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Title: **New Songdo City – The Making of a New Green City**

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Subjects: Sustainability/Green/Energy
Urban Design

Keywords: Sustainability
Sustainability Certification

Publication Date: 2008

Original Publication: CTBUH 2008 8th World Congress, Dubai

Paper Type:

1. Book chapter/Part chapter
2. Journal paper
3. **Conference proceeding**
4. Unpublished conference paper
5. Magazine article
6. Unpublished

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New Songdo City – The Making of a New Green City

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She is also co-chair of the Republican Leadership Council (RLC), which she founded with Senator John Danforth and Lt. Gov. Michael Steele. The RLC's mission is to support fiscally conservative, socially tolerant candidates and to reclaim the word Republican. The RLC was created in March of 2007 by joining forces with Governor Whitman's political action committee, It's My Party Too. She is the author of a New York Times best seller by the same name, which was published in January of 2005 and released in paperback in March 2006.

Governor Whitman served in the cabinet of President George W. Bush as Administrator of the Environmental Protection Agency from January of 2001 until June of 2003. She was the 50th Governor of the State of New Jersey, serving as its first woman governor from 1994 until 2001.

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James von Klemperer is an architect at Kohn Pedersen Fox (KPF), where he has been Design Principal since 1997. His work has included award winning tall office towers such as Plaza 66, the tallest building in PuXi Shanghai, the Dongbu Financial Center in Seoul, and Zhongguancun Tower in Beijing. Mr von Klemperer has also led significant urban planning and design projects, including Seaport Square in Boston and New Songdo City in Korea. The latter is a 1,500 acre \$20 billion free economy zone planned as a sustainable and functionally integrated market hub. In that setting his designs for a residential neighborhood, an international school, a convention center, a 68 story mixed use tower, and a 100 acre central park are all currently under construction.

In addition to these urban developments driven by commercial forces, Mr von Klemperer has designed buildings for public and cultural institutions such as the Foley Square Courthouse in New York, the Ilsan Cultural Center in Seoul, and the Peterson Institute for International Economics in Washington DC.

Mr von Klemperer graduated from Phillips Academy Andover, from Harvard College, and received his Architectural degrees from Trinity College Cambridge and Princeton University.

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Abstract

In a region dominated by a boom of large scale urban growth and a new order of magnitude of pollution and congestion issues, the need to accommodate the trend towards urbanization in a more sustainable fashion is increasingly paramount. Adapting sustainability onto existing urban landscapes can be extremely challenging, which is why the opportunity to create a new city from the ground up represents such a significant opportunity. The New Songdo City International Business District Development in the Republic of Korea – a new, 1500 acre, master-planned and mixed use private development of reclaimed land along Incheon's waterfront – represents such an opportunity, not unlike Battery Park City in New York City or the City of Dubai in the UAE. The developers and designers of the site are seeking to identify sustainable development best practices, opportunities, and metrics, integrate urban planning, infrastructure engineering, architecture, and construction, and ultimately, deliver a city that meets the internationally recognized, third-party benchmarks of LEED for Neighborhood Development (LEED-ND), LEED for New Construction (LEED-NC), and the Korean Green Building Rating System. This paper outlines the process for approaching sustainable development and explores the opportunities and challenges that exist throughout the development process, from planning and design, to construction, and eventual long-term operation.

Keywords: green building, LEED, sustainable development, Songdo

The Need and the Vision for Green Cities

Once a location for a development has been selected, the building typology determined, and the infrastructure built, it becomes very difficult to significantly alter the course of how that development is used and operated. The result is that the selection and layout of a new development can - for better or worse - dictate the future impacts of the project for many years to come. In the absence of sustainably designed developments, environmental concerns will not only be difficult to address, they will be amplified.

It should be recognized that the need for new development is driven by both a growth in population and a steady trend towards increased global urbanization. These patterns are resulting in a simultaneous decrease in the availability of prime agricultural lands and an increase in automobile use, with all the related damaging local, regional, and global impacts. As people find places to live that are farther from where they work, study, shop, eat, and interact, the greater the environmental degradation and planetary harm. The result is that developers, planners and designers have started to rethink how a community can best sustain its residents in the face of scarce resources, local and global pollution issues, and transportation congestion.

While there is a noticeable trend globally towards urbanization and increased city densities, standard urban development cannot alone mitigate the environmental problems faced in urban enclaves

around the world. A poorly designed, built, and operating urban development will not adequately address the need to reduce greenhouse gas levels, water usage, energy consumption, or health interior and exterior environments for inhabitants. Despite a broad recognition that the way standard community development occurs is unsustainable, current community-scale developments very rarely address infrastructure in the integrated, holistic fashion that can result in real environmental and social sustainability. Rarely is much consideration given to the opportunity to reuse wastewater for example, promote alternative transportation, or consider the financial benefits to on-site energy production. Nor do developments necessarily provide for a mixture of residential and commercial uses within one project or design in easy connectivity to a diversity of everyday needs.

Sustainable development on a community scale provides the ability to connect and integrate many components of an urban fabric that are usually compartmentalized and segmented. At a fundamental level, a sustainable city is one in which present needs are met without forsaking the needs of the future. A sustainable city should ideally achieve an environmental, social and economic equilibrium. Societal indicators like inclusion (lack of discrimination), cultural amenities, universal access, architectural beauty, user comfort, and health and safety need to be considered along with economic indicators like diverse employment and skills base, and

environmental indicators like land utilization, air quality and pollution, construction materials, and energy and water usage. These concerns are interwoven and a truly sustainable community cannot exist without each in harmony with the other.



Figure 1. New Songdo View, Gale International

Until recently, the elements of transit oriented, mixed use development were difficult to measure, let alone “certify” as sustainable. But the new LEED for Neighborhood Development (LEED-ND) rating system from the US Green Building Council – currently in its pilot phase – provides planners and developers a transparent set of metrics by which they can assess, measure, and document these factors, making it one of the most comprehensive rating systems available.

Overview of New Songdo City

New Songdo City is a sustainably designed, high-tech, international business zone on 607 hectares (1,500 acres) of reclaimed land along Incheon’s waterfront, 64 kilometers (40 miles) south west of Seoul. It is to be connected to the Incheon International Airport by a 6-mile bridge, currently under construction. New Songdo City is a US\$25 billion master-planned development on a scale unmatched worldwide. It is both a Korean national project and a unique international partnership, although one that remains essentially a private initiative. The owner of New Songdo City Development, LLC, a 70:30 joint venture between Gale International and Korean-based POSCO Engineering & Construction Co. Ltd., a subsidiary of the second largest steel company in the world. It is the first international real estate investment in South Korean history. Construction commenced in November 2004, and will be completed in 2014. The project is in the early stage of construction with six buildings currently underway. In total, the project includes the design, construction, and operation of a total of 350 buildings totaling 50 million square feet of office space, 30 million square feet of residential space, 5 million square feet of hotel space, and 10 million square feet of public space. The total usage mix will include retail and residential mixed uses, international schools, hotels, hospital, offices, retail space, a convention center, cultural and leisure venues, and

neighborhood development facilities. The new city will be home to an estimated 65,000 residents, who will be able to enjoy a canal system, a central park, and a robust public transportation system. New Songdo City is also in an International Free Economic Zone (IFEZ) with a goal of attracting multi-national corporations and foreign direct investment.

New Songdo City’s Masterplan was approved in 2003 and construction is currently underway. The design and construction effort to build New Songdo City spans two continents and embraces the best practices of the US and Korea. There are three milestones in the process. Design starts in New York City with master planning, programming, schematic design and design development. The end of design development is the first milestone as the effort is moved to Korea. Korean architectural and engineering firms transform the design development package into construction documents adequate for tender. Award of the construction contract to a Korean engineering and construction firm is the second milestone. Completion of construction, commissioning and hand-over is the third milestone which starts the operations phase.

A number of years prior to involvement by the current development team, the Korean government embarked on an ambitious plan to create an IFEZ linking Northeast Asia to global markets and companies. Because convenience and accessibility were two important factors in determining the home of the IFEZ, the government decided to create the project in close proximity to Incheon Airport and to Seoul. By reclaiming land from the Yellow Sea starting in 1996, the Korean government was able to locate the IFEZ in an ideal location, while not disturbing prime farmland or significant natural habitat. Indeed, on both economic and sustainability grounds, the location is excellent, and is within close proximity to:

- One third of the world’s population (3 ½ hour flight away)
- The center of the Northeast Asia economic region, which is comprised of approximately 60 cities with a population of over one million people and a GDP of \$1.3 Trillion (as of 2001)
- China. Korea is the 4th largest importer of goods from China and the 3rd largest exporter to China (as of 2003)
- Seoul, strengthened by infrastructure enhancements such as a subway line connecting Seoul to Songdo, currently under construction.
- A bridge under construction to link to the new Incheon International Airport, 15-minutes from New Songdo to the Airport
- One of Asia’s largest seaports

This regional connectivity is significant as Asia has evolved from an assemblage of urban centers within individual inward-looking countries into a

network of interconnected gateway hubs. New Songdo City's highly desirable setting and its forward-thinking sustainability agenda makes it an attractive and vital center for trade and international business, as well as a healthy and enjoyable place for future residents.

In many ways, New Songdo City demonstrates what the future of urban development will look like. It is one of the largest and most ambitious efforts to address environmental needs head-on with an integrated masterplanned design that takes the entire cityscape into consideration.

Examples of Urban Land Reclamation

New Songdo City is not the first urban development to take advantage of reclaimed land and then subsequently ensure that the development is environmentally superior to the conventional community development of the time. One other such example is New York City's Battery Park City. Battery Park City is a 92 acre (0.4 km²) planned community at the southwestern tip of Manhattan in New York City that was built on reclaimed land. The land area was reclaimed from the Hudson River using 1.2 million cubic yards (917,000 m³) of dirt and rocks excavated during the construction of the World Trade Center and certain other construction projects in the 1970's. The neighborhood, which is the site of the World Financial Center along with numerous housing, commercial and retail buildings, is named for adjacent Battery Park.

In January 2000, the Battery Park City Authority published Residential Environmental Guidelines to establish a process for the creation of environmentally responsible residential buildings, appreciably ahead of standards and practices at the time for development. These guidelines were responsible for the construction of the first "green" residential tower in the United States, the Solaire. This innovative building was the first in a succession of residential buildings that have become the model for healthier, ecologically responsible environments where occupants collectively enjoy the benefits of living in a sustainably designed community. In March 2002, the Battery Park City Authority issued Commercial and Institutional Environmental Guidelines. These guidelines responded to increased public awareness of environmental conservation and increased demand for high quality and healthier working environments. They provide both the direction and the metrics for sustainable design strategies throughout the development area. The result of this activity has been that Battery Park City has not only increased the livable space in New York City and allowed for greater density, but it has also raised the bar on how multi-building developments can greatly exceed standard construction practices in an economically profitable manner.

Battery Park City, as well as inspirations of large scale urban sustainable development success stories from throughout the world have served as inspiration to the New Songdo project team, and help frame the issue

of the relative merits of reclamation vs. non-development. Reclamation has the potential to add to an urban core (in addition to Battery Park City, much of the west side of Manhattan is reclaimed land), while non-development forces the development elsewhere, either to other urban infill projects (ideally) or to greenfield or suburban type projects for which the net environmental impact associated with land use, fossil fuel consumption, congestion, greenhouse gas emissions, infrastructure costs, etc. would be several times greater. On the other hand, non-development can preserve a given environmentally sensitive site or preserve the existing character of a landscape. In many ways, it is similar to the arguments for and against off-shore wind developments in pristine environmental areas: on the one hand there is the need to meet increasing demands for power and to displace capacity from greenhouse-gas intensive fossil production, and on the other, there is the desire for preservation.

It is with this understanding of the relative tradeoffs of infill vs. non-development that the New Songdo development team approached its task. The question was never whether or not to develop,¹ but rather how can this development meet the increasing urban, economic, social, and environmental needs of the region in the most sustainable form possible.

Approaching and Measuring Sustainability – Targeting Current Best Practices

In November 2006, an Environmental Opportunity Charrette was undertaken to identify ways to improve environmental performance and quality of life in New Songdo City. The effort focused on the need for future oriented design in which long-term sustainability would be considered in every design decision, and systems should be adaptable to changing needs, including those that could not be anticipated at present. Specifically, the issues addressed included site planning, energy, building design, water, transportation, materials, waste, and the project's larger impacts, both 'upstream' and 'downstream.' Moreover, the charrette focused not only on the environmental aspects of sustainability, but also in creating an urban social fabric that combines the principals of transit oriented development and new urbanism with the traditional Korean "Dong" or neighborhood.

In general, sustainability's guiding principles include the need to create a city that is better for the inhabitants, better for the region, and better from a planetary perspective. As a part of that, sustainability looks at not only direct environmental impacts of resource use but also the indirect environmental

¹ New Songdo was slated for reclamation by the Korean government and reclamation activities commenced in 1996. After the 1997 Asian Financial Crisis, with the land already reclaimed and graded a revised vision for New Songdo was developed. The current form of the city took place in 2000, when Gale International became involved in the joint venture with Korean-based Posco steel, and formalized a transfer of land title in 2003.

benefits that come from creating a city that encourages social vibrancy and connectivity, embraces culture, and creates economic activity. Seemingly ‘soft’ infrastructure design considerations such as open space allowances, bike paths, public access to all streets and sidewalks, diverse retail/professional/civic uses, and wildlife habitat conservation zones, all impact the livability of an area. Attractive and well-designed landscape and open spaces encourage social interaction, improve ecology-biodiversity, improve air quality and add amenity-visual value. Additionally, when quality landscape and open spaces are conceived as part of the movement and connectivity network they can also contribute to the use of alternative transport modes such as cycling, boating and walking.

In line with this philosophy, New Songdo City will have 515 acres of landscaping and open space, equal to 34% of the total land area of the development. The centerpiece of New Songdo City is a great Central Park. It is an urban park, dense with activities such as outdoor concerts, exhibitions, sports and recreation. The orthogonal pattern of city streets is interrupted by dynamic spaces, open vistas, pathways and a system of canals. Central Park will rival New York’s Central Park and London’s Hyde Park as a public amenity providing the residents of New Songdo City a place to reflect, meditate, play, and be entertained. These features in turn provide incentives for residents to utilize the easily accessible amenities available within the project boundary instead of driving to a job, store, or park some distance away. Indeed, the relationship between land use and travel demand is fundamental to the consideration of any urban development that is using sustainable development as its design underpinnings. The need for transport impacts on the energy and land consumption of the development.

New Songdo City will be served by public transportation including a subway (with connections to Seoul and Incheon City), water taxis and buses. New Songdo City will also be a pedestrian city with nature trails within Central Park. New Songdo City has been designed with the idea that successful commercial neighborhoods organically grow in areas with a relatively small scale and which are located in proximity to dense residential districts. An urban planning concept utilizing graduated density and augmented by a bicycle infrastructure will encourage and enable local residents and visitors to get around the city car-free.

In the end, however, the team decided that it was not sufficient to design with these principles in mind, but to quantify and benchmark the level of sustainability within the city using the most appropriate measuring sticks. As a result the team decided to pursue the following:

1. Participate in the USGBC’s LEED for Neighborhood Development (LEED-ND)

pilot program and certify the entire city as being sustainably developed.

2. Certify each of the 350 buildings using the Korean Green Building Rating System and the LEED for New Construction (or other, more appropriate LEED rating system)
3. Develop a carbon footprint and greenhouse gas reduction analysis to understand the real climate impacts and mitigation opportunities represented by the projects



Figure 2. Commercial Masterplan. KPF

Carbon Footprint Initiative: Informing the creation of a city

Although not typically employed in the context of a new city-scale development, establishing a carbon footprint (baseline) can act as a powerful tool to inform the design, construction, and operations of the development. Analyzing the entire development process from a greenhouse gas reduction standpoint provides quantifiable metrics for the real climate impact a project – both now and into the future. By understanding the climate impact of any given sustainability strategy (e.g. on-site renewables, efficient glazing, alternative fuel transportation, etc.) the project team can pursue options with the greatest quantifiable benefit, and thereby realize the most cost-effective greenhouse gas reduction strategy.

The GHG emissions from New Songdo City can be divided into two distinct categories: construction-based emissions, primarily from the combustion of

diesel fuel in construction equipment and transportation of materials to the site, and the ongoing emissions associated with the City's operation. Emissions from the latter category are anticipated to come from the following sources:

- Indirect (i.e. off site) emissions from electricity generation
- Direct emissions from on-site fossil fuel combustion for building heating and domestic hot water
- Direct emissions from fossil fuel combustion for passenger and public transit vehicles
- Refrigerant leakage from HVAC systems
- Methane emissions from waste water treatment and solid waste disposal

Similarly, reduction strategies will likely fall into one of the following categories:

- energy efficiency of buildings
- energy efficient infrastructure
- waste to energy technologies
- reduction of vehicle miles traveled (VMT), including increased mass transit and bicycling
- efficiency of power supply (including on-site renewable energy generation)
- reduction of carbon intensity by fuel switching, including the use of biodiesel in mass transit buses
- improved waste management

The greenhouse gas emissions analysis will provide the emissions profile of New Songdo City – i.e. how much greenhouse gas will be emitted and from what sources – for the baseline and current design. For building energy performance, the baseline references the ASHRAE 90.1-2004 standard.

In the end, the total New Songdo emissions profile will be an aggregation of individual component emissions sources (passenger vehicles, building energy use, etc.). The baseline is intended to develop an understanding and quantify the emissions resulting from the business-as-usual development in the absence of a sustainability initiative at New Songdo City.

In order to reduce greenhouse gas emissions significantly, the design of the buildings and infrastructure needs to be significantly more efficient than standard practice. New Songdo's Carbon Footprint initiative will look at, among other things, the anticipated energy use of all 350 buildings, the amount of energy needed to pump water and wastewater throughout the 1500 acre site, the amount of projected VMT for both residents and commuters, and the frequency and distance traveled of public buses. At the conclusion of the analysis, New Songdo City will not only be aware of its carbon footprint, but will also be able to more easily identify the most significant areas of potential greenhouse gas reduction.

The Use of the LEED Rating Systems

The U.S. Green Building Council (USGBC), a non-profit organization of development industry professionals, developed the LEED (Leadership in Energy and Environmental Design) Green Building Rating System to define green buildings in a transparent, quantifiable manner. There are several LEED programs that cover different building types including New Construction (NC), Existing Buildings (LEED-EB), Retail (LEED-R), Schools (LEED-S), Core and Shell (LEED-CS), Commercial Interiors (LEED-CI), Homes (LEED-H), and most recently, Neighborhood Development. The LEED rating systems provide a point-based, step-by-step approach to determining whether a building can be certified as "green," and then achieve distinction by earning more points and earning certification levels of Silver, Gold, or Platinum. Although LEED certification can be an end in itself, LEED serves as a tool to both define green building, set quantifiable targets and goals, and to integrate the design process.

Given the effectiveness of LEED as a design tool, the New Songdo team decided to adopt the goal of LEED certification (using LEED-NC, LEED-CI, and LEED-CS) for all 350 buildings within the development. This is in addition to the goal of LEED-ND certification, described in greater detail below.² However, the challenges of LEED certification within New Songdo City are significant given the scale of the project and the resulting intersections of design and construction timelines, as well as the fact that this represents the first LEED project in Korea.

One example of the challenges faced is the lack of diversity of LEED-compliant materials and products on the market in Korea, which makes it difficult to solicit multiple vendors for each desired product type. This issue has surfaced on a number of occasions from the sourcing of roofing products with a high solar reflectance index, to low flow plumbing fixtures, low ozone depleting and global warming potential refrigerants for HVAC and fire suppression, materials with recycled content, rapidly renewable materials, and low-VOC (volatile organic compound) content for adhesives and sealants, paints and coatings, carpet systems, and composite wood and agrifiber products.

Challenges also exist in procuring materials that are extracted, processed and manufactured within an 804 kilometer (500 mile) radius to support local industries and reduce transportation. As a result, the project team has been working to utilize local manufactures whenever possible, create a new market for green building products, and stimulate awareness throughout the region.

² LEED-ND and other LEED rating systems are designed to complement one another.

LEED for Neighborhood Development

In addition to the building by building approach, the development team sought to participate in the LEED for Neighborhood Development (ND) pilot program to ensure that, from a macro level, there is appropriate integration between project site, infrastructure development, and actual building construction. LEED-ND is the USGBC rating system that integrates the principles of smart growth, new urbanism, and green building technologies and assesses projects based on the ability to successfully and quantifiably protect and enhance the overall health, natural environment, quality of life, and community experience.

New Songdo City is one of only three LEED for Neighborhood Developments projects in Asia (two much smaller projects are in China), and one of only five outside the United States and Canada. Indeed, at 1500 acres, 350 buildings, and 65,000 future residents, New Songdo City is by far the largest project outside North America to be included in the 18-month pilot program, which is expected to conclude in 2008.

The LEED-ND program has 53 prerequisites and credits, with 106 possible compliance paths in three main areas:

- Location and Linkages
- Neighborhood Pattern and Design
- Green Construction and Technology

The following subsections describe some of the core areas of LEED-ND and how New Songdo will work to embrace each of these areas.

Smart growth and new urbanism

Smart Growth and New Urbanist principles are embedded in many of the credits that New Songdo City will achieve in its LEED-ND submittal. Smart Growth is an urban planning and transportation theory that concentrates growth in the center of a city to avoid urban sprawl; advocates compact, transit-oriented, walkable, bicycle-friendly land use, including mixed-use development with a range of housing choices. Smart Growth values long-range, regional considerations of sustainability over a short-term focus. Its goals are to achieve a unique sense of community and place; expand the range of transportation, employment and housing choices; and equitably distribute the costs and benefits of development; enhance natural and cultural resources; and promote public health.

New Songdo City's master plan puts those principles to practice by designing in urban archetype overlays pedestrian thresholds and a hierarchy of streets typologies. Indeed, KPF's masterplan for New Songdo City defines the city as "*an urban center where the widest range of activities would take place*".

Smart Location and Linkage Credits in LEED-ND

LEED-ND's Smart Location and Linkage credits address much of the smart growth issues. The prerequisites within this section include locating the project site on an infill site (defined as a site in which 75% of its perimeter borders a previously developed site), near adequate transit infrastructure, near existing neighborhood services and facilities, or within a defined geographic area with a lower than average per capita Vehicle Miles Travelled (VMT). There are also prerequisites for locating near existing or planned water and wastewater infrastructure, protecting any imperiled species on or near development site, conserving wetlands or other water bodies, protecting agricultural land, and avoiding floodplains. New Songdo City will likely accrue additional credits by reducing automobile dependence, designing in a bicycle network (New Songdo will have an extensive bike path system with over 24 KM (15 miles) of bike lanes planned throughout the city), and creating housing in close proximity to jobs and schools. Bus service will be reach throughout the new city, with adequate bus stops ¼ mile from both residential and commercial buildings. Additionally, a new subway line will intersect the project site and will be within a ½ mile walk for a large percentage of the future residents.

Neighborhood Pattern and Design Credits in LEED-ND

LEED-ND's Neighborhood Pattern and Design credits address the New Urbanist principles of compact, walkable, vibrant, mixed-use neighborhoods with good connections to nearby communities. The prerequisites with this section include a requirement for the development to be an open community, with no private gated areas allowed. An additional prerequisite promotes compact development by requiring a minimum of 7 dwelling units per acre of buildable land and a minimum 0.50 FAR for commercial uses. Project teams can achieve additional points by increasing density and FAR's above those required minimums. It is likely that New Songdo City will achieve nearly all of the available points for this compact development credit, as currently the residential blocks of the development anticipating having a density of 62 dwelling units per acre. New Songdo City will also likely accrue points for diversity of uses and services, reduced parking footprint, walkable streets with appropriate building frontage/height/setbacks, appropriate street connectivity, safe and comfortable transit facilities, and access to public spaces.

Green Construction and Technology: Sustainable Infrastructure in LEED-ND

LEED-ND also encourages the creation of a sustainable infrastructure, including energy, water and transportation systems, in addition to the actual buildings within the development boundary. The sole prerequisite for this section is construction activity

pollution prevention, which ensures that there is a reduction of soil erosion, waterway sedimentation, and airborne dust generation. Additional credits that New Songdo City will likely achieve are: percentage of buildings achieving LEED certification (because New Songdo City is requiring that each one of the 350 buildings achieve a minimum of LEED-NC certification, the project will like attain maximum points for this credit), energy efficiency in buildings reduced indoor and outdoor water use, stormwater management (reducing adverse impacts on water resources by mimicking natural hydrology of the region), and heat island reduction. See Box 1.

Box 1: Vertical Design Strategies

- Building orientation that optimizes heat gain and natural lighting
- Energy efficient facades and roofs
- High performance glazing and shading systems.
- Energy efficient HVAC systems (VAV systems using variable frequency drives, variable volume pumping systems, free cooling using economizers)
- Demand controlled ventilation
- Semi-mixed (stratified) HVAC systems for spaces with large volumes such as the Exhibition Halls in the Convention Center.
- Parking garages ventilation systems using two-speed fans controlled by Carbon Monoxide sensors.
- Passive cooling systems (natural ventilation) when ambient conditions permit.
- Energy efficient lighting and lighting control.
- Intelligent Building Systems (IBS) that control and monitor buildings to keep them operating at the highest possible efficiency.
- Refrigerants with low ozone depletion and global warming potential.
- Low flow plumbing fixtures.
- Grey water systems in larger buildings where waste water from lavatories, showers and dishwashers is collected, treated and reused for non-potable uses such as flushing, cleaning and irrigation.

New Songdo City will be served by a district utility system that provides medium temperature hot water for space heating and domestic hot water heating, as well as cooling via absorption refrigeration. Innovative stormwater reuse is also part of the city's

infrastructure plans. Stormwater harvesting and reclamation is planned in Central Park and the Golf Course using swales and ponds. The landscape will utilize plantings that require little or no irrigation and the city will use treated discharge from the central waste water treatment plant for irrigation of the golf course. The design team is also continuing to research the possible use of sea water desalinization for irrigation and use of sea water in lieu of fresh water for the canal system.

Building by Building LEED Certification

On a building scale, most of the 350 buildings at NSC will be LEED Certified (public buildings must earn LEED-Silver) using one of the five rating systems that apply to new construction projects: LEED for New Construction (LEED-NC), LEED for Core and Shell (LEED-CS), LEED for Commercial Interiors (LEED-CI), LEED for Schools (LEED-S), and LEED for Retail (LEED-R).

Achieving certification on these projects will mean that each of the five main areas of environmental impact are addressed: sustainable sites, water efficiency, energy and atmosphere, materials and resources, and indoor environmental quality. Achieving this goal will take a disciplined effort on the part of the design team to make sure that lessons learned on the ground set the stage for future efforts. To help manage the issue of multiple partners in development, design, and construction, the development team is in the process of creating a New Songdo LEED Users' Manual. The intent of the manual is to provide guidance with the LEED rating systems and bridge the gap between design and construction teams in Korea by providing practical, on-the-ground guidance, regional context, and lessons learned. The LEED User Manual is designed to function as a "living document" that will accommodate the accelerated build-out on the project while providing support for all current and future phases of design and construction.

New Songdo City Case Study: The U-Life Complex

The U-Life Complex project being designed by HOK and ARUP will be a leading example of sustainable design for both Korea and New Songdo City. It is the first building in Korea currently being designed to meet the USGBC's rigorous LEED-NC Platinum criteria. A large part of the building and the site will be devoted to showcasing sustainable building materials, systems and technologies. This "living laboratory" will include rain gardens, native landscaping, solar electric automobile charging stations, full daylighting, optimized natural ventilation, fuel cells, rooftop wind turbines, greywater recovery, green roofs, material life-cycle analysis, building energy modeling, and a high performance envelope tuned to solar orientation. Large interactive digital displays on the first floor will register building electric

power generation, energy, water use and system performance. The U-Life building will link to the sustainable story of New Songdo City and allow visitors to digitally explore the building through many vantages, dimensions and scales.

Conservation, on-site generation, and measurement and verification are the focus of the U-life Complex energy strategy. All systems, from those regulating the building's thermal comfort to those providing lighting will be designed to reduce energy consumption beyond the typical building. Natural and passive cooling and ventilation, daylighting, and high efficiency equipment and appliances are strategies among others that will be employed. The building's demands for electricity will be offset by two sources of on-site renewable energy, wind and sun, which together provide a broad opportunity to generate electricity during a range of weather conditions. Reliance upon the electrical utility grid will be further reduced by employing on-site fuel cells, which generate electricity from hydrogen. The chemical reaction utilized by the fuel cells produces electricity with extremely high efficiencies and negligible pollution when compared to utility generated power. The water heated in the process of cooling the fuel cells will be recovered and used by the building's heating and cooling systems. Extensive use of energy metering devices will provide feedback to the building's operators so that inefficiencies can be detected and adjustments made to improve the building's energy performance.

The building will significantly reduce municipal water consumption through the use of high efficiency water fixtures and storm and gray water collection systems. Storm water will be stored in large tanks and will provide for all of the site's irrigation needs, completely eliminating the use of potable water for irrigation purposes. Gray water will be collected from hand sinks and re-used for flushing toilets, conserving potable water and reducing sewage conveyance. Rainwater collected at the roof will be used for cooling tower make-up. Rainwater collected on the site will be used for all of the site's irrigation needs and/or re-used in vehicle washing stations. Most elements in this system will be gravity-powered and designed for low maintenance.

Conclusion and Challenges:

Many of the challenges inherent with the "greening" of New Songdo City are those that are present in any project of this magnitude: multiple team members, a timeline spanning multiple decades, cross-cultural participation and communication, etc. But perhaps the most significant challenge from a sustainability perspective has been the development of an understanding of what constitutes "best practices" with regard to energy efficiency, water conservation, indoor environmental quality, etc. – both globally and in Korea. The emergence of LEED has given the

project team a globally recognized benchmark for sustainable development from both a master planning and building site perspective, including both social and environmental impacts, and has helped enable New Songdo City to be a showcase project for green development. Moving forward, the need to establish clear goals, organize and share on-the-ground knowledge and experience, and continue to transform the regional market will be necessary hurdles to overcome to make the ambitious sustainability goals of New Songdo City a reality.

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