Design Guidelines for a Carbon-neutral City

- Focused on Jungbu New City -

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Abstract

This study has intended to develop a carbon neutral new city guideline to cope with climate change under the design of level. This study consists of the following two steps. First, as for building a guideline form as reflected spatial characteristics, spatial factors and development factors of 5 zoning types (detached housing, apartment housing, commerce · business, innovation-cluster, industrial land) were drawn through case stud. Second, 10 planning domains (energy, industry · resource, spatial structure of urban, architecture, urban forest, agriculture, reducing the generator temperature, air quality control, flood and quantity of water control, quality of water control, etc.) were applied to each spatial factor as a development factor considering the characteristic of spatial factors of 5 zoning types. This study has found the following results. The guideline form was developed through drawing spatial factors and development factors of 5 zoning types. It appeared following characteristic; detached housing zone specialized solar energy, geothermal energy, household waste recycling, traffic calming, passive design, urban vegetable garden. Apartment housing zone specialized solar energy, geothermal energy, household waste recycling, open space, micro-climate, urban vegetable garden. commerce · business zone specialized solar photovoltaic energy, mixed-use development, pedestrian mall, transportation transfer system, zero energy house design, micro-climate, urban vegetable garden. Innovation-cluster zone specialized solar photovoltaic energy, bicycle path, household waste recycling, zero energy house design. Industry zone specialized solar photovoltaic energy, industry

waste recycling, playground, zero energy house design.

1. Introduction

Background

Due to global warming, the crisis of climate change has become globally urgent and as a critical issue, it demands a solution. In response to climate change, international society has set reduction goals for greenhouse gases, which are a major contributing factor to global warming; furthermore, reduction plans to be enforced through international agreement have been passed. South Korea is not a signatory to the Kyoto Protocol. However, it is a country that emits a substantial amount of greenhouse gases—among OECD countries, it was ranked sixth in CO_2 emissions from energy combustion and first regarding the increase of CO_2 emissions in 2007 (WEO, 2009); with the expiry of the Kyoto Protocol in 2013, South Korea was classified as a nation obliged to reduce greenhouse gas emissions. As such, based on the domestic and overseas situations, the central government has recognized energy conservation and greenhouse gas reduction as not only necessary to cooperating with global agreements, such as those related to climate change, but as correspondent to the long-term direction of development of the South Korean economy; it has strived to engage in carbon reduction domestically by establishing a comprehensive plan against climate change and a comprehensive elementary plan to respond to climate change.

Meanwhile, interdisciplinary research has yielded multilateral approaches for responding to climate change; Byun and Chae (2009) examined research regarding climate change responses at the city level and developed an evaluation index for verifying the suitability and effectiveness of climate change response plans; Ban et al. (2008), Lee et al. (2009), Kim et al. (2010), and Nam et al. (2010) derived planning factors for mitigation. Furthermore, for adaptation, planning techniques were suggested based on research (Jo et al., 2000; Choi et al., 2006; Byun et al., 2009; Um, 2010) that analyzed the vulnerability of various regions to climate change, disaster response plans, and environmental ecology plans (such as those related to biotopes and wind paths). As such, research on climate change responses at the city level has mainly dealt with basic content and has focused on deriving planning factors and suggesting techniques; however, research has also shifted in perspective toward the active notion of the “carbon-neutral city”as opposed to finding environmentally friendly approaches through mitigation based on sustainability or to finding adaptions to the inevitability climate change along with the mitigation measures of green and ecological cities.

Central New City is a new city with an area of 6.924 km^2 that has been constructed in the heart of Jincheon and Eumseong innovation cities; it was required to be constructed as an energy-reducing city and to lead participation in domestic flow and domestic plans regarding global warming and urban competitiveness.

For the comprehensive and realistic application of carbon-neutral cities, this research is based on comprehensive planning factors that include the non-physical planning factors of management software (cultivation) for carbon-neutral cities and the physical planning factors related to mitigation (i.e., carbon reduction and carbon adsorption) and adaptation to climate change. This study was conducted to develop design guidelines for carbon-neutral cities that reflect the spatial characteristics of the land use of such central new cities.

Methodology

This study investigated a central new town (Chungbuk Innovation City) constructed in Chungbuk-do in Jincheon-myeun, Duksan-gun and Mengdong-myeun, Eumseong-gun. The study derives spatial factors as the guideline components of carbon-neutral new cities, verifies the mitigation and adaptation strategy framework and the suitability of planning factors, and prioritizes suggestions for carbon-neutral new city design guidelines.

This study conducted a literature analysis of related terminologies, case studies on design guidelines, and a professional Delphi survey; the development of guidelines for the construction of carbon-neutral new cities proceeded as follows:

First, the concept of the carbon-neutral city was defined and the significance of design guidelines was discussed. Guidelines proposed in past studies were reviewed.

In order to develop design guidelines for the construction of carbon-neutral new cities, the research process was classified into three phases. First, domestically constructed design guidelines and spatial factors suggested by district plan case studies were derived to compose the design guideline framework. The derived spatial factors were grouped based on similar characteristics and selected to derive the final spatial factors. Second, the suitability of the strategy framework, strategies, and planning factors for mitigation and adaptation derived from past studies was verified by using a professional Delphi survey. Third, based on the executed study results, carbon-neutral new city design guidelines were suggested. The design guidelines were adjusted in consideration of the land use characteristics of each zone; strategic incentives and expenses are suggested.

2. Literature Review

Definition of Carbon-Neutral Cities

"Carbon-neutral" refers to the conversion of carbon emissions to limestone through carbon offsets in response to carbon emissions released due to human activity. Greenhouse gas emissions, one of the major factors contributing to global warming, are 60% composed of CO_2 and are over-emitted due to the use of fossil fuels and deforestation. In other words, the amount of CO_2 emitted from human activities could artificially be controlled through the restriction of carbon emissions and the procurement of carbon absorption. In this context, the application of the carbon-neutral concept is appropriate and essential in urban areas, where intensive economic and social activities of human society take place; cities that fulfill this concept are referred to as "carbon-neutral cities."

Climate Change and Carbon-Neutral Cities

In general, past studies have defined climate change as "significant changes in normal states of climate"; there are differences in opinion regarding its causes (Table 1). IPCC and the meteorological agency indicate that climate change is caused by "change in climate with time from either human activities or natural changes,"but the UNFCCC indicated that "human activities"are the cause. However, in its first report in 1990, IPCC stated that "the theory of climate change from human activities is unclear due to observational limitations"; however, in its report in 2007, it stated that "the possibility that global warming is due to human activities is 90% and that the major cause of this increase in greenhouse gas concentrations is the over-usage of fossil fuels."

People currently experience floods, droughts, and wildfires due to climate change and based on various climate change scenarios, IPCC (2007) predicted that if the massive consumption of fossil fuel continues, the average global temperature would increase up to 6.4℃ and the sea level would increase up to 59 cm by the end of the century. Therefore, awareness of this problem—i.e., that climate change concerns the survival of mankind ―has increased, and global agreements have been put in place to respond to climate change.

Because of these trends, attempts to convert current cities and construct low-carbon and carbon neutral cities have been made in the field of urban planning, which targets urban areas where intensive human socioeconomic activities take place. The carbon-neutral city, as its name suggests, is the concept that has been most actively taken up to comprehensively search for a climate change response that addresses all parts of urban planning, including urban structures that enable the reduction of carbon emissions and adsorption, energy planning, ecological restoration, reforestation, and the recycling of the natural resource of water. For the construction of carbon-neutral cities, "zero concentration"should be promoted through the restriction

(reduction) of greenhouse gases and the offsetting (adsorption) of emissions before and after the emission of greenhouse gases from each city component. Along with this, positive changes in human activities, which are primarily constitutive of cities, should be supported through institutional and educational approaches.

Significance of Design Guidelines

Design guidelines are a critical means of creating the characteristics of cities; in particular, in the case of new city construction, guidelines that are strongly connected to goal functions that could differentiate a city are essential (Kim, 2003). Design guidelines do not set a maximum index for good design but, rather, set minimum standards; furthermore, such standards should have practical characteristics. Moreover, unique regional characteristics of should be clearly understood to connect the city to the present condition of the region (Jung et al., 2000). Guidelines could have the characteristics of simple advice or regulations with legal enforcement, depending on their application. Hence, the establishment of design guidelines for new cities that can be legally enforced could give unique characteristics to the targeted new cities and could also ensure that balanced cities are designed.

Examples of design guidelines

Examples of design guidelines include "The Sustainable New City Development Standards"from the Ministry of Land, Transport, and Maritime Affairs; "The Design Guidelines for Yeongyeong District, Daegu"from the Korea Land and Housing Corporation; and a Type 1 district-unit plan established to systematically plan and manage a "Type 1 District-Unit Plan"area as defined by "the Regulations for Land Planning and Usages". With the goal of securing new city sustainability that meets the sustainable new city development criteria, these guidelines detail the planning and development factors, with a focus on "social development, social mixture, securing historical/cultural sustainability, securing economic/environmental sustainability, formation and management of landscapes, prevention of disasters and crimes, etc."The guidelines for Yeongyeong District, Daegu provide basic directions for "natural environment conservation"in developing sites, landscaping, environment-friendly designs, infrastructures, and individual facilities, to meet the goals of creating an ecological-cultural city. Furthermore, Daenong Districts 1 and 2 and Yeongjong District provide more overall specific plans for city building that fulfill the goal of implementing cities that are conscientious and environment-friendly, as well as high-class and complex, including "city land usages, city infrastructures, and city landscapes."Although the currently applied design guidelines and district-unit plans are not legally enforceable, systematic enforceability can result in licensing restrictions should the relevant contents not be implemented.

The application methods for design guidelines and the district-unit plans examined in the case studies are simply notices and guidelines that are not legally enforceable; however, systematic enforceability can impact licensing when the relevant contents are not implemented. The

establishment of such design guidelines is a systematic means of facilitating the achievement city building directions or concepts, while preventing indiscreet designs. Therefore, it is necessary to develop design guidelines that define practical application methods for comprehensive planning factors to successfully build a carbon-neutral city.

3. Design Guidelines of new carbon-neutral city development

Methodology to develop design guidelines

This study classified physical and non-physical planning factors and proceeded as follows in order to build a new carbon-neutral city.

First, to compose a design guideline framework for physical planning factors, spatial factors were extracted from case studies on the design guidelines for a sustainable city, an ecological city, and a low-carbon green city as proceeded in South Korea, as well as the district-unit plans. The design guideline case studies focused on the Yeongyeong District in Daegu, Gangneung, and the Sustainable New City Design Criteria (Ministry of Construction and Transportation, 2007), while the case studies on district-unit planning focused on Songdo New City in Incheon, Yeongjong District in Incheon, and Daenong District in Cheongju. Further, the extracted spatial factors were grouped and selected according to similar characteristics from which the final spatial factors were derived.

Second, a strategic framework, strategy, and planning factors were derived from literature reviews on the city planning paradigm and theories that aim at an ecological and sustainable city. The strategy and planning factors considered all physical/non-physical planning domains. Professional Delphi surveys were conducted to verify the suitability of the derived strategic framework, strategy, and planning factors. Each evaluation item used both open and closed questions to verify the suitability evaluation and re-evaluation processes. The professional Delphi surveys were conducted three times from January 25, 2010, to March 25, 2010. Using SPSS, technical statistical analyses such as frequency analysis, average, median value, percentiles, and standard distribution were performed on the data collected through the Delphi surveys.

Third, the final strategic framework, strategy, and planning factors provided by the suitability verification were applied to each spatial factor in order to develop the design guidelines for a new carbon-neutral city. The design guidelines were adjusted by factoring each usage and area characteristic, while incentives and costs by strategy were provided.

Table 1 The Spatial Factors of Design Guidelines and District-Unit Plans

Spatial Factors	Design Guidelines	District-unit Plans

	Yengyeong District	Gangneung	The Sustainable New City Planning Criteria	Songdo New City	Yeongjong District	Daenong Distrct
House/Building	●	●	●	●	●	●
Traffic	●	●	●	●	●	●
Parking space	●				●	
Park and Green Area	●	●	●	●	●	●
Water Resource		●	●		●	
Open Space	●		●	●	●	
Community Facilities			●		●	
City Infrastructures		●	●		●	
Relevant Facilities		●	●		●	

Design guideline framework

The spatial factors were selected following an examination of the case studies on design guidelines and district-unit plans proceeding in South Korea. We examined the spatial factors provided in the design guidelines of Yengyeong District in Daegu, and Gangneung, and the sustainable new city development criteria. In the guidelines for land development and landscaping, and environment-friendly infrastructure and individual facilities, the Design Guidelines for Yeongyeong District, Daegu (2008) encompassed the house/building plans by types of housing areas and use districts; road plans; plan types for parks and green areas; open space plans for public spaces and squares, etc. The Low-carbon Green City Model Development and Basic Concept Study for Gangneung (2009) encompassed the green traffic system, green architecture, green area system, water resource system, resource recycling, and new renewable energy. The Sustainable New City Planning Criteria (2007) was grouped by residence, public transportation system, ecological environment development, energy usage and resource recycling, expansion of open spaces, infrastructures of city, conservation and vitalization of cultural activities, etc. The district-unit plan for Songdo New City includes streets and buildings, traffic, roadside trees and plantings, parks and squares as per the guidelines for each zone/block/sector. The Type 1 district-unit plan for the Yeongjong Sky City, Yeongjong District, Free Economic Area of Incheon (2009) development project encompassed buildings, houses and lots, and city infrastructures. The Type 1 district-unit plan for Daenong Distrct 2, Cheongju

(2006) encompassed the plans for houses and lots, buildings, traffic, parks and green areas, and more. The plans for these spatial factors are organized as shown in Table 2.
The development factors derived from the case studies on the spatial factors of design guidelines and district-unit plans are as follows. The house/building component includes house driveways, accommodated households, the building's direction, placement, height, skyline, shape, and exterior appearance. The traffic component includes the shape of the street network, type of roads, pavement materials, relevant facilities, etc. The parking space (vehicle) component includes the shape and location of building and pavement materials. The park and green area component includes the green area axis and green area system. The water resource component includes rain water expulsion control facilities, multi-purpose control land, and waste water treatment plans. The open space component includes wind paths, outdoor spaces connected to parks, external spaces around schools, and low rise plans. The community facilities include the community centers, management offices, libraries, theaters, and gymnasiums. The city infrastructures include the garbage treatment facilities, and IT and hi-tech living facilities. The relevant facilities include energy usage efficiency facilities, waste heat recovery facilities, new renewable energy facilities, water retention facilities, and energy load equalization facilities.

Table 2 Deriving of strategic framework

Planning Sector		Planning Domains
Mitigation	Carbon Reduction	Energy
		Industrial Resources
		Urban Spatial Structures
		Buildings
	Carbon Absorption	Urban Forest
		Agriculture
Adaptation	Heat Island Management	Temperature Reduction
		Air Pollution Monitoring
	Water Management	Food and water quality management
		Water Quality Management
Ecological Cultivation	City Operation Methods	Governance
		Community
	Cultivation Activities	Energy Efficiency Improvement Program
		Strategies and Management Program
		Citizen Education and Promotion Program
		Community Vitalization Program.

Deriving strategic framework, strateging and planning factors

Using Delphi survey, the planning model was composed of the strategic framework (planning sectors and planning domains), and strategy and planning factors. The planning objective was composed of mitigation, adaptation, and ecological cultivation. The mitigation and adaptation have the characteristics of a physical planning domain, which includes carbon reduction, carbon absorption, heat island management, and water management. The ecological cultivation has the characteristics of a non-physical planning domain, which focuses on lifestyles and communities, such as city operation methods and cultivation activities. For each objective, two specific objectives were provided and sixteen planning domains were set up. In addition, a total of 34 strategies and 148 planning factors were developed.

Table 3 A Design Guideline Framework

Spatial Factors	Elements
House/Building	house driveways, accommodated households, the building's direction, placement, height, skyline, shape, and exterior appearance
Traffic	the shape of the street network, type of roads, pavement materials, relevant facilities, etc
Parking space	the shape and location of building and pavement materials
Park and Green Area	the green area axis and green area system
Water Resource	rain water expulsion control facilities, multi-purpose control land, and waste water treatment plans
Open Space	wind paths, outdoor spaces connected to parks, external spaces around schools, and low rise plans
Community Facilities	the community centers, management offices, libraries, theaters, and gymnasiums
City Infrastructures	the garbage treatment facilities, and IT and hi-tech living facilities
Relevant Facilities	energy usage efficiency facilities, waste heat recovery facilities, new renewable energy facilities, water retention facilities, and energy load equalization facilities

4. Design Guidelines of a New Carbon Neutral City

Design guidelines for creating a new carbon neutral city were proposed for each land use representing the characteristics of Jungbu's new city. These land uses were

categorized as detached housing, apartment housing, commercial-business, innovation cluster, and industrial areas. The planning area for the guidelines consisted of four types of carbon emission reduction sectors: energy, industrial resources, urban spatial structures, buildings, and two types of carbon absorption sectors: urban forest and agriculture.

Applications of renewable energy, such as solar heat and light, and energy efficiency were proposed for the energy sector of the detached housing area. Waste recycling through the installation of household waste emission sites and recycling was proposed for each block of the industrial resource sector. The construction of bicycle and pedestrian roads, vehicle control, and public transportation systems were proposed for the urban spatial structure sector. The use of eco-friendly building materials, as well as building efficiency and ventilation, were proposed for the building sector. Green walls and roofs on the detached house buildings, and ecological space creation were proposed for the urban forest sector. The introduction of agriculture to urban areas was proposed for the agriculture sector. Ventilation path considerations and air pollution monitoring were proposed for the air quality management sector. The installation of non-point source pollution control facilities was proposed for the water quality management sector, and runnels and permeable pavements were proposed for temperature reduction sector.

The proposed contents of the energy, industrial resource, urban spatial structure, urban forest, agriculture, and water quality management sectors of the apartment housing area were similar to those of the detached housing area. A building layout that effectively utilizes renewable energy and factors in the microclimate was proposed for the building sector. A housing complex development that considers a ventilation path and an afforestation plan were proposed for the air quality management sector. The introduction of water circulation systems in the apartment houses was proposed for the flood and water quality management sectors. The creation of ecological ponds in the apartment housing complexes was proposed for the temperature reduction sector.

The proposed contents of the industrial resource, urban forest, agriculture, air quality management, flood and water quantity management, and temperature reduction sectors of the commercial business area were similar to those of the detached housing area. Multifunctional complex building layouts and the creation of three-dimensional roads were proposed for the urban spatial structure sector. Shade installation to control incoming solar radiation, and effective ventilation using atriums and double-skin facades were proposed for the building sector. The construction of rain water retention

systems was proposed for the water quality management sector.
The proposed contents of the energy, urban spatial structure, industrial resource, urban forest, agriculture, air quality management, flood and water quantity management, and temperature reduction sectors of the innovation cluster area are similar to those of the detached housing area. The introduction of hybrid air conditioning systems for effective ventilation, as well as heating and cooling control, was proposed for the building sector. Non-point source pollution prevention equipment installation was proposed for the water quality management sector.
The proposed contents of the urban spatial structure, urban forest, agriculture, air quality management, flood and water quantity management, water quality management, and temperature reduction sectors of the industrial area were similar to that of the apartment housing and innovation cluster areas. Energy acquisition and re-utilization of unused energy from waste generated in the housing complex, along with water-retention equipment and efficient lighting equipment, were proposed for the energy sector. The establishment of a resource recycling network and infrastructure between industries was proposed for the industrial resource sector, including plans to build industries adjacently, construct a resource recycling network with local community assistance, and establish a resource recycling center. Spatial planning, which can be adapted to meet industry needs, was proposed for the building sector.
Expenditure support and the establishment of a union to assist with the renewable energy facilities installation were proposed as part of the ecological cultivation program's renewable energy supply vitalization program. The use of green cars and LED signs for outdoor advertising were proposed as part of the energy efficiency improvement program. The introduction of laws regarding the awareness and use of bicycles were proposed as part of the bicycle vitalization program. A transit discount system and a system to support use of public transportation were proposed as part of the public transportation network development program. Incentives for hybrid urban development and improvements to the floor area ratio of the public transportation area were proposed as part of the program intended for building low energy consuming urban spatial structures. A star rating-based incentive system for eco-friendly buildings and building energy, along with passive and active building guidelines management were proposed as part of the program intended to support and certify low energy consuming buildings. Support for village and school forests creation and rooftop greening, along with the formulation of ecological guidelines, were proposed as part of

the program intended to develop urban green space. Urban gardening and support center management, along with construction of a self-sufficient agricultural network, were proposed as part of the urban agriculture vitalization program. The formulation of urban climate maps and urban island heat management guidelines were proposed as part of the urban island heat management-based building program. An emissions trading system and urban island heat management guidelines were proposed as part of the air pollution management program. An obligation to install rain water and heavy water treatment facilities and to mitigate the loss of wetland and wetland banking were proposed as part of the water management program. A carbon point system and operation of a car sharing program were proposed as part of a carbon reduction campaign. An incentive system, consumption policy support, and guidelines for resource recycling were proposed as part of the resource recycling program. Incentives to be provided to participating companies, along with the establishment of a vitalized information network and mechanism, were proposed as part of the program intended to increase company participation. Cooperation among local communities, local government, and universities was proposed as part of the local community cooperation program. Environmental assessments, resource recycling support, laws, and institutional improvements were proposed as part of the strategies and management program. Carbon reduction, related citizen education, region-specific brands creation, and landmark creation were proposed as part of the citizen education and promotion program. Use of local currency use and a green product purchasing campaign were proposed as part of the community vitalization program.

5. Conclusions and Implications

In the present study, design guidelines for comprehensive and practical applications in a carbon neutral city were proposed. First, each space element was derived from a case study on the design guidelines and district unit planning adopted in Korea, while an expert Delphi survey was conducted to determine goodness-of-fit and priorities. From the results, a total of nine space elements were derived for the new carbon neutral city guidelines: furniture and buildings; transportation; parking lots; parks and green belts; water sources; open spaces; community facilities; urban infrastructure facilities; and related equipment. The results of the expert Delphi survey determined goodness-of-fit and priorities. From these results, the final design guidelines for the new carbon

neutral city were proposed for each land use category (detached housing, apartment housing, commercial-business, innovation cluster, and industrial areas)

However, it is necessary to propose a specific guideline framework, as the main purpose of this study is to propose design guidelines; in particular, each space element, as well as its development (planning) elements, should be clearly proposed.

Note 1. Area standards: standard elimination of seven people furniture, defined addition of number of rooms.

Facility standards: addition of bathing facilities, upgrade of standards for kitchen and toilets.

Bedroom standards: representation changes in bedroom separation standards (More than 5 years old→6 years and older).

Structural performance environment standards: elimination of cooling standards, additional regulations for locations that are vulnerable to the risk of natural disasters such as floods, tsunamis, and landslides (Korea Research Institute for Human Settlements, 2007)

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