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A Study on Strategies of Smart Green City
- The Priority Analysis and Application of Planning Technique-

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ABSTRACT

Purpose: The goal of this research is to identify the planning techniques of Smart Green City with Ubiquitous method and carbon-neutral city planning techniques and to induce the main planning techniques through the analysis of relative importance and practical adaptation. Method: First of all, eighteen planning techniques were derived and categorized into three organization systems and six sectors through literature review and FGI analysis considering the applicability of Ubiquitous service for carbon-neutral city planning techniques. Secondly, based on expert surveys and AHP analysis, the importance of Smart Green City planning techniques was evaluated. Thirdly, using case study, six cases related to Smart Green City were analyzed for the current status of application of planning techniques. Lastly, considering the importance of planning techniques and practical aspects, the characteristics of Smart Green City and its implication were estimated. Result: Energy, Resource and Waste and Transportation sector were identified as important sectors for Smart Green City. In addition, 'Construction of Smart Grid', 'System for Utilization of New & Renewable Energy', 'Smart Resource Circulation Management System', 'Establishment of Public Transportation Information System basis', 'Construction of Pedestrian / Bicycle oriented Road Environment' are essential planning techniques to create Smart Green City.

KEYWORD

Smart Green City
Carbon Neutral Eco City
U-City
Planning Technique

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1. Introduction

Recently, it is expected that infrastructure construction and technology developments based on advanced ICT would support the increase in pleasantness and convenience of citizens as well as efficiency in the aspect of management and maintenance for low carbon, low energy city realization. In city planning aspect, researches such as smart eco city, U-eco city and Smart green city applying ubiquitous technology are being proposed and the interest regarding them are still on the rise. Environmentally developed countries mainly composed of Europe such as Germany and Sweden recognize the need for shift towards low carbon society utilizing IT. Thus, policies are being propelled based on the researches that present specific strategies or planning factors to this and the quantitative researches regarding the effect of carbon reduction are still being done as well.

Domestic researches related to Smart green city are now just inclined to the aspect of ubiquitous technology development or ends with the strategy proposal which lacks differentiation with existing low carbon city planning technique. Thus, researches related to planning technique considering low carbon city planning and ubiquitous technology in integrated way are needed. Based on these backgrounds, this research intends to comprehend planning field or technique for carbon neutral city realization and ubiquitous service that supports this then examine the current application situation of examples and importance analysis to propose major planning technique of plausible smart green city in current stage.

The scope of planning technique of smart green city which is a major analysis target in this research is only limited to ubiquitous technology in service field and physical planning technique for carbon neutral city planning and design. Besides, spatial scope seeks for the way to integrate ubiquitous technology and carbon neutral city planning which are major concepts of smart green city and targets the city where model apartments are planned and implemented. Basically, it sets the dimension of urban planning but it also sets the contents of district unit planning and estate planning as well as architectural planning included in urban planning as the scope of the research.

We intend to progress the research with the following methods to confirm the core planning technique applicable in Smart green city plan. First, we induce planning technique of Smart green city considering ubiquitous supporting technology and carbon neutral

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city planning technique and analyze the importance of planning technique through experts survey. Second, we understand the application status of induced planning technique through foreign and domestic example analysis. Third, we try to confirm the implication in the aspect of urban planning and major features of Smart green city by comparing and analyzing the understanding about the current status in application and importance.

2. Organization system and concept of Smart green city

2.1. The concept of Smart green city

The concept of Smart green city can be defined integrating 2 aspects of ubiquitous city as a supporting technology through ICT basis and ecological city of carbon neutral that can aim for green city. In prior researches[1], Smart green city was defined as a city that minimizes carbon emission improving quality of life by integrating ubiquitous technology and advanced information communication infrastructure with the urban space.

Carbon Neutral Eco City is a goal-directed urban planning concept that tries to minimize the carbon emission amount by absorbing emitted carbon as well as reducing the amount of it as much as possible in order to solve carbon emission matters that possibly can cause climate change. Obeying this carbon neutral principle, we would like to reduce the energy consumption and dependency on fossil energy to minimize the carbon emission in the city then realize the neutralization through city energy system of new concept affiliated with renewable energy resources and energy reducing space structure. Also, we propose that efficient energy circulation system should be embodied. [2]

U-City, Ubiquitous City, is defined as a city that provides information communication service real-time dealing with every task occurring in the city real-time by grafting ubiquitous technology to information infrastructure and innovating existing information infrastructure for efficiency of management and city function in related researches. And they argue that city infrastructure such as ubiquitous information technology that can communicate anywhere whenever and road, buildings, facilities can be composed of intelligent infrastructure which has been interacted. Through this, we can create continuous city that can solve problems in city space with the aid of planning and systematic integration of ubiquitous information communication technology and physical, spatial city developments ultimately. [3]

In prior researches of Smart Green City, smart green city or advanced no carbon city are used as terms in the research. But advanced researches are the one that presents some strategies or concept establishment mainly thus presented strategy as well lacks differentiation or carbon neutral city strategy or researches focusing on advanced IT technology.

Based these concepts above, this research intends to define Smart Green city as the one where ubiquitous operation and management technology that can support design technology and city planning based on eco city to realize carbon neutral are planned in an integrated way.

2.2. Organization system of Smart Green City

Smart Green City plan required physical planning technique and various types of system introduction but we need to understand the scope of technique and system applicable in city planning in current stage targeting those and for this, we intends to check the organization system of Smart Green City first through examination of prior researches and related theories.

Organization system of Smart Green city intends to utilize the organization system of ubiquitous urban planning and planning system according to the city organization layer proposed in prior researches in Smart Green city by synthesizing and complementing these. Considering similarity between city planning ranks and planning techniques, we set organization system of Smart Green city as 3 kinds, urban spatial structure, urban environment system, urban building. [4]

If planning aspect of carbon neutral eco city included in organization system of Smart Green city is classified according to the ranks, urban spatial structure system includes land use, transport and green and water space scope, and urban environment system includes resources and waste, energy scope then urban building system includes architectural scope. On the other hand, we can accommodate planning concept of Smart Green city mentioned already in the inclusion of service basis that can realize this in ubiquitous planning aspect [5]. (Refer to Fig. 1)

Thus, 3 organization system and 6 fields of carbon neutral eco city are set and by synthesizing related service of ubiquitous that

1) Referred to the researches of Park. Sang-Hyun,2009; Jo, Hun-hoi, 2011; Lee, Gn-Hyung 2011; Yoon, Bum-Sun, 2011

2) Ban, Young-Woon and others, 2008; Lee, Myung-Sik and others, 2011; Kim, Jung-Gon and others, 2011; Kim, You-Min and others, referred to 2013 researches

3) Referred to the researches of Kim, Jung-Mi, 2005; Jung, Bu-Man, 2005; Shin, Dong-Bin, 2011

4) Lee, Gn-Hyung(2011) Classified Smart green platform into city space/Facility, environment/energy, building field, Lee, Sang-Ho(2012) classified it into district, facility, distance and building system. This research re-established organization system considering ubiquitous and low carbon technology level applicable in city space ranks, basic direction, definition of smart green city based on classification system proposed in prior researches.

5) In prior researches of ubiquitous city, it explains that 4 factors that are service, technology, infrastructure, management, get connected and form U-City. Service means connecting and providing or dealing the information after collecting them by major function of city such as administration, transportation, welfare and environment, disease prevention through ubiquitous city based facility. Technology and infrastructure can be seen as a mean to enable access towards various service through high-speed network and high-class communication service. Management means urban management method reflecting features of ubiquitous information technology. Thus, this research limits the scope of ubiquitous service that can check technology application in the aspect of urban organization system of Smart Green city and confirm this.

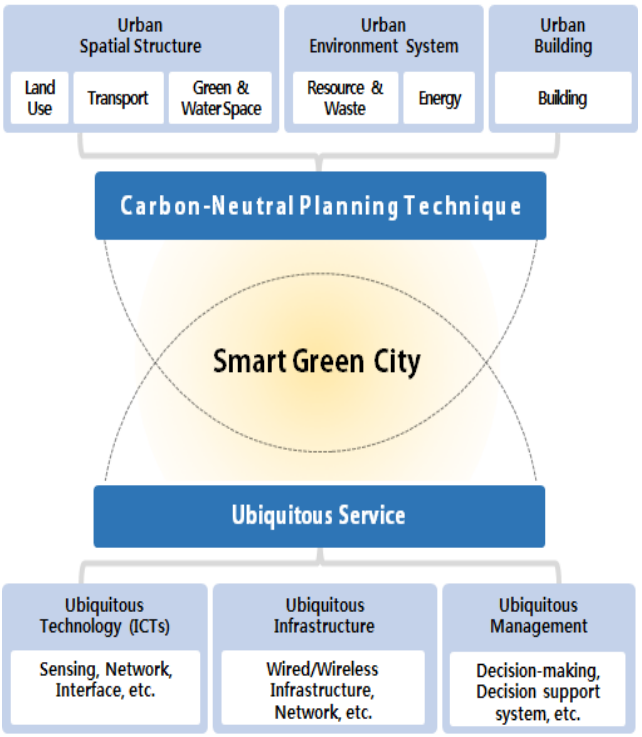


Fig. 1. Organization system of Smart Green City

can support this, following Smart Green City planning system can be organized. (Refer to category of Table 1) Following is the organization system finally drawn and the contents according to fields.

First, urban spatial structure is about construction of efficient, eco-friendly city structure and management system including land use, transport, green and water space fields. To be specific, compressive urban spatial structure, introduction of eco-friendly transportation and public transport centered system, database construction and creation of eco-friendly environment, supervision and monitoring, service that can deal in real-time will be required.

Second, urban environment system includes contents in the aspect of waste, resource, energy and urban infrastructure service area for realization of Smart Green City. We need water resource saving and re-use, waste minimization and recycle and re-use, active utilization plan for renewable energy and management system is provided on the basis of Smart Grid from each demand to supply.

Third, urban building aims for supply of intelligent and automated building with energy management system in building unit. In city aspects, we would like to realize energy reduction effect through service like passive and active building plan, automatic control of facilities, remote control in architectural aspects and real-time monitoring service, building efficiency improvement through architectural authentication system introduction in city aspects.

3. Major planning technique induction of Smart Green City

3.1. Planning technique induction

1) Induction of Smart Green City planning technique : advanced research contemplation

As the first step to induce planning technique of Smart Green city, we re-organized planning technique of carbon neutral city examining advanced researches of carbon neutral city and low carbon and carbon reduction city planning. [6] Among planning technique dealt more importantly in advanced researches, [Table 1] shows planning technique of 28 carbon neutral cities and 6 fields (land use, transport, green and water space, resource and waste, energy, building) considering suitability of ubiquitous technology application and carbon reduction effect.

Besides, through advanced researches related to ubiquitous city planning, [7] we examined ubiquitous service technology applicable to carbon neutral city planning technique. Considering the trend in recent researches, we organized factors determined to be necessary in carbon neutral planning technology among ubiquitous service technology dealt mainly in prior researches and those are shown in [Table 3].

Through this, 28 planning techniques of Smart Green City primarily drawn in this researches are organized. (Refer to 1st Suggestion of Table 3)

2) Planning technique verification : Experts FGI

We examined applicability of planning technique through Focus Group Interview (FGI) targeting experts regarding planning technique of 28 Smart Green Cities that induced and analyzed 9 advanced researches related to ubiquitous city planning, carbon neutral city and low carbon, carbon reduction city planning. [8]

Followings are organized contents of major points proposed in experts FGI process. First, terms that are ambiguous in meaning of planning technique are modified or changed into the ones that are representative or concise. Second, we integrated planning techniques where specific rank contents are different compared to other planning techniques or where similar concept is used more than once. Finally, we described the contents about specific

6) Analyzed and referred to the researches of Kang, Sang-Jun, 2009; Oh, Young-Jun and others, 2009; Kim, Jung-Gon and others, 2010; Lee, Myung-Sik and others, 2011; Yum, In-Sub, 2011; Kim, Yu-Min and others, 2013

7) Analyzed and referred to the researches of Lee, Jae-Sng, 2008; Son, Se-Gwan and others, 2009; Oh, Young-Jun, 2013

8) Experts group selected for FGI was composed of 5 members, 3 university professors, 1 researcher, 1 engineering worker and was done in seminar form that can speak freely on November 13th, 2013.
Before, FGI was done in the aspect of actual application probability and suitability of planning techniques in the creation of Smart Green city and intended to perform detailed modification like changes in terms or integration of items through this.

Table 1. Planning Technique of Carbon Neutral City in Precedent Studies

Category		Planning Technique	Main Precedent Studies					
			A	B	C	D	E	F
URBAN SPATIAL STRUC-TURE	Land Use	Decentralized Concentration Land Use		●	●	●	●	
		Mixed-Use Development	●		●	●	●	
		Optimal Development Density Management District	○				○	●
		Improving Pedestrian Accessibility		○				
		Transit Oriented Development	●	●			●	
		Wind Corridor & Atmospheric Circulation	●	●	●	●	●	●
		Nature-adapted Development			●	●	●	○
	Transport	Public Transport System	●		○	●	○	●
		Public Transport Management System					○	
		Transit Mall			●	●	○	
		Introduction of Eco-friendly Transport		●	●	●	●	●
		Protecting the enter of Automobile				●	○	
		Service of Car Sharing			●		●	
		Traffic Calming Schemes		●	○		●	
		Pedestrian, Bicycle oriented Transportation System	●	●	●	●	●	●
	Green & Water Space	Open Space	●	●	●	●	●	●
		Planting for Control of CO_2			○		○	
		Water-friendly Space		○	○	●	●	●
		Green·Blue Network		●	●	●	●	●
		Ecological Area Rate System		○				
		Ecological Corridor & Bio-top		●	●	●	●	●
URBAN ENVIRON-MENT SYSTEM	Resource & Waste	Water Circulation System	●	●	●	●	●	●
		Use of Rainwater & Water Saving		●	●		●	●
		Water Recycling	●		●	○	○	●
		Waste Refuse System	●		●		○	
		Waste Recycling & Waste to Energy	●	●	●	●	●	○
	Energy	Energy Management System of City[9]			○			●
		New & Renewable Energy	○	●	●	●	●	●
URBAN BUILD-ING	Building	Building Energy Management System			●	●		●
		Active Design		●	○	○	○	
		Passive Design		●	○	●	○	
		Use of Eco-friendly Material & Regional Material				○	●	
		Use of High Quality and Efficiency Material		●	●	●	○	●
		Environment friendly Soundproof Wall System				○	○	
		Renewable Energy system for Building			○	●	●	
		Three-Dimensional Planting		●	●	●	●	●

● : Using wholly as planning technique
○ : Using Partly or similarly as planning technique
A : Kang Sang-Joon(2009), B : Oh Young-Jun(2009), C : Kim Jong-Kon(2010)
D : Lee Myung-Sik(2011), E : Yeom In-Sup(2011), F : Kim You-Min(2013)

Table 2. General Information of FGI respondents

Division	A	B	C	D	E
Age	51	50	49	47	41
Gender	Male	Male	Male	Female	Male
Degree	Ph.D	Ph.D	Ph.D	Ph.D	Ph.D
Major	Green City Planning	Urban Planning	Urban Planning	Low-Carbon City	Ubiquitous Architec-ture
Job	Prof.	Researcher	Engineer	Prof.	Prof.
Career (yr.)	26	24	20	20	18

application method by planning technique because there were opinions that some explanation would be needed to help understanding on planning techniques. (Refer to FGI of Table 3)

Through this, we could organize first 28 Smart Green City planning techniques into 18. (Refer to 2nd Suggestion Planning Technique of Table 3) Followings are planning techniques, 3 organization systems, and its details.

① Urban spatial structure

Planning techniques that falls into the field of land use of urban spatial structure are ‘Establishing urban planning information system’, ‘Density differentiation development and management’, ‘Construction of urban micro-climate management system’. ‘Establishing urban planning information system’ means constructing database related to city development information (land use) and reflecting it in future plan. ‘Density differentiation development and management’ is planning technique that seeks efficiency improvement of land use with the density development management differentiated at the level of region. ‘Establishing urban planning information system’ continuously constructs city microclimate with data for plan reflection optimized to target region of development within the city.

Transport field was classified into 4 planning techniques which are ‘Establishment of public transportation information system’, ‘Creation of transit mall and management system basis’, ‘Establishment of infra-system for Eco-friendly transportation’, ‘Construction of pedestrian, bicycle oriented road environment’. ‘Establishment of public transportation information system’ provides information to be utilized and creates comprehensive management center for public transportation. ‘Creation of transit mall and management system basis’ creates specialized region for public transportation and provides traffic monitoring service within the region and management service. ‘Establishment of infra-system for Eco-friendly transportation’ introduces eco-friendly transportation means and provides its infrastructure expansion. ‘Construction of pedestrian, bicycle oriented road

9) Although not mainly dealt in advanced researches, selected as main carbon neutral city planning technique because of judgment regarding its connectivity with Smart Green City

Table 3. Planning Technique of Smart Green City

Category		Planning Technique of Carbon Neutral City	Ubiquitous Service	Planning Technique of Smart Green City		
				1st Suggestion of Planning Technique	FGI	2nd Suggestion of Planning Technique
USS	L	Decentralized Concentration Land Use	·Spatial Information Service ·Land Information Management System	Providing Urban Planning Information & Prediction Service of Urban Development	R	L1. Establishing Urban Planning Information System
				Compact Land Use	I	L2. Density differentiation development and management
		Mixed-Use Development	·U-Work Center	Mixed-Use Development		
		Optimal Development Density Management District	·Urban Development Forecasting Service	Setting Development Density Management Area		
		Transit Oriented Development	·U-TOD	Transit Oriented Development		
		Wind Corridor & Atmospheric Circulation	·Urban Meteorological Information Service	Construction & Monitoring of Wind Way Based on Urban Micro-climate Information	R	L3. Construction of Urban Micro-climate Management System
		Nature-adapted Development	·Natural Landscape Conservation Service	*(Integrated to 'G&B)*		
	T	Public Transport System	·Integrated Transportation Management Center ·U-Traffic Information Service (BIS, ITS, VMS, etc) ·Advanced Public Transportation Supporting System	Intelligent Transport System	R	T1. Establishment of Public Transportation Information System basis
		Transit Mall	·Traffic Surveillance & Control System ·RFID System on Weekday-based Car Control Program	Transit Mall	R	T2. Creation of Transit Mall & Management System
		Introduction of Eco-friendly Transportation	·CO_2 Emission Measurement/Control Service for Vehicle ·Eco-friendly Transportation Service	Introduction of Eco-friendly Transportation&Supporting Service	I	T3. Establishment of Infra-system for Eco-friendly Transportation
		Traffic Calming Schemes	·Advanced Traffic Management Systems : ETC, ATES, etc.	Integrated Application of Traffic Calming Schemes		
		Pedestrian, Bicycle oriented Transportation System	·Pedestrian Path Information & Monitoring Service ·Manless Bicycle Lease Service ·Traffic Safety Management Service	Construction of Pedestrian, Bicycle oriented Road System	R	T4. Construction of Pedestrian, Bicycle oriented Road Environment
UES	G&B	Open Space	·U-Soil Conservation System ·U-Vegetation Management System ·Environmental Pollution Management System ·Air Pollution Monitoring System	Composition of Open Space & Vegetation Management System	I	G1. Eco-friendly Space Creation and Monitoring System
		Water-friendly Space	·U-Ecology River Management Systems ·U-Water Quality Management System	Composition & Monitoring of Water-friendly Space		
		Green·Blue Network	·U-Green & Blue Network	Green·Blue Network	-	G2. Green·Blue Network Information System
		Ecological Corridor & Bio-top	·U-Ecological Environmental Management System	Composition of Bio-top /Ecological Corridor & Management System	R	G3. Ecological Environment Management System
	R&W	Water Circulation System	·Integrated Water Resources Management System	Water Circulation System & Integrated Management	I	R1. Smart Resource Circulation Management System
		Use of Rainwater & Water Saving	·Rainwater Collection and Storage System	Use of Rainwater		
		Water Recycling	·U-Water and Sewer Infrastructure Facility Management System	Wastewater Reuse System		
		Waste Refuse System	·U-Integrated Waste Management System	Integrated Waste Management System		
			·Waste Refuse Automatic Service ·Monitoring Service of Illegal Waste Disposal	Automatic Waste Separate & Disposal System	R	R2. Smart Waste Treatment System
		Waste Recycling & Waste to Energy	·Waste Tracking System ·Recycling Information Network System	Waste Recycling & Energy Recovery by Tracking/Management	R	R3. Waste Management & Energy Recovery from Waste System
	E	Energy Management System of City	·U-City Energy Management System (Smart Grid)	Construction of Smart Grid	-	E1. Construction of Smart Grid
		New & Renewable Energy	·Renewable Energy Integrated Management System ·Local Energy System	System for Utilization of New&Renewable Energy	-	E2. System for Utilization of New&Renewable Energy
UB	B	Building Energy Management System	·Building Energy Management System ·Building Energy Efficiency Service ·GHG Emission Management ·Intelligent Remote Control Service	Real-time Carbon Emission Measurement System	I	B1. Building Consumption Energy Management System
				Building Energy Management System		
		Active Design	·Home Automation Service ·Pollution Barrier & Remediation System	IT Automatic Control System	R	B2. Facility Control Automation of Building
		Passive Design	·Intelligent Facility Control/Management Service ·Weather Information Providing Service ·Energy Load Control Service	Passive Design	I	B3. Smart Building Monitoring System (Mapping of Smart Green Building)
		Use of High Quality and Efficiency Material	-	Use of High Quality and Efficiency Material		
		Renewable Energy system for Building	·Renewable Energy Generation & Management Service	*(Integrated to 'E')*		
		Three-Dimensional Planting	·Ecological Information Service	*(Integrated to 'G&B)*		

USS: Urban Spatial Structure, **UES:** Urban Environment System, **UB:** Urban Building
L: Land Use, **T:** Transport, **G&W:** Green & Water Space, **R&W:** Resource & Waste, **E:** Energy, **B:** Building **R:** Revised Item, **I:** Integrated Item

environment' creates various environment construction for walking and bicycle and expects conveniency and safety increase through this.

② Urban environment system

Green and water space included in city environment system are composed of 3 planning techniques which are 'Eco-friendly space creation and monitoring system', 'Construction of green and blue network information system', 'Ecological environment management system'. 'Eco-friendly space creation and monitoring system' means management automation through monitoring system and creation of eco-friendly space. 'Construction of green and blue network information system' seeks network and management method through information about green land water space, 'Ecological environment management system' means application of ecology management system and creation of ecology corridor together with ecological environment (Bio-top).

In the field of resources and waste, we could check 3 planning techniques that are 'Smart resource circulation management system', 'Smart waste treatment system', 'Waste management and energy recovery from waste system'. 'Smart resource circulation management system' is a planning technique for construction of integrated management system of resource (automated management system). It includes smart waste manage system that means automation system introduction of waste disposal and separation and recycling system as well as waste management planning technique for management automation and facility creation towards recycling and re-use of waste.

Energy field includes 2 planning techniques that are 'Construction of Smart Grid' and 'System for utilization of new & renewable energy'. 'Construction of Smart Grid' intends to realize city energy management system construction (energy supply, consumption information collection/bidirectional communication between supplier and consumer) aiming at utilization of renewable energy and efficiency of energy supply. Through planning technique of 'System for utilization of new & renewable energy', we can provide management method (production/ consumption monitoring) and renewable energy development facility construction.

③ Urban building

Building field of Urban building includes 3 planning techniques that are 'Building consumption energy management system', 'Facility control automation of building', 'Smart building monitoring system (map)'. 'Building consumption energy management system' intends to seek management method (consumption analysis, operation and efficiency) and energy system creation of building. 'Facility control automation of building' realizes facility control automation in order to deal with various environments of inside and outside the building. 'Smart building monitoring system (map)' planning technique is the one that eases the management, keeping and efficiency evaluation with information map construction of building within the city (highly efficient/ low energy building).

3.2. Importance analysis : AHP technique

Experts survey was done to understand priorities and comparative importance evaluation regarding planning techniques of Smart Green city organized through experts FGI. [10)]

As a result of survey, we could check weighted value of planning technique by each field and between 6 fields for creation of Smart Green city. Besides, we could confirm the comprehensive weighted value determined by its multiplication of planning technique by field and between fields understanding the importance.

In the results of weight value between fields, weight value of transport(0.237) and energy(0.231), resource and waste(0.184) was relatively evaluated to be higher than green and water space (0.133), land use (0.116) and building(0.099). Thus, application of planning techniques corresponding to the field of transport and energy, resource and waste can be seen as advantageous in creation of Smart Green city compared to other fields.

In confirmation of weighted value of planning technique by each field, establishment of public transportation information system in the field of transport(0.075), smart resource circulation management system in the field of resource and waste field(0.088), Construction of Smart Grid in energy field, Smart building monitoring system (map)(0.041) in the field of building were evaluated with high importance. This is because system construction for integrative management is determined to be more important than individual plan or business. Also in land use field, establishing urban planning information system(0.041) and construction of urban micro-climate management system(0.041), and eco-friendly space creation and monitoring system in the field of green and water space(0.56) showed high importance. This is because direct effect on carbon emission reduction is expected compared to other planning factors.

10) The survey used means to distribute and collect the questionnaire through fax or E-mail with people in charge or visit to related institutions. The period was from Nov, 18, 2013 to Nov, 25, 2013. Total 60 questionnaires were distributed and 54 of them were collected back then analyzed except 6 ones that couldn't be received or answered not well.
Afterwards, consistency verification was done targeting total 54 questionnaires and 45 of them except 9 ones with low consistency because consistency rate was bigger than 0.1 were used in analysis.
Questionnaire was composed of total 40 questions, 6 items asking personal data, 15 items for importance comparative evaluation between fields, 19 items for comparative evaluation between planning techniques by field. +Each item gets the method that measures the importance of planning techniques and field with 5-points criterion for comparison.
Experts responded to the survey were professor (6.7%), graduates (28.9%), researchers (18%), engineering and architectural company (7%), public officer (8.9%) and are experts in low carbon and ubiquitous city plan and building plan, related field of Smart Green city.

Table 4. Importance & Prioritize of Planning Technique

Category		Planning Technique	Level	Total Importance	
				Value	Rank
USS	L (0.116)	L1 (0.353)		0.041	10
		L2 (0.291)		0.034	11
		L3 (0.356)		0.041	10
	T (0.237)	T1 (0.317)		0.075	4
		T2 (0.189)		0.045	9
		T3 (0.197)		0.047	8
		T4 (0.297)		0.070	5
UES	G&W (0.133)	G1 (0.421)		0.056	6
		G2 (0.241)		0.032	12
		G3 (0.338)		0.045	9
	R&W (0.184)	R1 (0.480)		0.088	3
		R2 (0.249)		0.045	9
		R3 (0.271)		0.050	7
	E (0.231)	E1 (0.606)		0.140	1
		E2 (0.394)		0.091	2
UB	B (0.099)	B1 (0.322)		0.032	12
		B2 (0.268)		0.027	13
		B3 (0.410)		0.041	10

Refer to Index of category and planning technique in table 3

As a result of comprehensive weight value of planning technique, its rank were construction of Smart Grid(0.14) and system for utilization of new & renewable energy(0.091) in energy field. Next, Smart resource circulation management system(0.088) and establishment of public transportation information system(0.075), construction of pedestrian, bicycle oriented road environment (0.070), eco-friendly space creation and monitoring system (0.056), etc were shown in order. Aside from that, comprehensive weighted value of planning technique corresponding to the field of transport, resource and waste, energy were shown to take a high rank.

In conclusion, it means energy efficiency realization should be put first through construction of Smart Grid and utilization of new & renewable energy for Smart Green City plan. Smart resource circulation management system and public transportation information system should also be dealt mainly as well as management service on the basis of ubiquitous technology and creation of eco-friendly space for carbon absorption rate planned in the direction where it is provided actively. This can be understood it is because that integrative management system on the basis of ubiquitous infrastructure is determined to be core in Smart Green city plan than individual plan or business. Besides, it can be seen as results of decision that economics and conveniency on application of technology in existing cities on the basis of current technology were considered.

4. Analysis on planning technique application situation of Smart Green city : Case study

4.1. Case selection and introduction

This chapter intends to select and analyze the city that model apartments are planned or utilized and seek the way to integrate ubiquitous technology and carbon neutral city plan to confirm actual applied cases of Smart Green city planning technique. Case study focused on literatures such as thesis and domestic, abroad research papers and we examined detailed contents focusing on planning map of energy and resource, transportation circulation system and fllor plan proposed in each developmental stage. Moreover, related homepage and publications and other supportive means were utilized and examined.

This research selected target area to be analyzed based on ubiquitous based service provision, reflection of carbon neutral plan, specific carbon reduction effect. Through this, it fulfills organization system and the concept of Smart Green city and selected target area were Kitakyushu of Japan, Amsterdam of Netherland, Hammarby Sjöstadt of Sweden evaluated to be excellent in business contents and plan, domestic Grid test site in Jeju, Sejong, Gangneung.

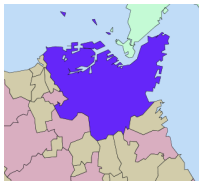
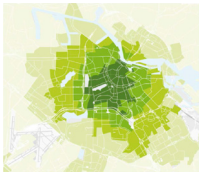
Kitakyushu of Japan had been a typical industrial city in Japan until 1970s experiencing environment pollution but was selected as 'environmental model city' with the endeavor of continuous civic activities and central government and it is planned to reduce CO_2 emission amount by 50% compared to 2005 until 2050 towards developments as low carbon society.

Amsterdam of Netherlands is conducting Amsterdam Smart City Project under the participation of global company and government with the goal of changing Amsterdam into neutral city in climate change based on advanced technology until 2015.

Hammarby Sjöstadt of Sweden, green waterfront city, constructed sustainable city housing model as a recycling means to solve environmental pollution matter and decrease in city function because of decline in manufacture business then implemented developmental plan by stage that forms the city focusing on green transportation and usage of renewable energy.

Smart Grid test site in Jeju aims for realization of model business related to bio-energy and plan in major field of Smart Grid in order to embody Smart Grid apartment at the largest, most advanced

Table 5. Case outline of Smart Green City

Classification	Foreign case			Domestic case		
	Kitakyushu, Japan	Amsterdam, Netherlands	Hammarby Sjöstadt, Sweden	Jeju, Korea	Sejong, Korea	Gangneung, Korea
Location						
Area	488㎢	219㎢	2㎢	186㎢	73㎢	18㎢
Population	990,000	767,000	25,000	15,080	115,388	13,000
Main Features	· Climate Prediction System · ITS · Environmental Monitoring · Community Energy Management System	· Advanced Public Transportation System · EV(Electric Vehicle) & EV Charging Infrastructure · Energy Monitoring	· Eco-friendly & Sustainable Transport · Hammarby Eco-cycle Model · Automated Waste Collection System · New & Renewable Energy	· Smart Meter · New & Renewable Energy · Smart Grid · Introduction of Electric Vehicles	· Intelligent Transport System · Total Operation Center(TOC) · Cable Tunnel Monitoring System for Power, Telephone, Water/sewer	· Environmental Monitoring Service · Transit Transfer Center & ITS · Smart Grid · BEMS

level as the first in the world as well as reducing 50% of CO_2 emission amount compared to 2005 until 2020.

Sejong proposed 'carbon neutral city' announcement aiming at 'sustainable environmental city' and intends to replace about 17% of total energy supply with green energy by applying Smart Grid technology utilizing ICT technology reducing CO_2 by 70% of Sejong until 2030.

Gangneung established low carbon green city operation and management plan through intellectualization, modernization of green IT and U-City technology in green city basic plan and is now propelling business such as comprehensive management in energy consumption amount and Smart Grid infrastructure, renewable energy usage, construction of transfer transportation system, environmental pollution monitoring and comprehensive management.

4.2. Analysis by field

1) Urban spatial structure

① Land use field

In land use field, currently applied situation of establishing urban planning information system planning technique can be checked through Sejong total operation center of city and information service related to city development of Jeju test site, U-total operation center of Gangneung. In these cases, we can see that they collect various city information focusing on total operation center of city and provide citizens information and related service.

As a part of planning technique of density differentiation development and management, Amsterdam reorganizes itself to energy saving space structure by realizing highly densed development focusing on nodes of public transportation together with compressed city policies. Kitakyushu and Hammarby Sjöstadt created intensive city structure with high energy efficiency then changed into space structure focusing on pedestrian and public transportation. It is difficult to check the management focusing on specific public transportation since plan at the size of test site is first being done in domestic cases.

For planning technique of construction of urban micro -climate management system, Hammarby Sjöstadt created space system considering wind path and Sejong is conducting continuous monitoring as well as securing wind path within the city.

Application of planning techniques of construction of urban micro-climate management system and density differentiation development and management in land use field was partly checked but compared to other planning techniques in other fields, it is still not enough and continuous research to construct city information data in the future and to reflect this in city planning would be required.

② Transport

Establishment of public transportation information system in transport field was seen to be applied in many cases. Kitakyushu, Jeju test site, Sejong. Gangneung constructed intelligent transportation management system (ITS, ATMS etc) focusing on public transportation and are now implementing those. Intelligent transportation management system provides real-time traffic running information such as route information, transfer information, public transportation information and improves conveniency of those who use public transportation and analyze, deal the traffic situation real-time.

Planning technique of creation of transit mall and management system basis could confirm the trial with operation of specialized

Table 6. Case Studies in terms of Urban Spatial Structure

Category		Planning Technique	K	A	H	S	J	G	Description
Urban Spatial Structure	Land Use	Establishing Urban Planning Information System				●	●	●	·Total Operation Center (Sejong) ·Urban information data construction and utilization (Jeju) ·U-Integrated Management Center (Gangneung)
		Density differentiation development and management	●	●	●				·High density development in area near transit center (Amsterdam) ·Transit Oriented Urban Structure for Energy Saving (Kitakyushu, Hammarby Sjöstadt)
		Construction of Urban Micro-climate Management System			●	●			·Urban structure considering urban micro-climate (Hammarby Sjöstadt) ·Construction and monitoring of wind way (Sejong)
	Transport	Establishment of Public Transportation Information System basis	●			●	●	●	·Intelligent transport system (ITS) (Kitakyushu, Sejong) ·The Advanced Traffic Management System (ATMS) (Jeju) ·Public Transportation Information System (Gangneung)
		Creation of Transit Mall & Management System		●					·Construction of Transit Mall (Amsterdam)
		Establishment of Infra-system for Eco-friendly Transportation	●	●	●	●	●	●	·Introduction of New Transit Systems (LRT, Monorail, etc.) (Kitakyushu, Jeju) ·Car-sharing Service (Kitakyushu, Hammarby Sjöstadt) ·Change to Eco-friendly transportation and Design Charging Infrastructure (Kitakyushu,, Amsterdam, Hammarby Sjöstadt, Jeju, Sejong, Gangneung)
		Construction of Pedestrian, Bicycle oriented Road Environment	●	●	●	●	●	●	·Manless bicycle lease system (Kitakyushu, Amsterdam, Jeju, Sejong, Gangneung) ·Construction of Pedestrian and Bicycle (Amsterdam, Hammarby Sjöstadt, Jeju, Sejong, Gangneung) ·Pedestrian and Bicycle Traffic Lights Control Service (Amsterdam)

● : Strong ○ : Weakness
K : Kitakyushu, A : Amsterdam, H : Hammarby Sjöstadt, S : Sejong City, J : Jeju City, G : Gangneung City

are for public transportation of Amsterdam. It is suspected that construction of domestic specialized region for public transportation would be difficult to be checked regarding its application and implementation because of difficulties existing in agreements of each interest and infrastructure construction.

Planning technique of establishment of infra-system for eco-friendly transportation and construction of pedestrian, bicycle oriented road environment are being implemented and applied in every case target. Kitakyushu and Hammarby Sjöstadt, Jeju test site introduced and operated new public transportation method such as LRT, monorail, natural gas bus and are now shifting vehicle for public business, Car-sharing service vehicle to eco-friendly car gradually. Especially, Hammarby and Amsterdam are now operating ship or ferry that can be charged electrically considering local environments as eco-friendly transportation means. Besides, Kitakyushu, Amsterdam, Jeju test site, Gangneung expand and provide facility to be used such as infrastructure that can be electrically charged and incentive support on users for activation of eco-friendly transportation means.

With the implementations of planning technique of construction of pedestrian, bicycle oriented road environment, Amsterdam, Hammarby, Jeju test site, Sejong, Gangneung now enlarge driveway for walking and bicycle. With this, Kitakyushu, Amsterdam, Jeju test site, Sejong and Gangneung construct comprehensive infrastructure such as installing supportive and service center for unattended bicycle rental.

In transport field, many businesses existed related to planning technique of establishment of infra-system for eco-friendly transportation and construction of pedestrian, bicycle oriented road environment and Establishment of public transportation information system was confirmed in many cases as well. This can be applied at current technology level and is determined so because it is the planning technique that can provide citizens direct conveniency.

2) Urban environmental system

① Green and water space

In regard to eco-friendly space creation and monitoring system, Amsterdam, Jeju, Sejong all together deal real-time and monitor continuously creation of green land and river, pollution in sail, green land, water space, atmosphere. Especially, in Kitakyushu, it is specifically being realized with development and application of environmental monitoring technology and dealing technology regarding air pollution as well as city plan reflection through weather forecast system development. Gangneung monitors river area real-time to see rainfall/water level/water quality/pollution source through disease prevention and U-Bye environment service and are now putting an endeavor to propagate prompt situation and understand the comprehensive situation such as flood damage or pollution accident.

Planning technique of construction of green and blue network information system is now conducting construction plan for green land affiliation of park in Kitakyushu, Hammarby, Sejong, Jeju. Gangneung but specific information or network and management method seeking are still in deficient level.

In planning technique ecological environment management

Table 7. Case Studies in terms of Urban Environment System

Category		Planning Technique	K	A	H	S	J	G	Description
URBAN ENVIRON-MENT SYSTEM	Green & Water Space	Eco-friendly Space Creation and Monitoring System	●	●	○	●	●	●	·Using Weather Research Forecast system (Kitakyushu) ·Composition and monitoring service of open space and stream (Kitakyushu, Hammarby Sjöstadt, Jeju, Sejong, Gangneung) ·Monitoring and Response system for Air, water, Soil pollution (Kitakyushu, Amsterdam)
		Green·Blue Network Information System	○		●	○	○	○	·Enhancing Green and water Network and Management of Information data (Hammarby Sjöstadt, Sejong)
		Ecological Environment Management System			●	●	●	●	·Composition of Bio-top (Hammarby Sjöstadt, Sejong, Gangneung) ·Monitoring of ecological environment and construction of ecology experience place (Jeju)
	Resource & Waste	Smart Resource Circulation Management System	●	●	●	●		●	·Resource recycling system (Water, Waste, etc.) (Kitakyushu, Amsterdam, Hammarby Sjöstadt, Jeju, Sejong, Gangneung) ·Integrated resource management system and automatic control system (Jeju)
		Smart Waste Treatment System		●	●				·Automated waste collection system (Amsterdam, Hammarby Sjöstadt)
		Waste Management & Energy Recovery from Waste System		●	●	●	○	●	·Waste recycling and energy recovery from waste (Kitakyushu, Hammarby Sjöstadt, Jeju)
	Energy	Construction of Smart Grid	●	●		●	●	●	·Energy management system based on smart grid (Management and monitoring of consumption and supply network) (Kitakyushu, Amsterdam, Hammarby Sjöstadt, Jeju, Sejong, Gangneung) · Integrated Energy Operations Center (Jeju, Sejong)
		System for Utilization of New&Renewable Energy	●	●	●	●	●	●	·Introduction and supply of new & renewable energy (Kitakyushu, Amsterdam, Hammarby Sjöstadt, Jeju, Sejong, Gangneung)

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system, Hammarby and Jeju test site are creating Bio-top for animals and plants. Especially Jeju test site provides not only monitoring for ecological environment maintenance but experience center for citizens.

Eco-friendly space creation and monitoring system, construction of green and blue network information system planning techniques in the field of green and water space can be checked mainly in cases. Especially in the cases planned recently, contents on maintenance and keeping applying ubiquitous technology with creation of existing green land and water space are considered actively.

② Resource and waste

For Smart resource circulation management system realization, Kitakyushu plans, operates and manages integrative resource circulation system that analyzed industrial and consumption pattern over the whole region aiming at resource circulating society. Also, it develops and applies environmental management technology and purification, waste management system in circulation aspect. Especially Hamamrby constructed independent eco-cycle considering water, resource, energy cycling. Amsterdam, Jeju, Gangneung increase availability of water resource and achieves energy saving effect with infrastructure construction related to excellent recycling system.

Smart waste treatment system can check its application in Amsterdam, Hammarby, Jeju test site. Amsterdam constructs automation system and monitoring system of waste, compression, collection. Hammarby as well constructs automation facility for waste collection by region then constructs waste management system composed of 3 steps (waste separation - recycling by block unit - waste collection facility by region)Jeju test site sets and propels waste minimization as a major plan. Sejong installs underground culvert that accommodates supplier facility such as electricity, water and enables prompt measures by creating automation control system.

In the application of planning techniques of Waste management and energy recovery from waste system, Kitakyushu systematically implements recycling such as automobile, lamp, electronic device, waste wood and food waste is utilized as fuel after being transformed into ethanol. Jeju minimizes the amount of waste generated based on resource circulation management system and intends to realize green city where resource is circulated through various utilization regarding emitted waste.

③ Energy

Planning techniques of Smart Grid are reflected in most cases as main plan. Kitakyushu, Sejong, Gangneung are test site of local energy management system (CEMS) and provide efficient energy operation service through information construction and monitoring, control utilizing Smart Grid. Amsterdam as well introduced energy management system and enabled network control over energy supply and real-time monitoring. For this, Smart Grid introduction and Smart energy network installment by household and application development were started. Jeju

Table 8. Case Studies in terms of Urban Building

Category		Planning Technique	K	A	H	S	J	G	Description
URBAN BUILD -ING	Building	Building Consumption Energy Management System	●	●		●	●	●	·Operating BEMS and HEMS (Kitakyushu, Amsterdam, Jeju, Gangneung) ·Monitoring and visualization system of appliances electricity usage (Kitakyushu, Amsterdam, Jeju, Gangneung) ·Online Service for energy consumption (Amsterdam)
		Facility Control Automation of Building				●			·Automated building equipment design system and specific housing plan (High-Green Home, Intelligent Home Networks, etc.) (Sejong)
		Smart Building Monitoring System (Mapping of Smart Green Building)	○	○	○	●	○		·Building Energy Rating System (Kitakyushu, Sejong) ·Encourage use of High-Efficiency building facility (Amsterdam, Hammarby Sjöstadt, Jeju, Sejong) ·Behavior Monitoring System of building at Integrated Management Center (Sejong)

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constructs intelligent electrical grid (Smart Grid) that can send left electricity to other region through electrical grid and can be used more widespread in household while wind energy, solar energy and generation are affiliated stably in electrical grid.

System for utilization of new & renewable energy planning technique was reflected in every case target according to the regional features. Kitakyushu supplies heating and electricity through cogeneration development that uses waste heat of factory and Amsterdam is active in utilization of biodiesel, gas, hydroenergy, biomass energy. Gangneung proposed usage plan and facility introduction for renewable energy that utilized waste resource and energy from temperature difference in seawater heat resource while Jeju island constructed generating facility for renewable energy to utilize green energy (wind and solar energy, etc) ample in Jeju along with renewable research complex plan. Hammarby, Sejong and Gangneung are increasing efficiency supplying group energy all over the city with the developments in cogeneration utilizing combustible waste, bio fuel. To supply 15% of total energy used over the city with renewable energy, it aims active endeavor and through cogeneration utilizing waste solid fuel and bio gas, it intends to increase efficiency by supplying group energy to total city development region.

In the field of resource, waste and energy, we could see that planning techniques such as Smart resource circulation management system and Construction of Smart Grid are mainly applied.

3) Urban building

Building consumption energy management system planning technique in building field collects, monitors, interprets energy consumption data of building that used Smart Grid in Kitakyushu and Amsterdam and realizes visualization. Especially Amsterdam provides online view service on building energy consumption. Jeju Smart Grid test site operates energy management system and automatically induces electricity usage of expensive time slot to cheap time slot actively supporting distribution of Smart home that minimizes electricity bill. Gangneung applied U-smart energy system at building level and manage electricity real-time through fusion of building energy information system (BEIS) and building energy management system (BEMS). Also, contents on real-time electricity management was enabled to be seen by residents through home display service and Internet along with remote control, modern guidelines using Smart meter.

Facility control automation of building planning technique can be seen in cases of Sejong. With green building utilizing renewable energy, specialized housing such as Korean high green hole, intelligent home network where building facility control automation system is applied is planned.

Kitakyushu, part of Smart building monitoring system (map), performs building environment performance evaluation utilizing CASBEE system and eco-friendly environmental material usage. Hammarby uses eco-friendly material and sustainable material suitable for the features of building material and regularly examines management of chemical products and harmful drugs, usage of eco-friendly material regarding building materials by installing environments monitoring group. Sejong introduced building energy efficiency class system, energy performance index (EPI) then provided and examined performance of guideline on management technology and building construction technology. Also, centering on city integrated management center, it performs continuous monitoring and deals through energy efficiency map of individual building.

In building aspect, we could see the application of Building consumption energy management system and in the case of city planned recently, it is determined that availability in the future would be high since Facility control automation of building based on IT technology was confirmed. In the case of Smart building monitoring system (map) planning technique, aspects of passive architect and utilization of high glazing and airtight material were observed in various forms but it was also shown that they are planning techniques applied generally regardless of case size.

4.3. Analysis synthesis

As a result of case study, application status of induced Smart Green city planning factors showed planning factors shown to have high weighted value are still mainly applied in actual cases. But we could see the partial difference in opinions regarding major planning factors in domestic and foreign cases. Besides, techniques in energy field where importance was evaluated the highest seemed to have been applied in most cases.

Specifically, Establishing urban planning information system planning techniques with high importance in land use field confirmed its application with the operation method of city integrated management center in domestic cases. Density differentiation development and management planning techniques confirmed its application with the realization of high density development centering on public transportation nodes alone with compression city policies in foreign cases.

Establishment of public transportation information system in transport field was evaluated to have highest importance but its application is confirmed partly with the construction of intelligent transportation management system (ITS, ATMS, etc) focusing on public transportation centering on domestic cases. In actual application, establishment of infra-system for eco-friendly transportation and construction of pedestrian, bicycle oriented road environment planning techniques evaluated to have relatively low importance checking high availability of these planning techniques in every case.

Eco-friendly space creation and monitoring system planning technique evaluated to have the highest importance in the field of green and water space could be confirmed in every domestic and foreign case. This planning technique could check its availability of application in actual plan not to mention the importance.

Smart resource circulation management system planning factors in resource and waste field are methods that plan the resource circulation system then operates and manages it being recognized with high impotance for it was all applied in 5 case.

Construction of Smart Grid planning technique evaluated to have the highest importance among entire planning factors and among energy field could confirm the overall reflection of plan to introduce Smart Grid actively after confirmation of its application in every plan case except Hammarby. Bioenergy utilization system construction planning techniques could confirm its application in every case thus it was actively utilized in actual plan.

Building consumption energy management system planning technique evaluated to have the highest importance as well in building field confirmed its application in every case with the method of energy consumption monitoring and management system. Compared to planning factors in other building field, its importance and availability were all evaluated to be high.

5. Synthesis and conclusion

This research intended to comprehend major planning technique and service considering ubiquitous service and carbon neutral city in an integrated way for creation of Smart Green city. For this, the concept of Smart Green city was established through experts FGI and advanced, related theory contemplation then 18 planning techniques were induced. Regarding induced planning technique, importance was understood with the method that comprehends weighted value of planning technique through experts survey and AHP analysis of this then current applied status of planning technique was confirmed through analysis of 6 cases in th country and abroad. Conclusion of induced contents through mentioned researching process is as follows.

First, 18 planning techniques, belonging to 6 fields and 3 organization system were confirmed for planning techniques for Smart Green city. Induced planning techniques are the ones validated by experts FGI and organized ubiquitous system that can be supported and major planning techniques by organization system and field of Smart Green city.

Second, as a result of importance analysis, importance in the fields of transport, energy, resource and waste was evaluated to be higher than other fields among 6 fields. This is because it is the field shown in result of direct effect on carbon emission reduction and energy consumption at city level compared to other fields. In planning techniques, the importance of construction of Smart Grid, system for utilization of new & renewable energy, smart resource circulation management system, establishment of public transportation information system, construction of pedestrian, bicycle oriented road environment, eco-friendly space creation and monitoring system was shown high. This can be understood because management system through integrated affiliation based on ubiquitous infrastructure was determined to be major in efficiency increase in operation management of Smart Green city rather than individual plan. In the case of construction of pedestrian, bicycle oriented road environment and eco-friendly space creation and monitoring system, they are planning techniques that can have effect on energy saving and direct carbon emission amount at the background of current technology, thus determined to be the decision result that considered conveniency and economics of technology application together.

Third, we could check that planning techniques in the fields of transport, green and water space, resource and waste and energy were being actively reflected as a result of analysis of applied status

in cases. Especially energy integrated management system through smart resource circulation management system and construction of Smart Grid evaluated to have high importance was shown to be applied in actual case. We can see that endeavors to increase energy efficiency are being done beyond prior development methods which only focused on renewable energy introduction and expansion. Also, as related technology develops in recent years, planning techniques of building consumption energy management system and facility control automation of building were being mainly dealt in cases that are not old in its building history. But data construction of city development information has high investment cost occur in initial phase and system for information reflection has not been organized in details upon propelling urban development policies until now so application on Establishing urban planning information system and density differentiation development and management is not being done, and it is expected this environment creation would be difficult even in the future.

Fourth, as a result of evaluation, importance analysis of planning technique and analysis of applied status showed similar result. Fields and planning techniques evaluated with high importance (transport, green and water space, resource and waste) were confirmed to have them even in actual applied cases (transport, energy, resource and waste). These results can be said to be techniques that can reflect or actively apply Smart Green city plan induced in this research in city plan within a short period of time. Also, through case study, we could confirm various application of Smart Green city planning techniques thanks to advancements in IT and fusion technology in the country. But in case of policies, it just happens that city plan and ubiquitous city for carbon neutral are implemented separatively so specific plan for implementation would be required with establishment of affiliated plan in the future.

Smart Green city planning technique induced in this research is based on case study and experts survey and it is considered it has its meaning in that it considered ubiquitous planning technique applicable to city plan in an integrated way. But this research is only limited to comprehending applied status shown in planned case and experts survey analysis in planned dimension not quantitatively considering economic aspect of each technique, operation and maintenance management, problems in the process of analyzing the importance of planning techniques thus it is considered supplements to make up for this would be needed in the future.

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