Whole Building Design Approach to Achieve High Performance Buildings

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The goal of the "Whole Building Design Approach" is to create a successful high performance building by applying an integrated design and team approach to the project during planning and programming phases (Whole Building Design). In residential buildings, to achieve success in building a high performance building, the project must consider sustainability.

Sustainability is defined as the "quality of not being harmful to the environment or depleting natural resources, and thereby supporting long-term ecological balance" (Dictionary.com). Practicing sustainability means being conscious of our actions and taking responsibility of maintaining our natural resources to protect the harmonious balance with our surroundings while taking into consideration our environmental, economic, and social values — the triple bottom line of sustainability.

Environment

Our environment (a physical system consisting of exchanged mass, energy, or other properties) is changing and demanding that we adapt to the changes we are experiencing, i.e., climate change. What is at risk if we choose not to preserve the environment? See below the major trends of the environment, its natural resources and the impacts of building development on people:

> The global average temperature has increased by 0.76°C (0.57°C to 0.95°C) between 1850 to 1899 and 2001 to 2005, and the warming trend has increased significantly over the last 50 years. While this report focuses on the energy sector, forest clearing and burning and land use change, and the release of non-CO2 gases from industry, commerce and agriculture also contribute to global warming (IPCC, 2007b). In the absence of additional climate policies, the IPCC (2007a; see Figure 1.4) projected that global average temperature will rise over this century by between 1.1°C and 6.4°C over the 1980 to 1999 average, depending on socioeconomic scenarios (IPCC, 2000).
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> GHG [greenhouse gases] emissions associated with the provision of energy services are a major cause of climate change. The AR4 concluded that "Most of the observed increase in global average temperature since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations". (IPCC, 2007)
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> Heat is already the leading cause of weather-related deaths in the United States, with more than 6,300 deaths resulting from exposure to extremely hot weather between 1979 and 2006. Rising temperatures, however, might result in fewer deaths from extreme cold.
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> On average, we spend about 90 percent of our time indoors, where pollutant levels are often higher than those outside. Indoor pollution is estimated to cause thousands of cancer deaths and hundreds of thousands of respiratory health problems each year. In addition, hundreds of thousands of children have experienced elevated blood lead levels resulting from their exposure to indoor pollutants. An estimated 17 million Americans suffer from asthma (U.S. EPA 1999). In addition, about 5,000 deaths occur yearly from asthma—an increase of 33 percent in the last decade (Mannino et al. 1998).

The U.S. Environmental Protection Agency (EPA) found that indoor air pollution, commonly called sick building syndrome, costs businesses $60 billion annually.

In the mid-1990s, one in five U.S. schools reported unsatisfactory indoor air quality, and one in four schools reported ventilation as unsatisfactory.

Buildings in the United States contribute 38.9 percent of the nation's total carbon dioxide emissions, including 20.8 percent from the residential sector and 18.0 percent from the commercial sector (2008). (U.S. Department of Energy, 2008)

Buildings accounted for 72 percent of total U.S. electricity consumption in 2006 and this number will rise to 75% by 2025. 51 percent of that total was attributed to residential building use, while 49 percent was attributed to commercial building usage. (U.S. Department of Energy, 2008)

Of the 26 billion gallons of water consumed daily in the United States, approximately 7.8 billion gallons, or 30 percent, is devoted to outdoor uses. The majority of this is used for landscaping. The typical suburban lawn consumes 10,000 gallons of water above and beyond rainwater each year. (U.S. EPA)

The information provided is presented only to make aware the relationship between the built and the natural environment; and the importance of addressing these issues in residential building. When these factors are considered during each stage of development (planning, integrated building design & construction, commissioning, building systems, management and operations) the value on improved health, natural settings and productivity is substantial. Ian McHarg's book, *Design with Nature* encouraged Americans to map and understand wetlands, floodplains, soils, hillsides, erosion-prone areas, and vegetation patterns before starting to lay out buildings and roads (Duerksen, 2009). We can make the choice to enhance our quality of life and serve the needs of residents without compromising our natural environment (our means of survival).

Society

In recent years communities have incorporated sustainable comprehensive plans and developers are supporting green building; identifying the correlation between our natural and built environment. A Comprehensive Plan is a guide used by land use planners to determine the goals or vision of a community development. The guide can be used to dictate public policy in housing, utilities, land use, recreation, etc. A Sustainable Comprehensive Plan takes into consideration the built environment on the surrounding natural environment and larger community, seeking to balance the quality of life, resource conservation and economic vitality. For example, communities such as Greensburg, KS, and the City of Northampton, MA have adopted a sustainable comprehensive plan seeking to be humble stewards of the earth's resources to offer higher quality of life for future generations. The citizens of Greensburg, KS, and the City of Northampton, MA have taken a sustainable approach in guiding the building of their communities; it includes aligning city programs, public/private projects, and government initiatives in developing the sustainability plan. Their plans lay out their goals, guiding principles, and measurements of progress.

The demand and cost of energy is rising as building owners are seeking creative ways to offset growing operating cost. Buildings accounted for 72 percent of total U.S. electricity consumption in 2006 and this number will rise to 75% by 2025; 51 percent of that total was attributed to residential building use, while 49 percent was attributed to commercial building usage (U.S. Department of Energy, 2008). The construction and operation of buildings account for about forty percent of worldwide consumption of raw materials and energy (The Economics of Green Building, 2005). Occupants, building managers, and investors are affected by the impacts of energy cost as well. Residents today are faced with difficulties in maintaining the American dream of home ownership. Community involvement in development has increased due to these concerns. For example, the community residents and stakeholders are recommending the project development proposal of a D.C. lot located in the Shaw Neighborhood to consider architectural excellence, planned unit development [PUD], affordable housing units, variety of unit mixes, LEED certification, retail space, improvement of streetscape, and local presence and hiring. The partnership between the District government, Advisory Neighborhood Commission (ANC) and local community organizers are seeking to revitalize the District's neighborhood business districts through a preservation-based strategy for attraction of preferred neighborhood uses. The District of Columbia is known for community participation in policies and programs affecting their neighborhoods, including traffic, parking, recreation, street improvements, zoning, economic development, police protection, sanitation and trash collection, and the District's annual budget.

Economics

The U.S. green building market continues to accelerate, according to McGraw-Hill Construction's 2013 Dodge Construction Green Outlook report. The value of green building has seen growth from $10 billion in 2005 to $78 billion in 2011. In 2012, the total market — non-residential and residential — is expected to be worth $85 billion, and by 2013, overall new green building is projected to rise to between $98 billion and $106 billion. It is expected that by the end of 2012, green homes will comprise 20 percent of the market, and in 2013 a 22-25 percent share by value is expected, equating to a $34-$38 billion opportunity (Greensburg Sustainable Comprehensive Plan). As the U.S. economy continues to grow while population and energy use increases there will be greater need for housing. For example, according to the statistics provided by the Office of Planning, the District of Columbia is adding about 1,100 residents per month and 70 percent of those new residents are under the age of 35. This creates a demand for smaller and furnished units especially since it is likely that newer residents will be moving in with less furniture and materials. Delta Associates CEO Greg Leisch believes a rise in rents would keep multifamily a healthy investment for years to come. Dr. Stephen Fuller, George Mason University's Center for Regional Analysis, also projects that housing will bounce back in 2014 and 2015.

There are several proposed and active decision making opportunities that support the economics of high performance residential buildings such as policies and planning tools. As presented in the Sustainable Comprehensive Plans of Greensburg, KS, and the City of Northampton, MA, decisions are made from community planning efforts. The outcome of planning usually dictates public policy and may lead to the formation of private/public partnerships. There are also regulations that guide residential building decisions such as zoning. Just as coordination of environmental review (includes natural, cultural and historic resources) involve interagency and public participation to be efficient and effective in federal

planning and project development, the same is needed for residential building planning. The coordination of regulations such as green building codes to involve interdisciplinary design fields and public participation to develop high performing residential building projects are needed.

Today, government action encourages and support sustainable planning and building. For example, there are public policies referencing various LEED initiatives including legislation, executive orders, resolutions, ordinances, policies, and incentives found in 45 states, including 442 localities (384 cities/towns and 58 counties), 35 state governments (including the Commonwealth of Puerto Rico), 14 federal agencies or departments, and numerous public school jurisdictions and institutions of higher education across the United States. (U.S. Green Building Council, 2010) In comparison to the average commercial building, green buildings consume 26% less energy, have 13% lower maintenance costs, 27% higher occupant satisfaction, and 33% less greenhouse gas emissions. (USGBC, 2008)

The challenges we find in the availability of research information on energy efficient buildings to offset energy consumption, green features and technology such as environmentally sensitive construction techniques and materials are an opportunity for economic revitalization. The U.S. Department of Energy's Energy Innovation HUBs attempt to cultivate innovation in areas of energy science and engineering. The primary focus of the HUB is to provide tools for integrated design, identify sub-system components and controls, diversify workforce development, develop public policy, and promote education and management of knowledge. Finding contractors with sustainable design experience and locally manufactured sustainable materials are scarce. There is also a mistaken belief that green building is costly and excessive compared to standard building. Research shows that green building will support 7.9 million U.S. jobs and pump $554 million into the American economy over the next four years (2009-2013). (USGBC , 2009) Energy efficiency retrofits in Philadelphia could spur $618 million in local spending and support 23,500 area jobs according to a recently released report conducted by Philadelphia-based Econsult Corporation and commissioned by the Greater Philadelphia Innovation Cluster (GPIC) for Energy-Efficient Buildings. (Energy, 2011) Perceived cost benefits of green building according to building owners are; operating costs decrease 13.6% for new construction and 8.5% for existing building projects, building value increases 10.9% for new construction and 6.8% in existing building projects, return on investment improves 9.9% for new construction and 19.2% in existing building projects, occupancy increases 6.4% for new construction and 2.5% in existing building projects, and rent increases 6.1% for new construction and 1% in existing building projects. (USGBC, 2008) This information shows that green features enhance marketability, justify higher rents and asset value, and are in demand.

Whole Building Design Approach Process

In order to understand the need for high performance residential buildings one must understand the relationship between people, the built environment, and the natural environment. Once these factors are considered, specific to a residential building's location, the integrated design team can be effective in creating a sustainable high performing building. High Performance Buildings are energy efficient, have limited environmental impact, and operate with the lowest possible life-cycle costs. (Whole Building Design) Green building, green architecture, sustainable building, high-performance building, and low-

impact development are among the terms used to denote practices that reduce the environmental impact of components of the built environment. (FPC State Government)

The characteristics of green building may consist of:

SUSTAINBLE SITE

- ✓ Bicycle parking to encourage bicycling to work and a healthy lifestyle
- ✓ Designated preferred parking spaces are available for hybrids and fuel efficient/low emitting cars
- ✓ Abundant green open space; green roof, roof top deck and open green space at ground level
- ✓ Located within walking distance of transit; Metro, bus stops, and bike share

WATER USAGE

- ✓ Water efficient fixtures and low flow urinals in restrooms which will reduce water use creating savings in operating expenses

ENERGY EFFICIENCY

- ✓ Thermal efficient building envelope integrated with mechanical requirements; reducing perimeter heating and size of HVAC unit
- ✓ Contract to purchase green power from clean and renewable sources
- ✓ High- efficiency lighting design and enhanced penetration of daylight
- ✓ Efficient building design practices that allow for less energy consumption resulting in cost savings i.e. cross ventilation and selecting building products for durability and design for adaptability
- ✓ Program fundamental and enhanced commissioning to better the performances of the building systems over its life time
- ✓ Provide ongoing accountability of building electricity performance i.e. building management system and benchmarking program, EPA Energy Star Portfolio Manager

INDOOR AIR QUALITY

- ✓ Indoor Air Quality (IAQ) Management Plan was developed and implemented for all development phases
- ✓ Low-emitting/low-VOC materials (formaldehyde free wood products, paints and adhesives) used to reduce indoor air contaminants
- ✓ Entry systems to capture pollutants are included in the design
- ✓ HVAC system designed to meet Thermal Comfort Conditions for Human Occupancy and Acceptable Indoor Air Quality i.e. Dedicated Outdoor Air System (100% outdoor air)
- ✓ Energy Star lighting and appliances

RENEWABLE MATERIALS

- ✓ More than 50% of non-hazardous construction and demolition debris recycled and salvaged
- ✓ Certified wood used in at least 50% of wood
- ✓ Specified and procured new regional materials that contained recycled content
- ✓ At least 20% of new materials obtained from local/regional manufactures; preference given to local and regionally extracted materials when possible i.e. reclaimed wood cabinetry
- ✓ Central area dedicated to the collection and storage of materials for recycling including paper cardboard, glass, compost and plastic bottles
- ✓ Green cleaning and integrated green landscape adopted to maintain the building

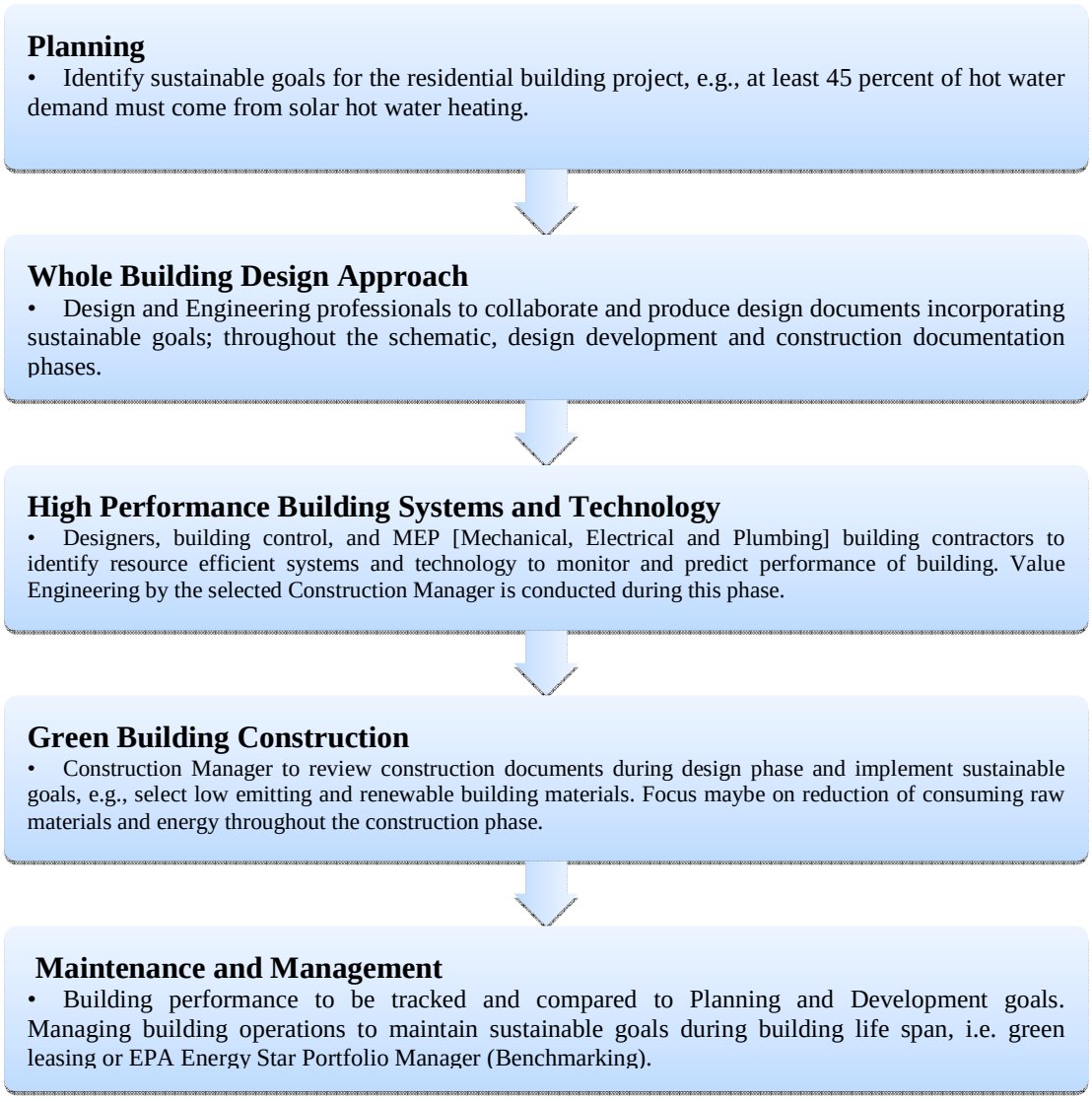
This approach was used on a much smaller scale on the U.S. Department of Energy Solar Decathlon project; challenging academic teams to design and build solar-powered houses. The objective is to build an affordable, attractive and energy-efficient home while considering comfort, healthy indoor environment, sufficient hot water, and producing more energy than it consumes. The teams are judged on aesthetic features, affordability, consumer appeal, and design quality with energy efficiency. This program not only benefits the students and participants involved, but also homeowners, building professionals, developers, designers, and teachers.

Figure 1 – U.S. Solar Decathlon – Solar Home

The University of Maryland received first place for their WaterShed home on Friday, Sept. 30, 2011; pictures shown in Figure 1. The WaterShed is able to manage storm water onsite with the use of a green roof; and to monitor indoor air quality, use of water and energy by means of an automation system. Its solar panel system, mechanical system and effective building envelope were engineered to reduce the need for fossil fuel. This high performing home was designed for the Washington DC area climate.

The Whole Building Design Approach structure will allow the integrations of services from the design to operation and maintenance phase; architect, interior designer, engineers, construction manager, and building operators. Unlike traditional delivery methods, the collaborative process brings together the owner, designer, and builder at the beginning of the project and promotes participation from all parties at all project stages (Integrated Project Delivery). The construction manager will be available as early as the design phase to provide input such as value engineering, cost comparison information or guidance on performance of proposed systems. A few advantages that this structure has over traditional methods

of procurement are lower project cost, ability to handle project changes more easily, and places emphasis on building relationships. The phases involved in this approach are a multifaceted process. There are initiatives that can take place at each phase to improve energy efficiency in buildings or encourage high building performance while reducing the usage of natural resources, a diagram explaining this process is shown below:



The project development team can include the developer, land owner, architect/design team, construction contractor, consultants, traffic engineer, legal counsel, etc. Each field offer a wealth of knowledge where opportunities such as charrettes can provide the outlet to share expertise and building information while creating a channel to interact and execute decisions in developing a high performance building. Technology, design tools, and building information models can help facilitate the Whole Building Design Approach. For example the electrical engineer, lighting consultant and designer for the building envelope can design the performance and systems of a building during the summer

months; focusing on ways to reduce overdesign and over usage of resources. The design team to be selected to carry out the sustainable design intent must be experienced with high quality green design and be familiar with latest building technology as well as have a good working relationship with private and public sector. The design team will be expected to have a qualified team of building architects, interior designers, mechanical/electrical/plumbing engineers, structural engineers, civil engineers, and landscape engineers. For example, The Advanced Commercial Buildings Research group at the National Renewable Energy Laboratory (NREL) develops and utilizes advanced energy modeling tools [Opt-E-Plus Software] to help architects, engineers, and facility managers understand the energy implications of their designs and maximize the efficiency of their buildings (Opt-E-Plus Software). This team will work closely with other disciplinary groups such as a green roof consultant, within the development team, to reduce overdesigning and over usage of resources. In constructing a green building, precautions must be taken to ensure the design intent is communicated effectively and efficiently to the construction management team. The construction contractors to be selected will be expected to have a professional working relationship with other project stakeholders, allowing flexibility in appointing individual sub-contractors and be highly skilled in advanced building technology systems. The construction team will be expected to be knowledgeable in the latest building codes that influence green building, experienced in green construction, and available for value engineering during design phase. The District of Columbia Green Building Act of 2006 defines a green building as an integrated, whole building approach to the planning, design, construction, operation, and maintenance of buildings and their surrounding landscapes that help mitigate the environmental, economic, and social impacts of buildings, so that they are energy efficient, sustainable, safe, cost-effective, accessible, healthy, and productive. The development team can use this definition as a project goal using the whole building design approach for implementation.

Incentives can stimulate the adoption of sustainable goals for residential building projects. For example, performance based fees based on the level of performance of the building can be included in the request for proposals for each discipline; architect/engineers, construction contractors, commissioning agent, etc. The U.S. Department of Energy provides a resource guide in procuring these services to ensure energy efficiency and sustainability goals are met (Office of Energy Efficiency and Renewable Energy). The Harvard University Office for Sustainability provides guidance on green building request for proposal language (Owner's Project Requirement).

Conclusion

The Whole Building Design Approach intends to synthesize economic, environmental and social impacts of residential development while protecting and ensuring the health, safety, and welfare of the people. The information provided seeks to educate, involve and support the public in sustainable residential building development and reducing resource consumption, encourage the development community to advance the practice of high performing buildings, promote the improvement of policies affecting these practices, and inspire smart growth and smart life principles.

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