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Standard Guide for General Principles of Sustainability Relative to Buildings[1]

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1. Scope

1.1 Sustainabilty has three types of general principles: environmental, economic, and social. This guide covers the fundamental concepts and associated building characteristics for each of the general principles of sustainability.

1.2 This guide distinguishes between ideal sustainability and applied sustainability. Ideally, human activities would not require making trade-offs among environmental, economic, and social goals. However, this guide recognizes that, in applying sustainability principles to buildings, decision makers must often balance opportunities and challenges associated with each of the general principles.

1.3 This guide identifies general methodologies associated with the decision-making process used in pursuing sustainability.

1.4 This guide addresses buildings individually and in aggregate (collectively).

1.4.1 The general principles identified in this guide are applicable to all scales of building projects, including: interior spaces, individual buildings and groups of buildings, infrastructure systems, and land use.

1.4.2 The general principles identified in this guide are applicable to all life-cycle stages of a building and its components, including: material extraction, product manufacturing, product transportation, planning, siting, design, specification, construction, operation, maintenance, renovation, retrofit, reuse, deconstruction, and waste disposal of buildings.

1.5 A variety of tools and standards exist that qualify and quantify impacts of buildings, building materials, and building methods in terms of one or more of the general principles of sustainability. It is not within the scope of this standard to recreate or replace these tools.

1.6 This guide does not provide direction as to the specific implementation of the general principles; nor does it provide direction as to the specific weighting of principles necessary for achieving balance.

1.7 Applying the principles in this guide will require professional judgment. Such judgment should be informed by experience with environmental, economic, and social issues as appropriate to the building use, type, scale, and location.

1.8 This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.

1.9 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.10 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E631 Terminology of Building Constructions

E917 Practice for Measuring Life-Cycle Costs of Buildings and Building Systems

E2114 Terminology for Sustainability Relative to the Performance of Buildings

[1] This guide is under the jurisdiction of ASTM Committee E60 on Sustainability and is the direct responsibility of Subcommittee E60.01 on Buildings and Construction.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

2.2 *ISO Standards:*[3]
ISO 14040 Life Cycle Assessment

3. Terminology

3.1 *Definitions:*

3.1.1 For terms related to building construction, refer to Terminology E631.

3.1.2 For terms related to sustainability relative to the performance of buildings, refer to Terminology E2114.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *carbon sinking, n*—an approach to offset carbon dioxide emissions through the absorption potential of forests and other vegetation.

3.2.2 *Design for the Environment (DfE), n*—the systemic consideration of design performance with respect to environmental, health, and safety objectives over the full product life-cycle.

3.2.3 *external costs/benefits, n*—economic impact associated with the action of a party that is not borne by that party, but rather by a third party or parties.

3.2.3.1 *Discussion*—This is intended to include economic costs and benefits associated with environmental and social impacts arising out of the action.

3.2.4 *green roof system, n*—an assembly that supports an area of planting/landscaping, built up on a waterproofed substrate at any level that is separated from the natural ground by a human-made structure.

3.2.5 *heat island effect, n*—a phenomenon in which urban air and surface temperatures are higher than nearby rural areas due to the replacement of natural land cover with pavement, buildings, and other infrastructure.

4. Significance and Use

4.1 Every building and building product has environmental, economic, and social impacts. These impacts occur at all life-cycle stages in multiple ways and on local, regional, and global scales. It is imperative to understand the nature of these impacts and their relationship to the general principles of sustainability in order to address the opportunities and challenges they present in buildings.

4.1.1 Buildings impact the environment. In order to advance sustainability, it is necessary to identify environmental impacts, mitigate negative environmental impacts, and promote positive environmental impacts.

4.1.2 Buildings have economic impacts. In order to advance sustainability, it is necessary to quantify and optimize life-cycle costs/benefits and external costs/benefits to the greatest extent possible.

4.1.3 Buildings impact society. In order to advance sustainability, it is necessary to identify the health, safety, and welfare impacts, and to contribute to a positive quality of life for current and future generations.

4.2 The general principles of sustainability—environmental, economic, and social—are interrelated. Decisions founded on the opportunities and challenges of any of the principles will have impacts relative to all of the principles. However, to facilitate clarity in the presentation of the general principles of sustainability relative to buildings, they are discussed individually in Section 5.

4.3 Sustainability is an ideal. The practical application of the general principles of sustainability relies upon balancing environmental, economic, and social impacts and committing to continual improvement to approach this ideal. Section 6 discusses this balancing of environmental, economic, and social impacts in pursuit of sustainability.

4.4 The marketplace is evolving as technology, economics, and society become globalized. The range of topics and approaches to standards development has evolved in tandem with the changes in the marketplace. This guide addresses one of the primary issues of today's global marketplace—sustainability. It provides an overview of sustainability, as it is applicable to buildings. It provides general guidance but does not prescribe a specific course of action.

4.5 This guide is intended to inform professionals associated with the building industry, including specifiers, planners, developers, architects, landscapers, engineers, general contractors, subcontractors, owners, facility managers, financial organizations related to the building industry, product manufacturers, and government agencies including building officials, and other building professionals.

4.5.1 The general principles identified in this guide are intended to assist users in making decisions that advance sustainability.

4.5.2 The general principles identified in this guide are intended to inform the development and refinement of tools and standards to qualify and quantify impacts of buildings, building materials, and building methods.

5. Principles of Ideal Sustainability Relative to Buildings

5.1 *Environmental Principles*—Buildings impact the environment. From gathering raw materials, production of components, assembly into structures, day-to-day operations, periodic maintenance, to the final disposition of the components, there are impacts on the environment. Environmental impacts affect ecosystems, biodiversity, and natural resources. In order to advance sustainability, it is necessary to identify environmental impacts, mitigate negative environmental impacts, and promote positive environmental impacts.

5.1.1 *Fundamental Concepts:*

5.1.1.1 *Ecosystems*—Ecosystems provide critical services that support life on the earth and the continued viability of a large range of flora and fauna. Sustainability protects existing ecosystems and strives to restore damaged ecosystems.

5.1.1.2 *Biodiversity*—Biodiversity provides environmental options, both known and unknown, that contribute to the genetic resilience of the earth's flora and fauna. Sustainability protects or enhances the biodiversity and interdependencies of species.

5.1.1.3 *Natural Resources*—Natural resources provide the basic requirements of life and the material/energy from which all human-made material/energy is derived. Sustainability

[3] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

balances the use of earth's renewable, non-renewable, and perpetual resources in order to preserve these resources for future generations.

5.1.2 *Associated Building Characteristics:*

5.1.2.1 *Ecosystems*—Sustainable buildings contain features that protect or enhance local, regional, and global ecosystems. For example, energy efficiency features, both active and passive, can reduce the amount of energy used by the building. This approach can reduce the regional impacts associated with air emissions from electric power generation facilities and reduce the local impacts of the heat island effect.

5.1.2.2 *Biodiversity*—Sustainable buildings contain features that protect or enhance species' habitats. For example, a green roof system can retain and utilize stormwater through the use of climate-appropriate plants. This approach can reduce the amount of polluted stormwater runoff and creates new habitats within the built environment.

5.1.2.3 *Natural Resources*—Sustainable buildings maximize the effective use of resources. Sustainable buildings preserve or enhance the quality of resources and do not adversely alter the balance between renewable resources and their rate of consumption for building-related purposes. For example, water resource stewardship approaches such as water-efficient, native landscaping, and permeable surfaces can reduce the use of water and help to naturally filter contaminants. These approaches can assist in recharging groundwater resources. Similarly wood building products obtained from sustainably managed forests offer a renewable resource that can contribute to the preservation of forests for future generations. This approach can support biodiversity and contribute to carbon sinking.

5.2 *Economic Principles*—Buildings have both direct and indirect economic impacts that are inherent to the process of their acquisition, construction, use, maintenance, and disposition. Direct economic impacts are those associated with the life-cycle costs/benefits of materials, land, and labor directly attributable to the building. Direct costs/benefits are typically evaluated using life-cycle cost (LCC) methods. Indirect economic impacts are those associated with external costs/benefits. External costs/benefits accrue to those indirectly impacted by the building. In order to advance sustainability, it is necessary to quantify and optimize direct and indirect economic impacts to the greatest extent possible.

5.2.1 *Fundamental Concepts:*

5.2.1.1 *External Costs/Benefits*—Sustainability reduces external costs associated with social and environmental impacts while promoting external benefits associated with social and environmental impacts.

(1) Social Costs/Benefits—Sustainability requires economies with diverse job opportunities, equitable distribution of resources, and educated, healthy workers.

(2) Environmental Costs/Benefits—Sustainability requires healthy, functioning ecosystems that provide services that support local, regional, and global economies. Such services include pollination of crops, cleansing of water and air, the decomposing of detritus for food, and the regulation of disease and pests.

5.2.1.2 *Life-Cycle Costs/Benefits*—Sustainability recognizes the full life-cycle costs/benefits of a building, including costs/benefits associated with designing, purchasing/leasing, constructing/installing, using/operating, maintaining, repairing, replacing, and disposing/deconstructing of buildings. Economic evaluation of sustainable buildings is based on the evaluation procedures delineated in Practice E917.

(1) First Costs/Benefits—First costs/benefits include the costs associated with design and construction of the building and the acquisition of land on which to build. Sustainable building practices rely on first costs/benefits being evaluated with consideration of associated cost/benefits for operation, deconstruction, and disposal.

(2) Operating Costs/Benefits—Operating costs/benefits include utility costs, maintenance and repair costs, and costs associated with replacement of component materials and systems. Sustainable building practices rely on full accounting of life-cycle operating costs/benefits during initial program planning. Operating costs/benefits can be significant and can outweigh first costs/benefits and future end use cost/benefits. Building components and systems are operated, maintained, and replaced possibly many times over the life of the building.

(3) End Use Costs/Benefits—End use cost/benefits for deconstruction and disposal will accrue in the future, when new information relative to potential environmental/social impacts may be available. Sustainable building practices consider end use costs/benefits when reliable data is available. Sustainable building practices consider future costs/benefits including the potential risks and liabilities associated with materials and methods incorporated into the building.

5.2.2 *Associated Building Characteristics:*

5.2.2.1 *External Costs/Benefits*—Sustainable building practices seek to identify associated external costs/benefits, minimize associated external costs, and maximize external benefits. These costs/benefits tend to be specific to regions, programs, and combinations of circumstances unique to the building under consideration.

(1) Social Costs/Benefits—Sustainable buildings enhance the building industry and create and provide healthy and productive workplaces. For example, the use of low-VOC interior finishes contributes to construction worker health and improved indoor environmental quality of the finished building. Improved indoor environmental quality can contribute to worker productivity.

(2) Environmental Costs/Benefits—Sustainable buildings have reduced environmental costs and provide environmental benefits to society. For example, landscaping with indigenous plants can contribute to wildlife corridors. This approach can support both local ecosystems and migratory species, many of which are pollinators vital to the economic foundation of the agricultural industry.

5.2.2.2 *Life-Cycle Costs/Benefits*—The use of sustainable building practices strives to provide the best comprehensive value over the life-cycle of the building.

(1) First Costs—Sustainable buildings do not need to be more expensive than other buildings when measured on a first cost basis. Integrating features early in the planning and design

process controls initial costs. For example, indigenous landscaping techniques incorporate water-efficient plants. This approach can negate the necessity for supplemental watering and the costs associated with labor and materials to install an irrigation system.

(2) Operating Costs—The use of sustainable building practices applies efficiencies of operation, reducing associated operating costs. For example, selecting durable materials can reduce the need for repair and replacement. This approach cannot only minimize costs associated with labor and materials for repair/replacement but also the costs associated with possible disruption in the operations and services of the building.

(3) End Use Costs/Benefits—Reduces the use of sustainable building practices applies DfE (Design for the Environment) and reduce potential regulatory and liability costs. For example, mechanically fastened systems can facilitate future deconstruction. This approach can advance the reclamation of materials and reduce costs associated with landfilling.

5.3 *Social Principles*—Buildings impact society. Social structures vary in complexity and hierarchies of inclusion. Sustainable buildings support societal goals at the levels appropriate to their interaction. In order to advance sustainability, it is necessary to identify, without imposing interpretive cultural prejudice, the potential health, safety, and welfare impacts, and to contribute to a positive quality of life for current and future generations.

5.3.1 *Fundamental Concepts:*

5.3.1.1 *Health, Safety, and Welfare*—Sustainability maintains or improves health, safety, and welfare.

5.3.1.2 *Transparency*—Sustainability requires that there be ample opportunity for affected parties to access information and actively participate in the decision-making process.

5.3.1.3 *Equity*—Sustainability is founded upon intergenerational ethics, which emphasize that current actions will impact the quality of life of current and future generations.

5.3.2 *Associated Building Characteristics:*

5.3.2.1 *Health, Safety, and Welfare*—Sustainable buildings protect and enhance the health, safety, and welfare of building occupants, neighbors, and the public throughout the building's life. For example, locating a building outside limits of a flood plain can reduce the potential for flooding not only of that structure but also of the flood plain. This approach supports the natural functioning of ecosystems and contributes to the overall health, safety, and welfare of the community.

5.3.2.2 *Transparency*—Sustainable buildings demand inclusiveness and transparency of purpose and method. Those who are potentially affected by the building should be provided with information and the means to contribute to the decision-making process. For example, engaging building occupants in the design process contributes to a broader, more informed decision-making process as well as an increased appreciation of the building objectives. This approach increases the understanding of building operations and can improve the operations of the building, especially as those operations may be affected by occupant actions.

5.3.2.3 *Equity*—Sustainable buildings protect and may contribute to local social and cultural values, traditions, and institutions. In addition, design and operation decisions can have impacts that extend far beyond the local community and have regional or global impact. These consequences of building-related choices should be identified. Sustainable building strives to minimize and equitably distribute local, regional, and global social impacts that occur throughout a building's life. For example, building with products from sustainably managed forests helps to ensure the continued viability of the logging culture and economy in those communities. This approach not only helps to maintain the forests as functioning ecosystems, but also helps to maintain the welfare of the communities that depend upon the forests for their livelihood.

6. Applied Sustainability Relative to Buildings

6.1 *Balance*—In applying the concept of sustainability, it is necessary to assess and balance three dissimilar, yet interrelated general principles—environmental, economic, and social—based on the best information available at the time the decisions are made. For buildings, this is further complicated by the length of time and span of distance affected by a building throughout its life-cycle.

6.1.1 Decisions should be based upon an ever-evolving knowledge base and an understanding of the complex interactions among economic, environmental, and social systems.

6.1.2 Decisions should be based upon local, regional, and global opportunities and challenges.

6.1.3 Decisions should be based upon the recognized and potential needs of current and future generations of all species.

6.1.4 Decisions should be based upon recognized and potential environmental, economic, and social impacts throughout the life-cycle of the building. The various life-cycle stages are:

6.1.4.1 Raw material extraction,

6.1.4.2 Product manufacturing,

6.1.4.3 Transportation of raw materials and products,

6.1.4.4 Siting,

6.1.4.5 Construction,

6.1.4.6 Use and maintenance,

6.1.4.7 End of initial service life,

6.1.4.8 Renovation,

6.1.4.9 Deconstruction (or demolition), and

6.1.4.10 Disposal.

6.2 *Methodologies*—A variety of tools and standards exist that qualify and quantify impacts of buildings, building materials, and building methods in terms of one or more of the general principles of sustainability. Applied sustainability requires data on the environmental, economic, and social impacts in order to find balance and inform the decision-making process.

6.2.1 *Environmental Assessment*—Life-cycle assessment (LCA) provides a formal process of examining the environmental impacts of a material, product, or service through its entire life-cycle. Instead of a single-attribute analysis of a material's environmental impact, such as its recycled content, LCA takes an holistic approach to assess the possible impacts of materials throughout their respective life-cycle.

6.2.2 *Economic Assessment*—Through a life-cycle cost (LCC) method the economic impacts of buildings can be assessed and estimated over the life of the structure. Building owners, designers, governmental entities, and interested parties can use life-cycle cost/benefit analyses to aid in making of decisions that advance sustainability of buildings. Through LCC, direct costs/benefits to the building owner or tenant and indirect external costs/benefits to the community or society can be estimated.

6.2.3 *Social Assessment*—Social assessment examines measurable change in: demographics, health, community and institutional structures, cultural and historical resources, employment/income characteristics, distribution of power and authority, and perceptions of risk, safety, and social well-being resulting from the proposed activity. Assessment attempts to forecast change(s) associated with the proposed activity, based on research and information accumulated from comparative studies of similar situations.

6.3 *Continual Improvement*—Implementation of one or more of the general principles does not provide a guarantee for sustainability. Nevertheless, without consideration for each of the principles, sustainability is almost impossible to achieve. In striving for sustainability, decisions and their implementation should be continually monitored, assessed, and adjusted, as necessary, in a process that incorporates continual improvement.

6.3.1 Continual improvement involves short-term, intermediate-term, and long-term goals and objectives.

6.3.2 Continual improvement requires goals and objectives appropriate to the affected geographical scale(s) such as personal areas, rooms, buildings, city blocks, cities, regions, and the earth.

7. Keywords

7.1 building; general principles; sustainability; sustainable building; sustainable development

APPENDIX

(Nonmandatory Information)

X1. INTERNATIONAL PERSPECTIVE AND CONTEXT

X1.1 Historical Overview

X1.1.1 The 1970s began a new era in domestic environmental law and international treaties. Most of these statutes and treaties addressed environmental concerns one at a time (ocean dumping, air pollution, endangered species, and so forth). After nearly two decades of implementing this limited, piecemeal approach to environmental protection, governmental and industrial leaders around the world began seeking a more holistic approach. These approaches became collectively known as "sustainable development." In 1987, the World Commission on the Environment and Development (also referred to as the Brundtland Commission), published *Our Common Future*, which included the definition of sustainable development that has been widely adopted in a number of documents, including this standard: "a form of development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

X1.1.2 As support for sustainability grew among nations, plans to hold an Earth Summit crystallized. In June of 1992, virtually all of the governments of the world, more than 100 of which were represented by their heads of state, gathered in Rio de Janeiro, Brazil. In Rio, conventions on climate change and biodiversity were adopted and negotiations for a convention to combat desertification were launched. Additionally, the Rio Earth Summit established sustainability as a goal leaders worldwide supported and agreed to work towards achieving.

X1.2 Industry Impacts

X1.2.1 Many industry leaders saw hope in the holistic framework offered by sustainability. This broad new framework needed to be further defined so that these industries could incorporate sustainable approaches to the varied types of work. A number of organizations around the world have undertaken efforts to develop tools to meet this market demand. This standard is one of those efforts.

X1.2.2 Many organizations have articulated sustainability principles. Five sets of such principles are referenced here. These were selected for reference because of the level of support they enjoy across nations and industrial sectors or their relevance, or both, to the building industry. Inclusion of these reference documents is not an endorsement of such documents by ASTM International.

X1.3 International Examples of Sustainability Principles

X1.3.1 The Rio Declaration on Environment and Development (1992)[4]

X1.3.2 Center For Environmentally Responsible Economies (CERES) Principles[5]

X1.3.3 The Natural Step System Conditions[6] (See also, Azar, Holmberg, and Lindgren, "Socio-Ecological Indicators for Sustainability," *Ecological Economics*, 18, 1996, pp. 89–112.)

[4] Available from United Nations Environment Programme (UNEP), United Nations Avenue, Gigiri, PO Box 30552, 00100, Nairobi, Kenya, http://wedocs.unep.org/handle/20.500.11822/19163?show=full.

[5] Available from Coalition for Environmentally Responsible Economies (CERES), 99 Chauncy Street, 6th Floor, Boston, MA 02111 USA, http://www.ceres.org.

[6] Available from The Natural Step, 25 One Community, 251 Bank St., #208, Ottawa, ON K2P 1X3, Canada, http://www.naturalstep.ca/four-system-conditions.

X1.3.4 The Hannover Principles[7]

X1.3.5 The World Business Council on Sustainable Development[8]

[7] Available from William McDonough at http://www.arch.virginia.edu/Hannover/hannover_principles.html.

[8] Available from World Business Council for Sustainable Development (WBCSD), Maison De La Paix, Chemin Eugène-Rigot, 2B, Case Postale 2075, CH-1211, Geneva 1, Switzerland, http://www.wbcsd.org.