Green Design of Residential High-Rise Buildings in Livable Cities

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Abstract
This paper illustrates the interdependency of the sustainable design of high-rise residential buildings and their urban habitats. It argues that increased density is commensurate with the goals of sustainability and fosters a livable city with residences, goods, and services concentrated onto a smaller land area. Green design for buildings is achieved by adopting certain strategies such as passive solar gain, high performance façade technology, solar energy, wind energy, fuel cells, smart materials, etc.

LEED criteria, which have been written primarily for commercial and institutional buildings, are just beginning to be applied to multi-family residential buildings. With more residential high-rise buildings being constructed in cities, there is a need for more specialized criteria to address sustainable design. Significantly, LEED does not address social sustainability that encompasses community development, social infrastructure, demographics, and social integration. Also, ecological sustainability is not explicitly considered in LEED criteria. That is to say, the space-defining characteristics of high-rise residential buildings and their conformity with the natural surroundings and environmental impact on the city must be considered. Social sustainability and community development, in conjunction with the design of buildings and infrastructure, determine the livability of cities and effect high-rise residential living. The paper will present some propositions in this regard. Case study examples, such as The Solaire located in Battery Park City in New York and The Helena, also in New York City, demonstrate how sustainability and livability are achieved through resource conservation, passive and bioclimatic design, and technological innovation. The paper concludes that the livable city is intrinsically related to the design and integration of sustainable principles applied to high-rise residential buildings and their urban environments.

Introduction
There is widespread agreement among climate scientists today that human activity mainly through the burning of fossil fuels is one of the principal contributors to climate change (Smith, 2005). In a report prepared for the LEED-ND Core Committee, the authors established a relationship between public health and the built environment. They found a direct correlation between the automobile and public health. The compactness of land uses and the organization of the transportation system determine, to a large extent, how much individuals drive. “The more sprawling and disconnected that houses are from workplaces and shops, the more miles and hours individuals must travel to get from one place to another. If there are no reasonably convenient or affordable alternatives to driving then all of those hours traveling will be spent behind the wheel of a car” (Ewing and Kreutzner, 2006). Their findings indicate that organization of the environment
affects travel, both in the form of vehicle trip rates and distances traveled. The pollutants that have been attributed to vehicle travel include carbon monoxide (CO), particulate matter (PM), and other toxins, which are harmful in their own right; as well as nitrogen oxides (NOx) and volatile organic compounds (VOC), which combine to form ozone (Frank et al., 2000).

The core of the carbon dioxide (CO2) emissions problem lies in the disparity between the industrialized and developing countries in terms of CO2 emission per individual. The USA at twice the European average is still increasing its emissions which currently stand at 23 percent of the world’s total (Smith, 2005). The Kyoto Protocol, signed by over 187 countries in 1997, pledged to cut CO2 emissions by more than 5.2 percent globally based on 1990 levels. But one great anomaly is that air travel is excluded from the calculations of CO2. It is estimated that by 2050 air transport will be responsible for two thirds of all greenhouse gas emissions in the UK alone (Smith, 2005).

Buildings being designed now will, in most cases, still be functioning when fossil fuels are depleted. By 2010, the projected fuel mix for the UK will be:

- Coal 16 percent
- Nuclear 16 percent
- Renewables 10 percent
- Gas 57 percent.

The pressure to incorporate the external costs such as damage to health, buildings, and above all the biosphere into the price of fossil fuels will intensify as the effects of global warming become increasingly threatening.

The U.S. Green Building Energy Council (USGBC) has created the Leadership in Energy and Environmental Design (LEED) Rating System as the nationally accepted benchmark for the design, construction, and operation of high performance green buildings. LEED gives building owners and operators the tools they need to have an immediate and measurable impact on their buildings’ performance. LEED promotes a whole-building approach to sustainability by recognizing performance in five key areas of human and environmental health:

1) Sustainable site development,
2) Water savings,
3) Energy efficiency,
4) Materials selection, and
5) Indoor environmental quality.

LEED provides a roadmap for measuring and documenting success for every building type and each phase of a building lifecycle (USGBC, 2007).

The LEED Rating System was created to transform the built environment to sustainability by providing the building industry with consistent, credible standards for what constitutes a green building. LEED for New Construction and Major Renovations is a green building rating system that was designed to guide and distinguish high-performance commercial and institutional projects, with a focus on office buildings. Although it has been applied by practitioners to other building types, it has limitations when applied to evaluating high-rise residential buildings. With more residential high-rise buildings being constructed in cities, there is a need for more specialized criteria to
address sustainable design. LEED is currently developing a residential set of ratings, but it is limited to only six-story buildings, and not high-rise buildings. Until recently, LEED did not address social sustainability that encompasses community development. It has yet to develop criteria that address social infrastructure, demographics, and social integration. Furthermore, ecological sustainability is not explicitly considered in LEED criteria where the space-defining characteristics of high-rise residential buildings and their conformity with the natural surroundings and environmental impact on the city must be considered. Social sustainability and community development, in conjunction with the design of buildings and infrastructure, determine the livability of cities and effect high-rise residential living.

Sustainable Community Design

The idea of community is central to social and ecological sustainability. The materials and energies that constitute ecology create the form and pattern of the community, and these constituent elements are characteristics of the community’s scale and size (Williams, 2007). Community may be defined as an organism—“a complex structure of interdependent and subordinate elements whose relations and properties are largely determined by their function in the whole” (Miriam-Webster Dictionary, 2007).

Much of the current thinking in urban and community design in the U.S.A. focuses on the form of neighborhood and community. This includes walkable neighborhoods; small-scale streets; good edge definition, design, and location of town and neighborhood centers; transportation; and community gathering places. As cities grow, consideration must also be given to where people will live, especially in densely populated and developed cities. Mid- and high-rise residential buildings must be factored into the housing equation, especially with regard to creating sustainable communities where available land area is at a premium and as the distances between living, working, and other functions increase. A sustainable urban and community pattern, therefore, comes from understanding and connecting and adapting to local sustainable resources (Williams, 2007).

The social model stems from two considerations. First is the relationship of residents to one another as individual members of a community. For high-rise communities, “the biggest social problems in the case of the high-rise are isolation and the increasing alienation of the inhabitants from one another” (Yeang, 2002). Second is the relationship of the high-rise residence to its site and surroundings, and the resulting impact on its occupants. Where and how people live share a direct relationship to the products and services in their daily lives. Thus social infrastructure essentially means the framework of services relevant to social organization, and is a principal determinant of the nature and extent of social sustainability.

The ecological model, on the other hand, when applied to urban and community design, guides the form of the urban pattern. The elements of the pattern will help to maximize the use of existing resident renewable energy and resources. Sustainable urban and community design connects these natural elements so that the community works together as an urbanism, creating independent patterns that sustain each other (Williams, 2007). Ecological sustainability in residential high-rises requires the architect to regard the environment as a functioning natural system and to recognize its interdependence with the built environment.
By reconnecting to “the ecology of a place” planners and architects can develop sustainable land-use patterns that provide connections to local renewable resources and a sense of place within a regional context. Livable communities are improved by orienting streets and buildings to improve comfort within structures and within the civic realm, developing building codes that promote healthy-building design, material reuse, deconstruction, and green building industry standards.

The American Institute of Architects (AIA, 2007) has developed the following principles for livable communities:

1. **Design on a human scale**: Compact, pedestrian-friendly communities where residents can walk to shops, public services, cultural resources, and jobs to reduce traffic congestion, benefit people’s health, and provide a sense of community.
2. **Provide choices**: People want variety in housing, shopping, recreation, transportation, and employment. Variety creates lively neighborhoods and accommodates residents in different stages of their lives.
3. **Encourage mixed-use development**: Integrating different land uses and varied building types creates diverse, vibrant, and pedestrian-friendly communities.
4. **Preserve urban centers**: Restoring, revitalizing, and infilling urban centers take advantage of existing streets, services, and buildings and avoid the need for new infrastructure. This helps to curb sprawl and promotes sustainability of cities.
5. **Vary transportation options**: Giving people the option of walking, biking, and using public transit, in addition to driving, reduces traffic congestion, protects the environment, and encourages physical activity.
6. **Build vibrant public spaces**: Citizens need welcoming and well-defined public spaces to stimulate face-to-face interaction, collectively celebrate and mourn, encourage civic participation, admire public art, and gather for public events.
7. **Create a neighborhood identity**: A sense of place gives neighborhoods a unique character, enhances the walking environment, and creates pride in the community.
8. **Protect environmental resources**: A well-designed balance of nature and development preserves natural systems, protects waterways from pollution, reduces air pollution, and protects property values.
9. **Conserve landscapes**: Open space, farms, and wildlife habitat are essential for environmental, recreational, and cultural reasons.
10. **Design matters**: Design excellence is the foundation of successful and healthy communities.

**Community Green Building Programs**

Sustainable development is not a new concept. Rather, it is the latest expression of a long-standing ethic involving peoples’ relationships with the environment and the current generation's responsibilities to future generations. For a community to be truly sustainable, it must adopt a three-pronged approach that considers economic, environmental and cultural resources. Communities must consider these needs in the short term as well as the long term.

Green building is becoming more widespread both as a solution to specific building-related problems, and as a means of working toward a sustainable future (SCN, 2007). Community green building programs such as the following are making great strides toward promoting public acceptance of green building and its benefits, as well as
encouraging builders to adopt green building practices. While some green building programs are sponsored by state or local government, others are administered by home building industry associations or by other nonprofit groups.

**Blueprint 2030:** Adopted in December 2002 by the Metropolitan Council, the regional planning agency serving St. Paul and Minneapolis, MN, Blueprint 2030 is a new strategy for how the region can strengthen its quality of life and addresses integrated land use, infrastructure development, affordable housing, natural resource protection, and agricultural land preservation.

The 2030 Regional Development Framework is the initial “chapter” and unifying theme of the Council’s metropolitan development guide. Together with the Council’s regional policy plans, the Framework is intended to help ensure the orderly, economical development of the seven-county area and the efficient use of four regional systems: transportation, aviation, water resources (including wastewater collection and treatment) and regional parks and open space. The Framework was adopted in January 2004, and amended in December 2006. The amendments are incorporated into the text and maps below.

The Council’s strategies are organized around four policies (Metropolitan Council, 2004):

- Accommodating growth in a flexible, connected and efficient manner.
- Slowing the growth in traffic congestion and improving mobility.
- Encouraging expanded choices in housing locations and types.
- Conserving, protecting and enhancing the region’s vital natural resources.

The Framework recognizes that “one size does not fit all” – that different communities have different opportunities, needs and aspirations. It includes tailored strategies for different types of communities: fully developed communities, those that are still developing, and four different types of rural communities.

**The Hannover Principles:** Written by architect William McDonough and Michael Braungart (1992), the Hannover Principles is a 70-page philosophical tract that outlines a sustainable design philosophy for buildings, cities and products. Within the document, nine principles guide sustainable development:

1. Insist on rights 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 upon 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 creation 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. Incorporate 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 as 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.

The Hannover Principles should be seen as a living document committed to the transformation and growth in the understanding of our interdependence with nature, so that they may adapt as our knowledge of the world evolves.


The purpose of the Green Building Design Guidelines is to create a successful high-performance building. It requires the integrated design approach and the integrated team approach to the project during the planning and programming phases. Variations of these guidelines have been adopted by municipalities and governing bodies throughout the U.S. For example, Alameda County, California has published a guide titled *Multifamily Green Building Guidelines* (Alameda County Waste Management Authority, 2004) which is a comprehensive resource for architects and project managers, including 63 recommended measures and 8 case studies. It contains information about

- what measures are appropriate to use in specific developments
- at what point to incorporate measures into the project schedule
- the relative costs and benefits of specific measures
- where to get additional technical information or materials
**Community-Based Initiatives:** Arlington County, Virginia offers both a Green Choice Home Program that promotes green residential construction and a Green Building Incentive Program that requires all site plan applications in the county to include a completed LEED scorecard.

Built Green Colorado was developed to highlight green builders in the Denver Metro Region, which now applies statewide. The program is voluntary and serves as a guide and a marketing tool for homes that meet certain green criteria. Builders and remodelers that participate in the program receive technical assistance, discounts on educational seminars, and other benefits.

The California Green Builder Program is a voluntary program developed by the Building Industry Institute that sets standards for improvements in energy efficiency, reduction in air emissions, on-site waste recycling and reduction in water use.

The City of Portland’s Green Building Program is an integrated, conservation-based effort to promote resource-efficient building and sustainable site design practices throughout the City. Coordinating the expertise and resources of six City bureaus, this initiative sets aggressive goals and recommends a carefully selected set of strategies to leverage local expertise and develop cost-effective solutions for builders, developers, and building owners and users.

The Maryland Green Building Program works with county and municipal planners to evaluate and modify codes, ordinances and policies that foster green building and green development. Also coordinates a traveling green building exhibit and sponsors workshops.

New York’s Battery Park City Green Guidelines establish a process for the creation of environmentally responsible residential buildings that are appreciably ahead of current standards and practices. The guidelines address the following areas of concern (Carey, 2006):

1) Enhanced indoor air quality;
2) Water conservation and purification;
3) Energy efficiency;
4) Recycling construction waste and the use of recycled building materials; and
5) Commissioning to ensure building performance.

**LEED for Neighborhood Development.** The LEED for Neighborhood Development Rating System integrates the principles of smart growth, urbanism, and green building into the first national standard for neighborhood design. LEED certification provides independent, third-party verification that a development’s location and design meet accepted high standards for environmentally responsible, sustainable, development (USGBC, 2007). The LEED for Neighborhood Development Public Health Report (Ewing and Kreutzner, 2006) comprehensively summarizes the relationship between how our communities are built and a series of public health outcomes such as physical activity, traffic crashes, respiratory health and mental health. This is one of the first reports that not only summarizes the impact of the built environment on public health topics but also discusses how this information can be translated into positive changes to the built environment. The report was supported by funding from U.S. Environmental Protection Agency and the Centers for Disease Control and Prevention, and sponsored by the LEED for Neighborhood Development partnership.
The pilot program is expected to conclude in 2008. Based on feedback gathered during the pilot, the rating system will be revised to improve its effectiveness and applicability to the marketplace. The revised rating system will then be balloted according to the U.S. Green Building Energy Council’s consensus process and undergo approval by the Congress for New Urbanism and the Natural Resources Defense Council.

The Congress for the New Urbanism (CNU) is the leading organization promoting walkable, neighborhood-based development as an alternative to sprawl. CNU takes a proactive, multi-disciplinary approach to restoring our communities. Members include planners, developers, architects, engineers, public officials, investors, and community activists who create and influence the built environment, transforming growth patterns from the inside out (CNU, 2007).

The Natural Resources Defense Council’s (NRDC) purpose is to safeguard the Earth: its people, its plants and animals and the natural systems on which all life depends. It has the following goals (NDRC, 2007):

- To restore the integrity of the elements that sustain life -- air, land and water -- and to defend endangered natural places.
- To establish sustainability and good stewardship of the Earth as central ethical imperatives of human society. NRDC affirms the integral place of human beings in the environment and to protect nature in ways that advance the long-term welfare of present and future generations.
- To foster the fundamental right of all people to have a voice in decisions that affect their environment and to break down the pattern of disproportionate environmental burdens borne by people of color and others who face social or economic inequities.

**Green Building Design Strategies**

The term “place-based design” refers to designs that include, integrate, and connect the site’s natural characteristics and resources into the design of buildings and environments. Sustainable design includes all aspects of the region and microclimate including analysis of site and regional environmental conditions, ecology, biology, geological history, anthropology, and climate data. An in-depth analysis of the site will help determine the following (Williams, 2007):

- Optimum form and size of the building footprint;
- The building’s orientation relative to natural light and ventilation;
- The glazing location, orientation, and size necessary for natural and passive daylight;
- The location of glazing to promote or reduce heat gain;
- Locations of openings for natural ventilation;
- Building materials and finishes appropriate to the impacts from the climate and the weather;
- Landscape type, size, location, and variation; and
- Low-maintenance strategy for the upkeep and operational costs of the structure.

Buildings and project sites also contain a considerable amount of infrastructure such as structure, stormwater controls, sewers, water supply, heating, ventilating, and air
conditioning (HVAC), lighting, electrical circuitry, and data management among other things. As a community ages, the infrastructure and utilities require considerable retrofitting, as do the buildings. Because of this, architects and planners look toward new approaches to solving problems without using the old infrastructure such as green roofs instead of stormwater piping or additional operable glass for ventilation and daylighting instead of new lighting or mechanical ventilation. Renovating and reusing existing infrastructure and infilling the urban grid, therefore, are two of the most effective sustainable design approaches (Williams, 2007).

**High-Rise Residential Buildings.** Residential buildings as a class represent the most critical building types with regard to developing a livable city and a healthy, sustainable community. Where and how we live impacts all other functions of daily life, and the condition and quality of the residential infrastructure directly impacts the vitality of neighborhoods, communities, and urban living in general. Developing quality, affordable housing for large, diverse populations in urban centers has been a goal of architects and planners for a long time. Only recently have they begun to consider the importance of sustainability as a determinate of urban development and the livable city.

High-rise residential buildings are vitally important when considering the sustainable design of our cities and communities. While not all people should live in high-rise buildings, they have become a reality for many people throughout the world, particularly in cities and countries where land is expensive or limited and population and urban density, especially in megacities, is a factor (Beedle et al, 2007). Many criteria that apply in general to all buildings can be used to determine the green design of residential high-rise buildings. However, it must also be remembered that the criteria for LEED certification, which have been developed primarily for office buildings, have limitations when applied to residential buildings.

The three elements of a building are floor, wall, and ceiling. The corresponding structural elements are the foundation, column (wall), and roof. Each has finish, a material composition, and a structure, and each impacts the flow of energy from one point another within the structure. The embodied energy required to make and transport the material from its raw state to the manufacturing and processing plant and then to the construction site must also be considered. Therefore, it is usually desirable to use local materials or reuse materials from a local stockpile to achieve more sustainable buildings (Williams, 2007).

The proper design of a building envelope or enclosure is a critical component in sustainable design of buildings. If a building is bioclimatically designed, then the building skin or layers should be breath, let water out (or in for evaporative cooling), and be impervious to moisture and cold. It should, therefore, have a lose fit and be anchored for reuse. Most important, it should be functionally layered rather than relying on one material to perform all its functions (Williams, 2007).

**Renewable Technologies.** The sun is the primary source of renewable energy. Beside’s offering a direct source of energy, it drives the Earth’s climate creating opportunities to draw energy from wind, waves, tides (together with the moon), and a host of biological sources (Smith, 2005). It is particularly appropriate as an energy source for buildings.
**Solar Energy.** Solar energy includes passive and active solar design. *Passive solar* energy has been used for a long time, especially for vernacular buildings. However, few advances in the technology have been made (Smith, 2005). It is estimated that passive solar design could lead to a reduction in CO₂ amounting to 3.5 million tons per year in the UK alone by the year 2025 (DTI, 2003).

*Active solar* refers to the conversion of solar energy into some form of usable heat. In temperate climates the most practical application of solar radiation is to exploit the heat of the sun to supplement a conventional heating system.

In areas where there is substantial sunshine, solar energy can be used to generate electricity in a number of ways. Designed primarily for desert locations, a *solar chimney* consists of a tall column surrounded by a glass solar collector. The air is heated by the circular greenhouse and drawn through the chimney which acts as a thermal accelerator. Within the chimney are one or more vertical axis turbines. A prototype was built in Manzanares, Spain, for example, with a 644-foot (195m) high tower served by a greenhouse collector 792 feet (240m) in diameter and gave an electrical output of 50 kilowatts (Smith, 2005).

The *parabolic solar thermal concentrator* is another option for collecting solar energy for locations that receive a lot of sun. It focuses solar radiation to produce heat up to 800 degrees C.

*Photovoltaic (PV)* cells are one of the most promising systems for converting solar radiation into usable energy. PV materials generate direct electrical current (DC) when exposed to light. The advantage of PV cells over other methods of converting solar radiation into energy is the “photoelectric quantum effect in semi-conductors,” which means that they use no moving parts and requires minimum maintenance. Silicon is the dominant PV material, which is deposited on a suitable substrate such as glass. Its disadvantages are its high cost, capability of a relatively low output of energy per unit of area, and ability to operate only during daylight hours and, therefore, subject to fluctuation in output due to diurnal, climate, and seasonal variation.

**Wind power.** Wind has been used as an energy source for over 2,000 years. There are two types of wind generators: vertical and horizontal axis. The great majority of wind generators in operation are the horizontal axis type with either two or three blades. Vertical axis machines such as the helical turbine are particularly appropriate for placement on high-rise buildings. However, like other alternative energy sources wind power has disadvantages including aesthetics, distances from population centers, noise, electrical interference to home appliances, communications, and radar, hazardous to bird migration routes, and unpredictable output (Smith, 2005).

**Biomass energy.** The term *biomass* refers to the concept of either growing plants as a source of energy or using plant waste such as that obtained from managed woodlands or sawmills. It is estimated that the mount of fixed carbon in land plants is roughly equivalent to that which is contained in recoverable fossil fuels (*The World Dictionary of Renewable Energy*, 2003). There are three ways in which biomass can be converted into energy:

- Direct combustion;
- Conversion to biogas;
Conversion to liquid fuel.

**Geothermal energy.** Geothermal systems extract energy directly from the earth for heating and cooling buildings. The borehole heat exchanger (BHE) uses boreholes in the earth through which water is pumped and returned to the surface for heating and cooling buildings. This system is used in Switzerland for every 300 persons (Smith, 2005).

**Hydrogen.** Hydrogen is widely seen as the fuel of the future. It is non-polluting, has a reasonable calorific value, and can be safely stored. Off-peak or PV electricity can be used to split water molecules via an electrolyser to make hydrogen, which can be used as a direct fuel or to make electricity thought the chemical reaction of a fuel cell.

A fuel cell is an electrochemical device which feeds on hydrogen to produce electricity, heat, and water. The most common fuel cell type today is the proton exchange membrane type (PEMFC) which uses pure hydrogen. It has an operating temperature of 80 degrees C and is 30 percent efficient (Smith, 2005).

**Development of Additional Criteria**

As stated before, LEED does not currently consider social and ecological sustainability criteria in its rating system. Sustainable residential high-rise buildings should use these two additional criteria as a guide to a building’s overall performance. For example, under social and sustainability, the following credits may be considered:

1. Centralization of social services
2. Individual psychological well-being
3. Socio-economic diversity of residents
4. Demographic diversity of residents
5. Social interaction
6. Redevelopment of “social brownfield”

Similarly, under ecological sustainability the following credits may be considered:

1. Energy consumption with regard to the natural environment
2. Building impact on surroundings
3. Reusable/recyclable materials
4. Climatic contexts
5. Vegetation and landscaping

By following the above strategies of social sustainability high-rise residents can become integrated into the neighborhood community while also forming a community of their own within their own building. Likewise, the ecological credits proposed here are plausible notions that can act as guidelines for buildings seeking harmony with nature. To design an ecologically-responsive building, the designer should take on a more proactive and responsible attitude towards environmental issues. An ecologically designed building must have minimal impact on the environment, and aim for drawing renewable energy from natural sources, and utilize renewable materials thereby providing a comfortable and healthy environmental within the building.
Green Residential High-Rise Buildings

High-rise living in major cities in the U.S. is enjoying a surge in popularity due in part to demographic shifts, investments in real estate, and smart growth principles. Donald Kaplan observes that these trends are part of a larger set of “life-style and health choices” related to environmental awareness and sustainability. “These issues are not only changing the way we live, but they are impacting and reinventing how we build high-rise residential buildings” (Kaplan, 2007).

Although residential buildings from a key component in any sustainable urban network, they frequently become “background” buildings, in that they do not receive the same attention and inventiveness as high-rise commercial buildings. Opportunities for building quality, high-rise residential buildings are emerging as customers are beginning to mandate a more advanced quality of life.

As buildings increase in height designing for sustainability becomes even more critical. Tall buildings, in general, consume more energy than low-rise buildings. Therefore, their “carbon footprints” are bigger. Designers can make tall buildings more energy efficient by using high-performance technologies, such as photo-voltaic panels, wind turbines, fuel cells, and passive design to augment conventional heating and cooling systems. Other strategies include using green materials, passive solar, natural ventilation, maximizing daylighting, and creating landscaped spaces within the building to control microclimate and improve indoor air quality.

Figure 1: The Solaire, 2003, Battery Park City, New York City, Caesar Pelli and Associates.

The Solaire: Located at Battery Park in New York City, the Solaire (Fig. 1) is the first residential high-rise building in the U.S. to integrate green features in a comprehensive way (Carey, 2006). It is a 27-story, 293-unit luxury apartment building located on the Hudson River developed by the Albanese Organization and designed by Cesar Pelli & Associates. Its sustainable features include PV panels incorporated into the building’s facade, a planted roof garden, and fully operational blackwater treatment system. It is based on guidelines developed by the Battery Park City Authority, which address five areas of concern:

1. Enhanced indoor air quality;
2. Water conservation and purification
3. Energy efficiency;
4. Recycling construction waste and the use of recycled materials;
5. Commissioning to ensure building performance.

The Solaire was the first residential high-rise building in the U.S. to be built under the Battery Park City Authority’s (BPCA) Residential Environmental Guidelines (Carey, 2006). In planning the Solaire, the Authority realized that LEED guidelines for high-rise buildings are geared toward office buildings, which are vastly different from apartment buildings in terms of systems requirements, energy and water usage, and occupant fluctuations. Though the Green Guidelines required energy efficiency 30% greater than what was mandated by the NYS Energy Code, The Solaire uses 35% less energy than a similar building designed to NYS code requirements, and 65% less electricity during peak demand periods. In addition, the building’s design incorporated 382 solar panels, which generate no less than 5% of the building’s base electrical load (Carey, 2006). The BPCA’s Residential Guidelines, developed by a green team of architects, engineers, and environmental consultants led by Bob Fox, of Cook & Fox, have since become a model for green high-rise residential buildings throughout the world.

The Helena. The Helena (Fig. 2) is an award-winning LEED Gold-rated building located in New York City on Manhattan’s West Side. The 38-story, 600,000 gross square foot (55,964 sq.m) building, designed by FXFOWLE Architects, was constructed to have a minimal impact on the environment, while incorporating high-performance, sustainable design elements in practical yet unexpected ways. While it targets urban professionals, 20% of the units are set aside for low- or moderate-income households. The Helena features over 580 studio and one- and two-bedroom apartments, most with river views and a host of amenities.

The building’s integrated green design features 11,906 square feet (1,093 sq.m) of green roofs, which contribute to energy use reduction, minimize stormwater runoff by 75%, and mitigate the urban heat island effect—while creating a year-round outdoor amenity for residents (Kaplan, 2007). Because the building envelope is sealed and insulated for energy efficiency and moisture management, the Helena’s ventilation strategy includes high filtration of the air supply and “trickle vents” in each operable window for cold weather ventilation. Other sustainable contributing factors include maximizing daylight, low-emitting materials, and a blackwater treatment plant that conditions 76% of the building’s waste wastewater on site. The building’s design reduces energy use by 65% by using high-efficiency water source heat pumps, micro-turbines, occupancy sensors in stairwells and corridors, master switches in every apartment, as well as Energy star appliances, corresponding to 33% cost savings per year (Kaplan, 2007).
340 On the Park. 340 On the Park (Fig. 3) was designed by Martin Woolf of Solomon, Cordwell, Buenz (SCB) in partnership with LR Development. It is a new multi-family residential condominium building on a parcel of the Lakeshore East development at 340 East Randolph in downtown Chicago. The 64-story clad building contains approximately 325 units and 430 parking spaces. In addition to the standard amenities for a luxury residential building, this project takes full advantage of the site by offering a 25 yard pool and a two-story winter garden on the 25th floor overlooking Grant Park and Lake Michigan. Reinforcing a commitment to sustainability, 340 on the Park is Chicago’s first green residential high-rise and has achieved Silver LEED certification.

It incorporates many ecological design features that can save about 10% in energy costs (Bange, 2007). The most obvious green characteristics are its bamboo floors—a natural resource which is readily renewable—energy efficient lights with motion detectors, floor to ceiling high-tech insulated windows, and counter tops made of recycled materials. It also has two outdoor terraces and a rooftop that are designed to collect rain water, which is stored in an 11,000 gallon tank located in the basement and can be used for watering plants during dry spells. During construction, about 80 percent of the construction waste—approximately 2,800 tons—was diverted from landfills back into recycling programs.
**Elephant and Castle Eco Towers.** The Elephant and Castle Eco Towers (Fig. 4) are part of an extensive 180-acre plan to redevelop south-central London. The mixed-use towers are situated to the east of a railway interchange that divides the overall site. They are intended to function together as a vertical city offering amenities found within a typical urban block. The central feature of each tower is a vertical landscaped environment, configure around a landscaped core. Large intermittent voids progress from public parks and semi-public private entrance courts to private balconies, providing communal “sky pods” and “sky courts.” The towers’ “green” features include the landscaped spaces to buffer wind as well as absorb and reflect a high percentage of solar radiation, reduce ambient temperatures during warmer months, and rehabilitate the site’s ecosystem (Riley and Nordstrom, 2003).
Conclusions

LEED criteria, which have been written primarily for commercial and institutional buildings, are just beginning to be applied to multi-family residential buildings. With more residential high-rise buildings being constructed in cities, there is a need for more specialized criteria to address sustainable design. This paper has shown that while LEED does not adequately address social sustainability that encompasses community development, social infrastructure, demographics, and social integration, initiatives such as the Hanover Principles and Blueprint 2030 have already framed some of the criteria for designing sustainable communities. LEED for Neighborhoods is a pilot program which, if successful, could be a model for developing sustainable neighborhoods in urban areas. However, ecological sustainability is not explicitly considered in any LEED criteria to date.

The paper proposes some plausible design strategies that can be used to address social and ecological criteria. While ecological criteria may be relevant to both residential and commercial buildings, social sustainability is especially important for residential and multi-use tall buildings where separation from the ground and communal spaces is a factor. Although this paper has been focused on high-rise buildings, the authors contend that many of the ideas can be applied to low-rise and mid-rise structures, as well as to single- and multi-unit dwellings with some modifications.

The space-defining characteristics of high-rise residential buildings and their conformity with the natural surroundings and environmental impact on the city also must be considered. Social sustainability and community development, in conjunction with the design of buildings and infrastructure, determine the livability of cities and effect high-rise residential living. A new generation of residential high-rise buildings such as The Solaire, The Helena, and 340 On the Park are setting new standards for designing sustainable buildings and livable cities through resource conservation, passive and bioclimatic design, and technological innovation. These buildings along with community
sustainable design initiatives serve to demonstrate that the livable city is intrinsically related to the design and integration of sustainable principles that must be applied both to high-rise residential buildings and their urban environments if we are to achieve livable cities, healthy communities, and ecologically balanced urban environments.

References


Alameda County Waste Management Authority, 2004. Multifamily Green Building Guidelines, Stopwaste.org., Alameda County, CA,


