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GREEN BUILDINGS:

AN OVERVIEW OF PROGRESS

CHARLES J. KIBERT*

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I. INTRODUCTION

A robust high performance buildings movement to rethink the built environment is rapidly emerging and affecting the design, construction, and operation of new buildings; changing the renovation process for existing buildings; and reshaping cities and communities. The terminology used here to describe the new type of facilities resulting from this rethinking is *high performance green buildings*. As is the case in many countries around the world, the movement in the U.S. is growing at an explosive rate and emerging on the radar screens of a wide range of actors, from developers to politicians, from designers to builders, from manufacturers to academics. This paper will provide some background on green buildings and a historical perspective on the international green building movement in general and the U.S. movement more specifically As is the case with any other truly serious effort, the roots of its existence are important to appreciate its evolution and current status.

High performance green buildings are facilities designed, built, operated, renovated, and disposed of using ecological principles for

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the purpose of promoting occupant health and resource efficiency plus minimizing the impacts of the built environment on the natural environment. In the context of green buildings, resource efficiency means high levels of energy and water efficiency, appropriate use of land and landscaping, the use of environmentally friendly materials, and minimizing the life cycle effects of the building's design and operation.

It should be noted at the outset that there is a wide variety of terminology used in the context of green buildings, the label *green* being just one of many possibilities. Perhaps the most complex terminology used is *sustainable construction* which encompasses the notion of green building, but, in the spirit of sustainable development, addresses the social and economic issues of habitat, as well as the community context of buildings. 'Green' buildings are a subset of sustainable construction, representing simply the structures. In effect truly sustainable 'green' commercial buildings that are designed to be sustainable in the sense of renewable energy systems, closed materials loops, and full integration into the landscape are scarce to non-existent. High performance green buildings represent the current state of best practices with respect to attempting to reach the Holy Grail of sustainable building. In the present era, green buildings generally represent incremental change rather than radical rethinking of the built environment. However this is an important first step and the green building landscape is populated with ever more experiments representing the trial and error process of getting to sustainable buildings.

The green building movement has had a major impact on building design, construction, and operation, as well as on the development and real estate markets. Considered just a small fringe activity on the periphery of construction - even in the late 1990's - green building design and construction is quickly becoming mainstream. Detailed knowledge of the process of developing green buildings and the various options for creating a green built environment are important knowledge for any organization procuring construction services. The number of buildings applying to the U.S. Green Building Council USGBC) for green building certification has been doubling each year since its implementation, from a few buildings in 1999 to 407 buildings in 2003. In terms of area, USGBC certified green buildings have grown in area from a few thousand square feet in 1999 to over 133 million square feet in 2003 (see Table 1). The exponential growth in buildings and building area marks the green building effort as an important and potent force in the construction and real estate markets. Federal and state governments, many cities, several universities, and a

growing number of private sector construction owners have declared green buildings to be their standard for procurement.

Year	1999	2000	2001	2002	2003
New Registered Green Buildings	0	45	267	331	407
Area, million SF	N/a	8.4	51	78	113
USGBC new members	115	309	649	1321	1634
USGBC total members	264	573	1076	2397	3616

Table 1: Growth of Green Building Movement in the U.S. (Source: www.usgbc.org)

II. BUILDINGS AND THE ENVIRONMENT

At the start of the 21st Century we are faced with human activities are having an enormous effect on the environment, ecological systems, and even on humans themselves. More thn any other human endeavor, the built environment has direct, complex, and long-lasting impacts on the biosphere. Materials impacts alone are enormous. Focusing on the U.S., construction and the production and manufacture of building components involves the movement of 6 billion tons of materials annually in the extraction of the basic materials needed for building. Some estimates are that as much as 90% of all materials ever extracted reside in today's buildings and infrastructure. Waste in the construction process is generated at the rate of about 0.5 tons per person each year in the U.S. or about 5-10 lbs per square foot (45-90 Kg per square meter) of new construction. Waste from renovation occurs at the 70-100 lbs per square foot level (318-900 Kg per square meter). The demolition process results in truly staggering quantities of waste with little or no reuse or recycling occurring.

We are literally at a crossroads where we have to make some difficult decisions and choices. There are many issues that threaten the existence of the human species, perhaps none more than global climate change. Energy is a major cause of climate change due to the release of carbon dioxide in the combustion of fossil fuels. The built environment is a major consumer of energy, using on the order of 30% of all primary energy in the U.S. The distribution of the built environment in the U.S. and the consequent need to rely on automobiles for movement between work, home, school, and

shopping result in disproportionate generation of carbon dioxide. Transportation consumes about 40% of primary energy in the U.S., much of linked to the how we distribute the built environment across the landscape.

Some would suggest that rather than a crossroads, a better metaphor would be a precipice. The increase in greenhouse warming gases has already produced temperature increases that are directly traceable to energy consumption of buildings and automobiles. Systems theory shows that the behavior of global systems such as climate are nonlinear. Each increase in carbon dioxide will not necessarily produce a proportional change in global temperature. The dynamic, chaotic character of the earth's climate is such that the climate can suddenly flip states, from one temperature regime to another in a relatively short time. The fossil record indicates that previous flips have occurred, with temperature increasing or decreasing almost 10 degrees Fahrenheit in about a decade. Climate change is just one of several effects that should be worrisome to humanity. Others include loss of biodiversity, loss of topsoil, depletion of major fisheries, toxification of soil, water, and air due to the release of tens of thousands of synthetic chemicals, some of which mimic natural hormones, causing havoc in both animal and human reproductive systems.

A. Conventional Versus High Performance Building Design

High performance green buildings are succeeding in their rapid, exponential penetration of the U.S. construction market for three basic reasons.

First, they are the ethical response to both global and local environmental and resource issues, the 'right' way to approach construction. A typical, code compliant building makes minimal efforts to address energy and water issues and totally ignores materials waste, impacts on the construction site and any other issue not specifically covered in the building codes. As has often been noted, if these buildings were built any cheaper, they would be against the law. Green buildings take a far different approach. Environmental impacts and resource consumption are of primary importance in the design and construction process. The entire life cycle of the building and its constituent components are carefully considered. For materials, architects and other design professional consider the entire life of the product, from resource extraction to use in the building and disposal at the end of its useful life. What happens in the factory producing building products is considered to be as important as its performance in the building. Emphasis is on renewable resources for energy systems; recycling and reuse of

water and materials; integration of native and adapted species for landscaping; passive heating, cooling, and ventilation; and a wide range of other approaches that minimize environmental impacts and resource consumption.

Second, green buildings make economic sense, not always on a capital or first cost basis, but virtually always on a life cycle basis. Sophisticated energy conserving lighting systems and air-conditioning systems with exceptional response to building and outdoor conditions will cost more than their conventional, minimal code-compliant counterparts. Rainwater harvesting systems that collect and store rainwater for non-potable purposes are an additional new system that will cost more money due to the need for additional piping, pumps, controls, storage tanks and filtration components. However most of the key features of a green building will provide a payback on their original investment within a relatively short time. As energy and water prices rise due to increasing demand and diminishing supply, the payback period will become much shorter. Life Cycle Costing (LCC) is an important evaluation technique that provides a consistent framework for evaluating alternative systems to determine their life cycle performance.[1]

Third, green buildings squarely address the spotty performance of conventional buildings with respect to human health. There is ample evidence that on the order of 40% of all illnesses can be traced to buildings and homes where people live, work, or attend school, church or sporting events. Conventional construction, unless forced to by lawsuits, generally ignores issues of Sick Building Syndrome (SBS) or Building Related Illness (BRI). Green buildings meet the challenges of building health directly and provide several layers of consistent approaches that promote occupant health. Some examples are the protection of ductwork during construction, specifying finishes with low to zero volatile organic components, and more attention to the precise sizing of heating and cooling components.

B. Green Building Organizations

The advent of green buildings has been drive by a wide variety of organizations around the world. Some of the key American organizations driving this shift in thinking have been the U.S Green Building Council, the U.S. Department of Energy, the

1. Greg Kats, *Cost and Benefits of Green Buildings*, A Report to California's Sustainable Buildings Task Force, October (2003); Greg Kats, *Green Building Costs and Financial Benefits*, Capital E, Inc. A Report for the State of Massachusetts (2003).

National Association of Home Builders, the Department of Defense, and other public and non-profit companies. The private sector has been led by several manufacturers, for example Interface Flooring whose Chairman, Ray Anderson, guided its transition from being a conventional carpet tile manufacturer to one that based its corporate philosophy on industrial ecology. The convergence of the work of these organizations over the past decade has resulted in a green building movement with a wide variety of available products. On the international scene, iiSBE (International Institute for a Sustainable Built Environment), has take the lead in the arena of building assessment and trying out new ideas in a reasonably large number of countries. RILEM and CIB are other organizations that have or had had a strong presence in the green building movement. The following paragraphs describe these organizations in more detail.

C. U.S. Experience

In the U.S. there are a wide variety of green building organizations. In the commercial building arena, the prime green building organization is the U.S. Green Building Council (USGBC). Homebuildng and residential development are represented by a proliferation of organizations, many of which preceded the USGBC and which sprang up independently in homebuilding organizations and municipalities around the U.S. The city of Austin, Texas is perhaps best known for its efforts in green building and was the recipient of an award at the first U.N. conference on sustainable development in Rio de Janeiro in 1992. Local residential green building movements rapidly emerged in Denver, Colorado; Kitsap County, Washington; Clark County, Washington; the Baltimore Suburban Builders Association; and more recently the EarthCraft Houses Program in Atlanta. The National Association of Homebuilders took note of this movement and issued guidance available to its 800 state and local associations, informing them on how to create a green building program in their local area.

Local and state government have been highly involved and very effective in the promotion of green building. Boulder, Colorado took an aggressive stance in 1998 with respect to green building by passing an ordinance requiring specific measures. Several U.S. states have made significant efforts to promote green building. For example, Pennsylvania established Governor's Green Government Council (GGGC) in part to address the implementation of green building principles in the state.

The key source of key information and critical analysis for the green building movement in the U.S. is *Environmental Building*

News, a monthly newsletter published by Build Green. Build Green also produces GreenSpec, a directory of products addressed to high performance building needs and the Green Building Advisor, software that assists the decision making process in the design of green buildings.

D. International Efforts

Perhaps the key organization engaged in green building on an international basis is a relatively new one, the International Institute for a Sustainable Built Environment (iisBE). iiSBE main efforts at present is to provide a portal for a wide range of green building information. iiSBE also has take over organization of the biannual Green Building Challenge and Sustainable Building Conference, the most recent recent of which were held in Oslo, Norway in 2002. iiSBE also serves as the center of international activity in efforts related to sustainable building assessment, especially with its main assessment method, Green Building Tool (GBT). GBT is used at these biannual conferences to assess or rate entrants from numerous national exemplar buildings worldwide.

III. HISTORY OF THE GREEN BUILDING MOVEMENT

Prior to addressing the details of green building, it is useful to know about the roots of this movement, both technically and philosophically. Green building in the U.S. has two distinct histories, one that emerged in the 1990s and the roots of the movement that can be traced back to the 19th century.

The U.S. green building movement can be traced to the same seeds as the country's environmental movement. The first Earth Day in 1970 and the creation of the U.S. Environmental Protection Agency in the same year are probably the key events marking the start of a major shift in thinking that has resulted in the current state of affairs. Rachel Carson's book *Silent Spring*, the efforts of a wide range of early environmentalists such as Barry Commoner, Lester Brown, and others laid the foundation for these events. The oil shocks of the early 1970's, a result of the Arab-Israeli conflicts of that era, marked the first serious concern about resources, more specifically American reliance on oil. The result was an explosion of interest in energy efficiency, solar technologies, retrofitting homes and commercial buildings with insulation, and energy recovery systems. The federal government provided tax credits for solar energy investments and innovative technologies as wide-ranging as solar air-conditioning and eutectic salt energy storage batteries were developed and tested. By the late 1970's, many of these efforts became standard practice and were embodied in model

energy codes adopted by the states. However the intense interest in saving energy abated, largely as a result of falling relative energy prices. A renewed interest in resource conservation, including energy, reemerged in the early 1990s as a consequence of a complex array of effects such as the publication of *Our Common Future*, commonly referred to as the Bruntland Report in 1987, the AIA meeting in 1989 and the establishment of its Committee on the Environment (COTE), and the United Nations Conference on Sustainable Development in 1992, commonly known as the Rio Conference. For the first time humans were beginning to seriously wrestle with global environmental issues such as ozone depletion, global climate change, destruction of major fisheries, and others. Energy concerns became more complex. While the 1970's energy movement focused on dwindling supplies of fossil energy, the current response is far more complex due to concerns with global environmental impacts.

The recent history of the American effort can be traced to several events that occurred in the early 1990's, among them the joint meeting of the International Union of Architects (UIA) and the American Institute of Architects (AIA) in Chicago in 1993. One of the outcomes of the UIA/AIA World Congress of Architects was the Declaration of Interdependence for a Sustainable Future.

Subsequently the AIA formed its Committee on the Environment. The USGBC was formed in 1993 in Washington, DC and held its first meeting in March 1994. At about the same time efforts in other countries were emerging and interacting with American efforts. The British green building rating system, BREEAM (the Building Research Establishment Environmental Assessment Method) was developed in 1992. Several task groups within an international construction research networking organization, Conseil International du Batiment (CIB), headquartered in Rotterdam, formed in 1992, most notably Task Group 8 (Building Assessment) and Task Group 16 (Sustainable Construction). In 1994, these Task Groups both held international meetings on this emerging effort in the U.K. and Tampa, Florida respectively. The first efforts at producing the LEED Standard appeared at about this time along with an effort to develop green building standards by the American Society for Testing and Materials (ASTM). The ASTM effort was eventually set aside as the USGBC's effort to create an American Green Building Standard moved to the forefront.

In the U.S., the renovation of Audubon House in New York City in 1992 was one of the first if not the first building that marks the start of the contemporary green building movement. It was not designed using LEED as the guideline for its creation because

LEED did not emerge on the scene until the late 1990s. Consequently, it like many other buildings of this era were designed by architects who were in essence laying the foundation for LEED. Green building in the U.S. has two distinct histories, one that emerged in the 1990s and the roots of the movement that can be traced back to the 19th century.

Supporting disciplines that address the various life cycle stages of the built environment are emerging to support the shift to green building (See Table 2). Planning in a sustainable fashion can use the emerging concepts of New Urbanism (NU), Transit-Oriented Development (TOD) and/or Conservation Subdivision Design. New Urbanism, alternatively referred to as Traditional Neighborhood Development (TND), proposes to replace the typical American suburban dominated urban landscape with urban landscapes that mimic the classic, pedestrian, mixed use, mass transit dominated cities people cherish. These include European cities such as Paris, London, and Rome, to name a few, and American cities such as New York, Boston, and Chicago. Cities such as Atlanta and Los Angeles are cited as the antithesis of the classic city because the automobile becomes the dominant species accompanied by dehumanizing sprawl. Conservation Subdivision Design, proposed by Randall Arendt, directly tackles the issue of suburbs by proposing homes be concentrated on smaller sites and that the land saved as a result be set aside as biological preserve that also has the function of providing environmental amenity.[2]

2. Randall Arendt, *Creating Greener Communities through Conservation Subdivision Design*, In Reshaping the Built Environment, Charles J. Kibert, Ed., Washington, D.C.: Island Press (1999).

Table 2 Conventional Built Environment Life Cycle Stages Compared to Sustainable Construction Stages

Life Cycle Stage	Conventional Built Environment	Sustainable Construction
Planning	Urban Design	New Urbanism Transit Oriented Development Conservation Subdivision Design Biourbanism Bioregionalism
Design	Conventional Architecture Conventional Landscape Architecture Conventional Interior Design Conventional Engineering	Ecological Design
Construction	Building Construction	'Green' Building Construction
Operation	Facilities Management	'Green' Facilities Management
Renovation/Retrofit	Conventional Design	Ecological Design
Disposal	Demolition	Deconstruction

Incorporating ecosystems into the urban fabric is addressed in Biourbanism while at large scale, Bioregionalism performs much the same role.[3] Ecological Design is the foundation of the design stage of the life cycle, covering architecture, landscape architecture, interior design and engineering (civil, structural, mechanical, and electrical). Ecological design is also applicable to building changes during the operational phase.[4] The construction and operational stages do not specifically have 'green' approaches associated with

3. Daniel Williams, *Biourbanism and Sustainable Urban Design*, In Reshaping the Built Environment, Charles J. Kibert, Ed., Washington, D.C.: Island Press (1999).

4. Van der Ryn, Sim and S. Cowan, Ecological Design, Washington, D.C.: Island Press (1996); Van der Ryn, Sim and Rober Peña, *Ecological Analogues and Architecture*,In Construction Ecology: Nature as the Basis for Green Building, Charles J. Kibert, Jan Sendzimir, and G. Bradley Guy, Eds. London: Spon Press (2002).

them, but these are certain to emerge in the near future. At present it is sufficient to refer to these as Green Building Construction and Green Facilities Management. Renovation and retrofit are again covered by Ecological Design. Building disposal at the end of a building's useful life, in a sustainable senses, can occur using the emerging new approach know as Deconstruction.

IV. SUMMARY AND CONCLUSIONS

The green building movement is growing rapidly in the U.S. and many other countries around the world. The USGBC's LEED building assessment standard has emerged as the document that essentially defines green buildings in the U.S. and also in several other countries around the world. Progress in green building is remarkable, with the number of green buildings doubling each year, with new products and services rapidly growing to meet the demand for ecologically compatible approaches. Despite the progress in creating green buildings, there is still much to be done with respect to understanding the concept of ecological design and the integration of natural systems with the built environment. The key to success in green building and the development of a coherent philosophy will be understanding how to create a synergistic relationship where natural systems perform services for buildings and where the built environment in turn provides support and nutrients for natural systems. In spite of its drawbacks, the green building movement has made substantial progress in the last decade and the effort to create environmentally responsible facilities is showing great progress and gaining momentum.

V. GREEN BUILDING RESOURCES

Building Research Establishment (BRE) www.bre.gov.uk
BRE is the national United Kingdom building research institution and the developer of the Building Research Establishment Energy and Environmental Assessment Method (BREEAM), the first successful tool of this type ever developed. Later building assessment methods such as the USGBC's LEED building assessment method are roughly based on the approach take by the BRE.

Conseil International du Batiment (CIB) www.cibworld.nl
CIB is an international construction research networking organization with members from national building research laboratories, universities, and corporations. Over the past decade it has been a leader in promoting sustainable construction through

its various Working Commissions (W) and Task Groups (TG). CIB TG8 (Building Assessment), later CIB W100, and CIB TG16 (Sustainable Construction) were in the forefront of developing frameworks for sustainability in the built environment and tools for rating buildings. Links to the various CIB groups addressing green building issues are available on the CIB website.

International Initiative for Sustainable Built Environment (iiSBE) www.iiSBE.org
iiSBE is an international non-profit organization whose overall aim is to actively facilitate and promote the adoption of policies, methods and tools to accelerate the movement towards a global sustainable built environment. Its objectives include: (1) Mapping current activities and establishing a forum for information exchange on SBE initiatives, so that gaps and overlaps may be reduced and common standards established; and (2) increasing awareness of existing SBE initiatives and issues amongst the international buildings and construction community. iiSBE also manages the Green Building Challenge process, a biannual international conference in which the best examples of green buildings around the world are displayed and compared to one another using GBTool, a building assessment method developed for this purpose.

U.S. Green Building Council www.usgbc.org
The USGBC is the primary green building organization in the U.S. and promulgates the Leadership in Energy and Environmental Design (LEED) suite of building assessment standards. It is far and away the leading U.S. green building organization and arguably the most successful in the world at mobilizing stakeholders to promote this new building delivery system.