]
- Design impact measures for total carbon footprint and life-cycle assessment for any resource used are increasingly required and available.^[10] Many are complex, but some give quick and accurate whole-earth estimates of impacts. One measure estimates any spending as consuming an average economic share of global energy use of 8,000 BTU (8,400 kJ) per dollar and producing CO2 at the average rate of 0.57 kg of CO2 per dollar (1995 dollars US) from DOE figures.[11]

The California Academy of Sciences, San Francisco, California, is a sustainable building designed by Renzo Piano. It opened on September 27, 2008

- Sustainable design standards and project design guides are also increasingly available and are vigorously being developed by a wide array of private organizations and individuals. There is also a large body of new methods emerging from the rapid development of what has become known as 'sustainability science' promoted by a wide variety of educational and governmental institutions.
- Biomimicry: "redesigning industrial systems on biological lines ... enabling the constant reuse of materials in continuous closed cycles..."[12]
- Service substitution: shifting the mode of consumption from personal ownership of products to provision of services which provide similar functions, e.g., from a private automobile to a carsharing service. Such a system promotes minimal resource use per unit of consumption (e.g., per trip driven).[13]
- Renewability: materials should come from nearby (local or bioregional), sustainably managed renewable sources that can be composted when their usefulness has been exhausted.
- Robust eco-design: robust design principles are applied to the design of a pollution sources.[14]

Bill of Rights for the Planet

A model of the new design principles necessary for sustainability is exemplified by the "Bill of Rights for the Planet" or "Hannover Principles" - developed by William McDonough Architects for EXPO 2000 that was held in Hannover, Germany.

The Bill of Rights:

1. Insist on the right of humanity and nature to co-exist in a healthy, supportive, diverse, and sustainable condition.
2. Recognize Interdependence. The elements of human design interact with and depend on the natural world, with broad and diverse implications at every scale. Expand design considerations to recognizing even distant effects.
3. Respect relationships between spirit and matter. Consider all aspects of human settlement including community, dwelling, industry, and trade in terms of existing and evolving connections between spiritual and material consciousness.
4. Accept responsibility for the consequences of design decisions upon human well-being, the viability of natural systems, and their right to co-exist.
5. Create safe objects of long-term value. Do not burden future generations with requirements for maintenance or vigilant administration of potential danger due to the careless creations of products, processes, or standards.
6. Eliminate the concept of waste. Evaluate and optimize the full life-cycle of products and processes, to approach the state of natural systems in which there is no waste.
7. Rely on natural energy flows. Human designs should, like the living world, derive their creative forces from perpetual solar income. Incorporating this energy efficiently and safely for responsible use.
8. Understand the limitations of design. No human creation lasts forever and design does not solve all problems. Those who create and plan should practice humility in the face of nature. Treat nature as a model and mentor, not an inconvenience to be evaded or controlled.
9. Seek constant improvement by the sharing of knowledge. Encourage direct and open communication between colleagues, patrons, manufacturers and users to link long term sustainable considerations with ethical responsibility, and re-establish the integral relationship between natural processes and human activity.

These principles were adopted by the World Congress of the International Union of Architects (UIA) in June 1993 at the American Institute of Architects' (AIA) Expo 93 in Chicago. Further, the AIA and UIA signed a "Declaration of Interdependence for a Sustainable Future." In summary, the declaration states that today's society is degrading its environment and that the AIA, UIA, and their members are committed to:

- Placing environmental and social sustainability at the core of practices and professional responsibilities
- Developing and continually improving practices, procedures, products, services, and standards for sustainable design
- Educating the building industry, clients, and the general public about the importance of sustainable design

- Working to change policies, regulations, and standards in government and business so that sustainable design will become the fully supported standard practice
- Bringing the existing built environment up to sustainable design standards.

In addition, the Interprofessional Council on Environmental Design (ICED), a coalition of architectural, landscape architectural, and engineering organizations, developed a vision statement in an attempt to foster a team approach to sustainable design. ICED states: The ethics, education and practices of our professions will be directed to shape a sustainable future. . . . To achieve this vision we will join . . . as a multidisciplinary partnership."

These activities are an indication that the concept of sustainable design is being supported on a global and interprofessional scale and that the ultimate goal is to become more environmentally responsive. The world needs facilities that are more energy efficient and that promote conservation and recycling of natural and economic resources.[15]

Applications

Applications of this philosophy range from the microcosm — small objects for everyday use, through to the macrocosm — buildings, cities, and the Earth's physical surface. It is a philosophy that can be applied in the fields of architecture, landscape architecture, urban design, urban planning, engineering, graphic design, industrial design, interior design, fashion design and human-computer interaction.

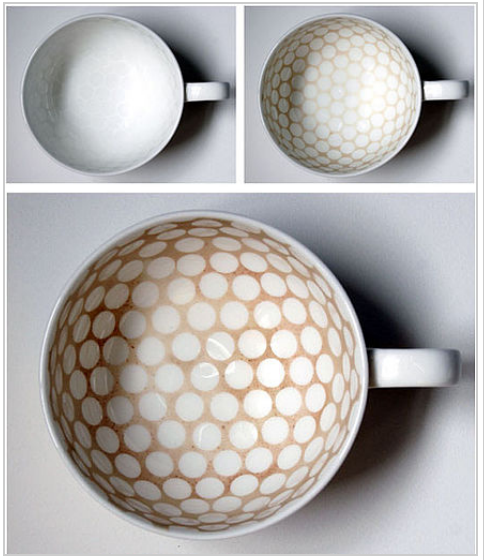
Sustainable design is mostly a general reaction to global environmental crises, the rapid growth of economic activity and human population, depletion of natural resources, damage to ecosystems, and loss of biodiversity.[16] In 2013, eco architecture writer Bridgette Meinhold surveyed emergency and long-term sustainable housing projects that were developed in response to these crises in her book, “Urgent Architecture: 40 Sustainable Housing Solutions for a Changing World.”[17][18] Featured projects focus on green building, sustainable design, eco-friendly materials, affordability, material reuse, and humanitarian relief. Construction methods and materials include repurposed shipping containers, straw bale construction, sandbag homes, and floating homes.[19]

The limits of sustainable design are reducing. Whole earth impacts are beginning to be considered because growth in goods and services is consistently outpacing gains in efficiency. As a result, the net effect of sustainable design to date has been to simply improve the efficiency of rapidly increasing impacts. The present approach, which focuses on the efficiency of delivering individual goods and services, does not solve this problem. The basic dilemmas include: the increasing complexity of efficiency improvements; the difficulty of implementing new technologies in societies built around old ones; that physical impacts of delivering goods and services are not localized, but are distributed throughout the economies; and that the scale of resource use is growing and not stabilizing.

Examples

Emotionally durable design

According to Professor Jonathan Chapman of the University of Brighton, UK, emotionally durable design reduces the consumption and waste of natural resources by increasing the resilience of relationships established between consumers and products."[20] In his book, *Emotionally Durable Design: Objects, Experiences & Empathy (http://www.amazon.co.uk/Emotionally-Durable-Design-Objects-Experiences/dp/1844071812)*, Professor Chapman describes how "the process of consumption is, and has always been, motivated by complex emotional drivers, and is about far more than just the mindless purchasing of newer and shinier things; it is a journey towards the ideal or desired self, that through cyclical loops of desire and disappointment, becomes a seemingly endless process of serial destruction".[21]



Stain Teacups: Bethan Laura Wood, 2009

According to Professor Chapman, 'emotional durability' can be achieved through consideration of the following five elements:

- **Narrative**: How users share a unique personal history with the product.
- **Consciousness**: How the product is perceived as autonomous and in possession of its own free will.
- **Attachment**: Can a user be made to feel a strong emotional connection to a product?
- **Fiction**: The product inspires interactions and connections beyond just the physical relationship.
- **Surface**: How the product ages and develops character through time and use.

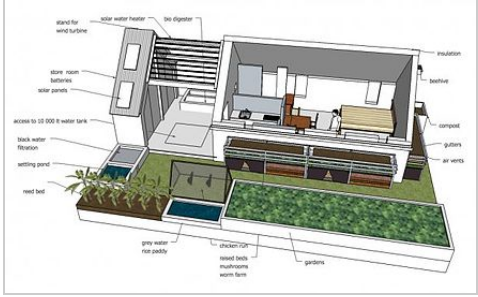
As a strategic approach, "emotionally durable design provides a useful language to describe the contemporary relevance of designing responsible, well made, tactile products which the user can get to know and assign value to in the long-term."[22] According to Hazel Clark and David Brody of Parsons The New School for Design in New York, "emotionally durable design is a call for professionals and students alike to prioritise the relationships between design and its users, as a way of developing more sustainable attitudes to, and in, design things."[23]

Eco fashion and home accessories

Creative designers and artists are perhaps the most inventive when it comes to upcycling or creating new products from old waste. A growing number of designers upcycle waste materials such as car window glass and recycled ceramics, textile offcuts from upholstery companies, and even decommissioned fire hose to make belts and bags. Whilst accessories may seem trivial when pitted against green scientific breakthroughs; the ability of fashion and retail to influence and inspire consumer behaviour should not be underestimated. Eco design may also use bi-products of industry, reducing the amount of waste being dumped in landfill, or may harness new sustainable materials or production techniques e.g. fabric made from recycled PET plastic bottles or bamboo textiles.

Sustainable architecture

Sustainable architecture is the design of sustainable buildings. Sustainable architecture attempts to reduce the collective environmental impacts during the production of building components, during the construction process, as well as during the lifecycle of the building (heating, electricity use, carpet cleaning etc.) This design practice emphasizes efficiency of heating and cooling systems; alternative energy sources such as solar hot water, appropriate building siting, reused or recycled building materials; on-site power generation - solar technology, ground source heat pumps, wind power; rainwater harvesting for gardening, washing and aquifer recharge; and on-site waste management such as green roofs that filter and control stormwater runoff. This requires close cooperation of the design team, the architects, the engineers, and the client at all project stages, from site selection, scheme formation, material selection and procurement, to project implementation.[24]



Sustainable building design

Sustainable architects design with sustainable living in mind.[25] Sustainable vs green design is the challenge that designs not only reflect healthy processes and uses but are powered by renewable energies and site specific resources. A test for sustainable design is — can the design function for its intended use without fossil fuel — unplugged. This challenge suggests architects and planners design solutions that can function without pollution rather than just reducing pollution. As technology progresses in architecture and design theories and as examples are built and tested, architects will soon be able to create not only passive, null-emission buildings, but rather be able to integrate the entire power system into the building design. In 2004 the 59 home housing community, the Solar Settlement, and a 60,000 sq ft (5,600 m^2) integrated retail, commercial and residential building, the Sun Ship, were completed by architect Rolf Disch in Freiburg, Germany. The Solar Settlement is the first housing community world wide in which every home, all 59, produce a positive energy balance.[26]

An essential element of Sustainable Building Design is indoor environmental quality including air quality, illumination, thermal conditions, and acoustics. The integrated design of the indoor environment is essential and must be part of the integrated design of the entire structure. ASHRAE Guideline 10-2011 addresses the interactions among indoor environmental factors and goes beyond traditional standards.[27]

Concurrently, the recent movements of New Urbanism and New Classical Architecture promote a sustainable approach towards construction, that appreciates and develops smart growth, architectural tradition and classical design.[28][29] This in contrast to modernist and globally uniform architecture, as well as leaning against solitary housing estates and suburban sprawl.[30] Both trends started in the 1980s. The Driehaus Architecture Prize is an award that recognizes efforts in New Urbanism and New Classical Architecture, and is endowed with a prize money twice as high as that of the modernist Pritzker Prize.[31]

Sustainable planning

Urban planners that are interested in achieving sustainable development or sustainable cities use various design principles and techniques when designing cities and their infrastructure. These include Smart Growth theory, Transit-oriented development, sustainable urban infrastructure and New Urbanism. Smart Growth is an urban planning and transportation theory that concentrates growth in infill sites within the existing infrastructure of a city or town to avoid urban sprawl; and advocates compact, transit-oriented development,

walkable, bicycle-friendly land use, including mixed-use development with a range of housing choices. Transit-oriented development attempts to maximise access to public transport and thereby reduce the need for private vehicles. Public transport is considered a form of Sustainable urban infrastructure, which is a design approach which promotes protected areas, energy-efficient buildings, wildlife corridors and distributed, rather than centralized, power generation and waste water treatment. New Urbanism is more of a social and aesthetic urban design movement than a green one, but it does emphasize diversity of land use and population, as well as walkable communities which inherently reduce the need for automotive travel.

Cohousing community illustrating greenspace preservation, tightly clustered housing, and parking on periphery, Ann Arbor, Michigan, 2003.

Both urban and rural planning can benefit from including sustainability as a central criterion when laying out roads, streets, buildings and other components of the built environment. Conventional planning practice often ignores or discounts the natural configuration of the land during the planning stages, potentially causing ecological damage such as the stagnation of streams, mudslides, soil erosion, flooding and pollution. Applying methods such as scientific modelling to planned building projects can draw attention to problems before construction begins, helping to minimise damage to the natural environment.

Cohousing is an approach to planning based on the idea of intentional communities. Such projects often prioritize common space over private space resulting in grouped structures that preserve more of the surrounding environment.

Watershed assessment of carrying capacity; estuary, riparian zone restoration and groundwater recharge for hydrologic cycle viability; and other opportunities and issues about Water and the environment show that the foundation of smart growth lies in the protection and preservation of water resources. The total amount of precipitation landing on the surface of a community becomes the supply for the inhabitants. This supply amount then dictates the carrying capacity - the potential population - as supported by the "water crop."

Sustainable landscape and garden design

Sustainable landscape architecture is a category of sustainable design and energy-efficient landscaping concerned with the planning and design of outdoor space. Plants and materials may be bought from local growers to reduce energy used in transportation. Design techniques include planting trees to shade buildings from the sun or protect them from wind, using local materials, and on-site composting and chipping not only to reduce green waste hauling but to increase organic matter and therefore carbon in the soil.

Some designers and gardeners such as Beth Chatto also use drought-resistant plants in arid areas (xeriscaping) and elsewhere so that water is not taken from local landscapes and habitats for irrigation. Water from building roofs may be collected in rain gardens so that the groundwater is recharged, instead of rainfall becoming surface runoff and increasing the risk of flooding.

Areas of the garden and landscape can also be allowed to grow wild to encourage bio-diversity. Native animals may also be encouraged in many other ways: by plants which provide food such as nectar and pollen for insects, or roosting or nesting habitats such as trees, or habitats such as ponds for amphibians and aquatic insects. Pesticides, especially persistent pesticides, must be avoided to avoid killing wildlife.

Soil fertility can be managed sustainably by the use of many layers of vegetation from trees to ground-cover plants and mulches to increase organic matter and therefore earthworms and mycorrhiza; nitrogen-fixing plants instead of synthetic nitrogen fertilizers; and sustainably harvested seaweed extract to replace micronutrients.

Sustainable landscapes and gardens can be productive as well as ornamental, growing food, firewood and craft materials from beautiful places.

Sustainable landscape approaches and labels include organic farming and growing, permaculture, agroforestry, forest gardens, agroecology, vegan organic gardening and ecological gardening.

Sustainable graphic design

Sustainable graphic design considers the environmental impacts of graphic design products (such as packaging, printed materials, publications, etc.) throughout a life cycle that includes: raw material; transformation; manufacturing; transportation; use; and disposal. Techniques for sustainable graphic design include: reducing the amount of materials required for production; using paper and materials made with recycled, post-consumer waste; printing with low-VOC inks; and using production and distribution methods that require the least amount of transport.

Sustainable agriculture

Main: Organic farming

Sustainable agriculture adheres to three main goals:

- Environmental Health,
- Economic Profitability,
- Social and Economic Equity.

A variety of philosophies, policies and practices have contributed to these goals. People in many different capacities, from farmers to consumers, have shared this vision and contributed to it. Despite the diversity of people and perspectives, the following themes commonly weave through definitions of sustainable agriculture.

There are strenuous discussions — among others by the agricultural sector and authorities — if existing pesticide protocols and methods of soil conservation adequately protect topsoil and wildlife. Doubt has risen if these are sustainable, and if agrarian reforms would permit an efficient agriculture with fewer pesticides, therefore reducing the damage to the ecosystem.

For more information on the subject of sustainable agriculture: "UC Davis: Sustainable Agriculture Research and Education Program" (http://www.sarep.ucdavis.edu/Concept.htm).[32]

Domestic machinery and furniture

Automobiles, home appliances and furnitures can be designed for repair and disassembly (for recycling), and constructed from recyclable materials such as steel, aluminum and glass, and renewable materials, such as Zelfo, wood and plastics from natural feedstocks. Careful selection of materials and manufacturing processes can often create products comparable in price and performance to non-sustainable products. Even mild design efforts can greatly increase the sustainable content of manufactured items.

Improvements to heating, cooling, ventilation and water heating

- Absorption refrigerator
- Annualized geothermal solar
- Earth cooling tubes
- Geothermal heat pump
- Heat recovery ventilation
- Hot water heat recycling
- Passive cooling
- Renewable heat
- Seasonal thermal energy storage (STES)
- Solar air conditioning
- Solar hot water

Disposable products

Detergents, newspapers and other disposable items can be designed to decompose, in the presence of air, water and common soil organisms. The current challenge in this area is to design such items in attractive colors, at costs as low as competing items. Since most such items end up in landfills, protected from air and water, the utility of such disposable products is debated.

Energy sector

Sustainable technology in the energy sector is based on utilizing renewable sources of energy such as solar, wind, hydro, bioenergy, geothermal, and hydrogen. Wind energy is the world's fastest growing energy source; it has been in use for centuries in Europe and more recently in the United States and other nations. Wind energy is captured through the use of wind turbines that generate and transfer electricity for utilities, homeowners and remote villages. Solar power can be harnessed through photovoltaics, concentrating solar, or solar hot water and is also a rapidly growing energy source.[33]

The availability, potential, and feasibility of primary renewable energy resources must be analyzed early in the planning process as part of a comprehensive energy plan. The plan must justify energy demand and supply and assess the actual costs and benefits to the local, regional, and global environments. Responsible

energy use is fundamental to sustainable development and a sustainable future. Energy management must balance justifiable energy demand with appropriate energy supply. The process couples energy awareness, energy conservation, and energy efficiency with the use of primary renewable energy resources.[34]

Water sector

Sustainable water technologies have become an important industry segment with several companies now providing important and scalable solutions to supply water in a sustainable manner.

A 35,003 litre rainwater harvesting tank in Kerala

Beyond the use of certain technologies, Sustainable Design in Water Management also consists very importantly in correct implementation of concepts. Among one of these principal concepts is the fact normally in developed countries 100% of water destined for consumption, that is not necessarily for drinking purposes, is of potable water quality. This concept of differentiating qualities of water for different purposes has been called "fit-for-purpose".[35] This more rational use of water achieves several economies, that are not only related to water itself, but also the consumption of energy, as to achieve water of drinking quality can be extremely energy intensive for several reasons.

Terminology

In some countries the term *sustainable design* is known as ecodesign, green design or environmental design. Victor Papanek, embraced social design and social quality and ecological quality, but did not explicitly combine these areas of design concern in one term. *Sustainable design* and *design for sustainability* are more common terms, including the triple bottom line (people, planet and profit).

Sustainable technologies

Sustainable technologies use less energy, fewer limited resources, do not deplete natural resources, do not directly or indirectly pollute the environment, and can be reused or recycled at the end of their useful life.[36] There is significant overlap with appropriate technology, which emphasizes the suitability of technology to the context, in particular considering the needs of people in developing countries. However, the most appropriate technology may not be the most sustainable one; and a sustainable technology may have high cost or maintenance requirements that make it unsuitable as an "appropriate technology," as that term is commonly used.

See also

- Active daylighting
- Active solar
- Agroforestry
- Appropriate technology

- BREEAM
- Bright green environmentalism
- Building Information Modeling
- Building services engineering
- Circular Economy
- Circles of Sustainability
- Cool roof
- Cradle to Cradle
- Daylighting
- Ecodistrict
- Ecological Design
- Ecological Restoration
- Eco-innovation
- Ecosa Institute
- Ecosystem services
- Energy-efficient landscaping
- Energy plus house
- Environmentally friendly
- Forest gardening
- Green building
- Green chemistry
- Green library
- Green roof
- Green transport
- History of passive solar building design
- Industrial ecology
- Landscape ecology
- Leadership in Energy and Environmental Design
- List of low-energy building techniques
- Life cycle assessment
- List of energy storage projects
- List of sustainable agriculture topics
- Metadesign
- Passive solar
- Passive solar building design
- Passive solar design

- Permaculture
- Principles of Intelligent Urbanism
- Rain gardens
- Renewable heat
- Renewable resource
- Social design
- Solar energy
- Source reduction
- Superinsulation
- Sustainability
- Sustainable agriculture
- Sustainable architecture
- Sustainable art
- Sustainable city
- Sustainable development
- Sustainable gardening
- Sustainable landscaping
- Sustainable landscape architecture
- Sustainable products
- Terreform ONE
- Transition Design
- Vertical garden
- Waste management
- Water conservation
- Watershed
- Zero energy building

Advocates and practitioners

- J. Baldwin
- Tom Bender
- Michael Braungart
- Jonathan Chapman
- Martin Crawford
- Ken Fern, founder of Plants for a Future
- Buckminster Fuller

- Robert Hart
- Paul Hawken
- Hellmuth, Obata and Kassabaum
- David Holmgren
- Mitchell Joachim
- Ben Law [7] (http://www.ben-law.co.uk/)
- William McDonough
- Bill Mollison
- Victor Papanek
- Mike Reynolds
- Vandana Shiva
- Paolo Soleri
- Daniel A. Vallero
- Sim Van der Ryn
- Ken Yeang

Events, conferences, workshops, classes, and organizations

- Agroforestry Research Trust
- AIA Committee on the Environment
- American Society of Landscape Architects
- Center for the Built Environment
- Compostmodern
- EC3 Global
- Lyle Center for Regenerative Studies
- o2 Global Network
- Permaculture Association [8] (http://www.permaculture.org.uk/)
- United States Green Building Council
- Worldchanging

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External links

- Sustainability in the Desert: A review of Sustainable Design in the Middle East. (http://www.carboun.com/sustainable-development/sustainable-design/sustainability-in-the-desert/) Via Carboun (http://www.carboun.com/)
- Chris Hendrickson, Noellette Conway-Schempf, Lester Lave and Francis McMichael. "Introduction to Green Design." (http://www.ce.cmu.edu/GreenDesign/gd/education/gdedintro.pdf)
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