Preliminary study on Low Carbon Development towards 2030 in Gyeonggi Province, Korea

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Preface

The Republic of Korea (Korea) has set a carbon emission reduction target to cope with climate change and endeavored to reach the target. Both the strong leadership of the national government and the efforts of local governments are indispensable for efficient carbon reduction. According to Article 11 of the Framework Act on Low Carbon, Green Growth has been established and local green growth strategy, which is aligned to the national green growth strategy, has been implemented to promote low carbon, green growth by each province. Furthermore, Clause 1 of Article 42 specifies those mid-/long-term and phased targets and the necessary measures to achieve those targets shall be considered to cope with the national government's global carbon emission reduction.

According to Gyeonggi research institute report, scenarios that aim - through various policies - to reduce 30% of the emissions in 2020 compared with 2020 BAU scenario have been envisioned. In this study, we estimated the carbon emission reduction target and analyzed the realizability of a low carbon city in Gyeonggi province to support the general urban development plan containing the establishment of a long-term urban developmental direction and reestablishment of the spatial structure.

This brochure includes the basic information and methodology for the analysis of the realizability of a low carbon city in Gyeonggi province. This study aims to be utilized as a basic guide and goal-setting scenario through the preliminary research results for the transition to a low-carbon society in Gyeonggi province.

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Contents

Executive summary

Local governments establish detailed plans for climate change. The role and cooperation of local governments, which are the main carbon emitters and the key force to solve the problems, are essential to achieve the national carbon reduction target. According to the "Comprehensive Plan on Combating Climate Change (CPCCC)" of the Republic of Korea, Korea plans to establish adaptation measures against climate change for all local governments by 2012 and to set local carbon emission reduction goals to support the national carbon emission reduction target.

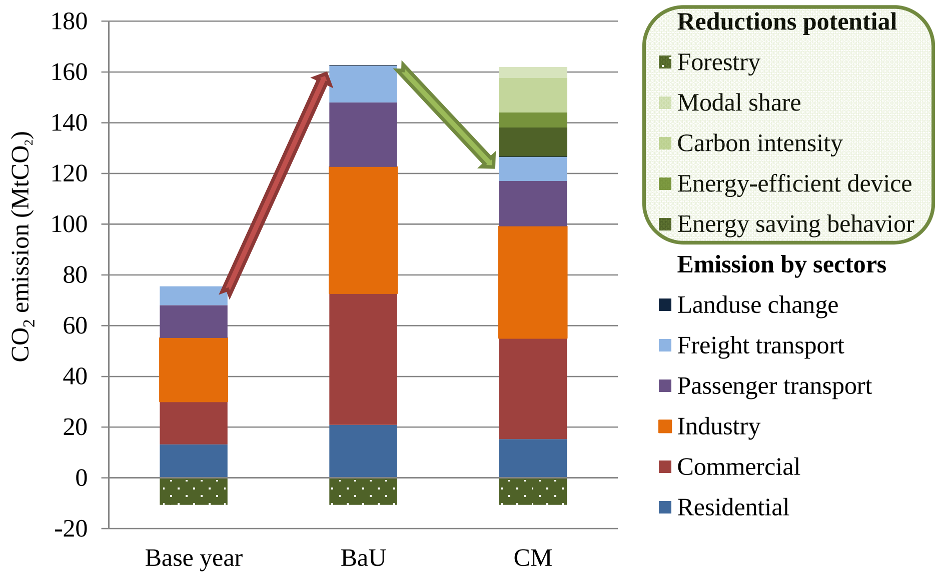

Figure 1 CO_2 emission and reduction in Gyeonggi province
(Base year: 2005, BaU: 2030 business as usual, CM: 2030 with counter measures)

This study aims to estimate the potential carbon emission reduction compared with the Busi ness As Usual (BAU) scenario in the case of Gyeo nggi province of Korea. The base year in this stud y is 2005 and the target year for the estimation of t he potential emission reduction is 2030. The sector s for the carbon emission level and reduction estim ation include the energy sector, the potential emiss ion reduction through land use, and the change in potential emission reduction by the change in land use. The carbon emission and potential emission re duction by human activity in energy sectors are cal culated by the ExSS (Extended Snapshot Tool). Th e amount of carbon emission and the change in the potential emission reduction through land use and the change in land use were obtained by the proto col presented in the IPCC LULUCF guideline.

According to the estimation of greenhouse gas (GHG) emission by energy usage changed by human activities for 2030, the emission is estimated to increase by 115% compared with 2005. However, the analysis shows that the changes in the usage of energy, such as using biomass energy and solar, and changes in lifestyle would reduce CO_2 emissions by 22% compared with the 2030 BAU.

Table 1 Estimated socio economic indicators in the base year (2005) and the target year (2030 BAU)

		2005	2030	Ratio (2030/2005)
Population (million)		10.6	14.0	1.32
Number of households (million)		3.3	5.5	1.64
GRDP (billion KRW)		169	424	2.51
Industrial structure	Primary	2.4	2.1	
	Secondary	63.3	55.9	
	Tertiary	34.3	42.0	
Land use (Km^2)	Settlement	122.4	155.9	1.22
	Rice field	167.1	144.3	0.86
	Crop field	101.5	97.3	0.96
	Forest	515.6	510.7	0.99
	Grassland	34.0	35.4	1.04
	Bare land	20.6	18.5	0.90
	Other	39.1	38.5	0.99

In Gyeonggi province, the change in land usage is expected to reduce the amount of inorganic carbon in the soil compared with 2005, with 0.21 $MtCO_2$ of GHG being emitted into the atmosphere in 2030. Due to the growth in forest vegetation, 10.6 $MtCO_2$ of carbon, which is approximately 10% of carbon absorption compare with 2030 countermeasure (CM) scenario, is expected to be reduced in all of Gyeonggi province.

From the analysis of the reduction potentials in 2030, because of the difficulty associated with achieving the goal of 2020, the establishment and attempted achievement of a realistic goal for reduction is necessary, rather than the establishment of an unrealistic goal.

To accomplish the goals of both 2020 and 2030, a road map towards achieving to this vision would be essential. Cutting down the GHG emissions through the guideline for each appropriate time is very important. In addition, as a future study, consideration of reduction measures' cost in the case of low-carbon policies is necessary.

Background

General information

Gyeonggi Province is the western central region of the Korean Peninsula, which is situated in Northeast Asia, and is located between east longitudes of 126 and 127, and north latitudes of 36 and 38. Its dimension is 10.2% of Korea's territory, 10,138 square kilometers. Seoul, the capital of the Republic of Korea, situated in its center. The location of its provincial government is Suwon, but some of its government buildings are situated in Uijeongbu for the administrative conveniences of the northern region.

The climate of Gyeonggi Province is the continental climate, which has a severe differentiation of temperature between summer and winter, and has clear distinctions of four seasons. The annual average temperature is between 11–13 °. The annual average precipitation is around 1,100 millimeters. It is rainy in summer and dry during winter. The topography of Gyeonggi Province is divided into southern and northern areas by the Han River, which flows from east to west. The area north to the Han River is mainly mountainous, while the southern area is mainly plain.

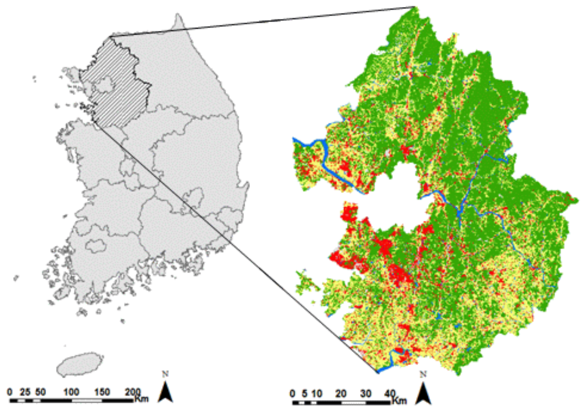

Figure 2 Location of Gyeonggi province

Demography

Gyeonggi Province has shown a rapid increase in population due to the modernization and urbanization of the Republic of Korea. Its population has increased from 2.7 million in 1960 to 3.3 million in 1970, 4.9 in 1980, 6.6 in 1992, 9.0 in 2000, 10.1 in 2005, and 12.1 million in 2010. The population of Gyeonggi province accounted for 22.6% of the total Republic of Korea population. In 2005 there were 3.3 million households, with an average of 3.2 people per family. The population density was 1,119 (people/km^2), almost double of the national average of 486 (people/km^2).

Economy and Industry

Gyeonggi's gross regional domestic product in 2008 accounted for 20.3% of the gross domestic product of Korea, and the average growth rate between 1995 and 2008 was 6.8%, a higher rate than the nation's average of 4.4%. The total number of the business body in Gyeonggi province in 2008 was 651,418, accounting for 19.9% of the total number in Korea and the second highest after Seoul (719,687 industries, 22.0%). The number of employee in 2009 was estimated to be approximately 5.8 million, and the employment rate of individuals older than 15 years reached 61.3%.

As the backbone of Seoul in the means of manufacturing complex, Gyeonggi Province has developed in various industries relatively evenly, such as heavy industry (electronics, machine, heavy and chemical industry, steel), light industry (textile), and farm, livestock and fisheries industry. Due to the influence of recent high wages, the weight of various manufacturing industries has decreased in Korea’s economy. Gyeonggi Province is also making efforts in many ways to improve and modernize the conventional industry structure. Gyeonggi Province is unsparingly investing in the promotion of service industries related to soft competitive power such as state-of-the-art IT industry, designing, conventions and tourism, along with its great leap as a commercial hub in Northeast Asia using the Pyeongtaek Harbor. Besides this, it is famous for its special local products such as Icheon rice and Icheon/ Gwangju ceramics. Also, the manufacturing base of global IT industries that represent Korea, such as Semi-conductor and LCD Complex are located in Gyeonggi Province.

Transportation

The number of registered vehicles of Gyeonggi in 2009 was 4.0 million which accounted for 23.2% of the total number of registered vehicles in Korea. From 1995 to 2009, the average growth rate was 7.1%, higher than that of the country's total of 5.3%. Gyeonggi's total extension of roads in 2009 was 13,178 km, with 11,145 km or 84.6% of the total extension being pavement roads. The proportion of the use of public transportation in Gyeonggi is 34.9%. The public transportation in Gyeonggi mostly connects Seoul and major cities in Gyeonggi, thus making it inconvenient to use public transportation within the province. The transportation system in Gyeonggi province, which occupies the vast majority of the metropolitan area, is built mainly on the roads, and thus the ratio of railroad sharing is at a very low level. In the case of transporting passengers in the Gyeonggi area, for each purpose of transportation in 2005, the average distance was 12.7 km for work, 4.9 km for school, 5.5 km for shopping and 7.9 km for leisure. For each transportation method in 2005, car travelled 11.6 km; buses, 8.7 km; subway or train, 19.6 km; taxi, 5.1 km and bicycle, 3.0 km. The characteristic of Gyeonggi's freight transportation, based on the means of production, is that the ratio of shared cargo is 98.6% by road, 1.3% by railroad, and 0.1% by coastwise shipping. With respect to arrivals, the ratio is 92.7% by road, 4.9% by railroad and 2.3% by coastwise shipping.

Land use and Land use change

According to the land cover change between 1985 and 2005, farmland and forest was reduced, and settlement area grew rapidly. In detail, settlement areas increased by 450%, farmland reduced by 17%, forest reduced by 9%, and wetland reduced by 80%. In Gyeonggi province, the forest area in 2009 covered 525,840 m^2, 51.8% of the total area, and it has been reduced by 0.3% each year during 1995 to 2009.

Energy Use

The materials regarding energy use in Gyeonggi province were derived from the report on local energy, the report on national energy and the report on energy usage characteristics by national and local agencies (Table 1). 28% of the energy is consumed in industry sector, 31% in transportation, 22% in household and 18% in commerce.

Table 2 Energy use in the base year (2005)

Energy Source (Unit: ktoe)	Industry	Transportation	Household	Commerce	Total
Coal	342		39	71	452
Petroleum	2,209	7,178	582	1,477	11,446
City Gas	1,021	88	2,865	135	4109
Electricity	2,771	25	967	2,150	5,913
Heat Energy	0	0	716	187	903
Other	307	8	10	201	526
Total	6,650	7,299	5,169	4,231	23,349

Reference: Yearbook of Regional Energy Statistics (2005)

Scenarios in 2030

Depictive Scenarios

Two scenarios were developed to figure the direction of future socio economic visions for achieving LCS goals toward 2030, i.e. BAU (business as usual) and countermeasure (CM) scenarios. BAU assumes that the existing society orientation will continue until 2030. The countermeasure scenario assumes that there will be changes in society orientation in the future. The CM assumes that the society behavior is depicted as sustainable low carbon society. Both scenarios (BAU, CM) use the same estimates of population, economic growth rate, land use change, and climate change.

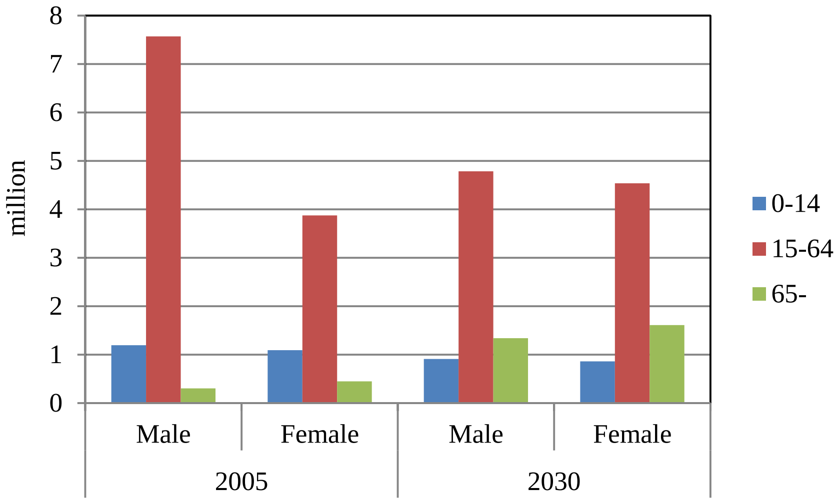

Figure 3 Projection of population by age

Estimated Socio Economic Indicators

According to the projection of the expected future population in each province, based on a study of the housing population in 2005, the national population is expected to have negative growth from 2018. However, the population in Gyeonggi province is expected to increase continuously until 2030. In 2030, the population will increase to 14.0 million. The average number of people per family will decrease to 2.6 in BAU scenario, 2.8 in CM scenario due to different scenarios on number of single households and in the population of elders, whereas the average number in 2005 was 3.2. As a result, the number of households will increase by 1.6 times to 5.8

million in 2030 BAU scenario from 3.3 million in 2005.

The gross regional domestic product of Gyeonggi province, based on the constant prices of 2000, increase by 2.5 times. The ratio of tertiary industries, such as education, hospitals, and recreation facilities, increased, and the ratio of secondary industries are expected to decrease at a comparatively slower pace. The total demand of settlement areas, as the expected area, will increase to 515.9 km^2 when considering the default plan of Gyeonggi province, including each city, county and district. Rice fields, crop fields and forest are expected to convert into settlement areas.

Table 3 Estimated socio economic indicators in the base year (2005) and the target year (2030 BAU)

		2005	2030	Ratio (2030/2005)
Population (million)		10.6	14.0	1.32
Number of households (million)		3.3	5.5	1.64
GRDP (billion KRW)		169	424	2.51
Industrial structure	Primary	2.4	2.1	
	Secondary	63.3	55.9	
	Tertiary	34.3	42.0	
Land use (Km^2)	Settlement	122.4	155.9	1.22
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	Other	39.1	38.5	0.99

Climate change (SRES A1B)

According to SRES A1B scenarios, the average temperature will rise due to climate change associated with increase of greenhouse gas concentrations in atmosphere. In SRES A1B, the average temperature in Gyeonggi in 2030 will increase to 11.9 ℃, a rise of 0.5 ℃ compared to 2005.

Table 4 Monthly temperature in the base year (2005) and the target year (2030 BAU) in Gyeonggi

	J	F	M	A	M	J	J	A	S	O	N	D	Average
2005	-3.2	-2.2	3.6	12.8	16.3	22.7	25.3	25.1	21.9	13.7	7.3	-4.8	11.5
2030	-2.9	-0.3	4.4	11.8	16.8	21.2	24.3	25.3	20.2	13.8	7.1	1.5	11.9

Results

GHG Emission and Reduction

Future greenhouse gas emissions were calculated based on two cases. The first case is the "business as usual" scenario in which the configuration of energy demand and other greenhouse gas emissions are maintained at the present levels. As a result, changes in greenhouse gas emissions will occur only when there are changes in the socioeconomic conditions. The second case is the scenario with “counter measures”, which envisions the socioeconomic conditions to be the same as those of the business as usual (BAU) case but the emission reduction measures are assumed to be implemented. In 2030 BAU scenario, the GHG emissions by energy use in 2030 is estimated to be increased by 115% compared with those in 2005. However, compared with 2030 BAU, in the CM, it will be decreased by 22% due to energy saving behaviors, energy-efficient devices and decrease in carbon intensity.

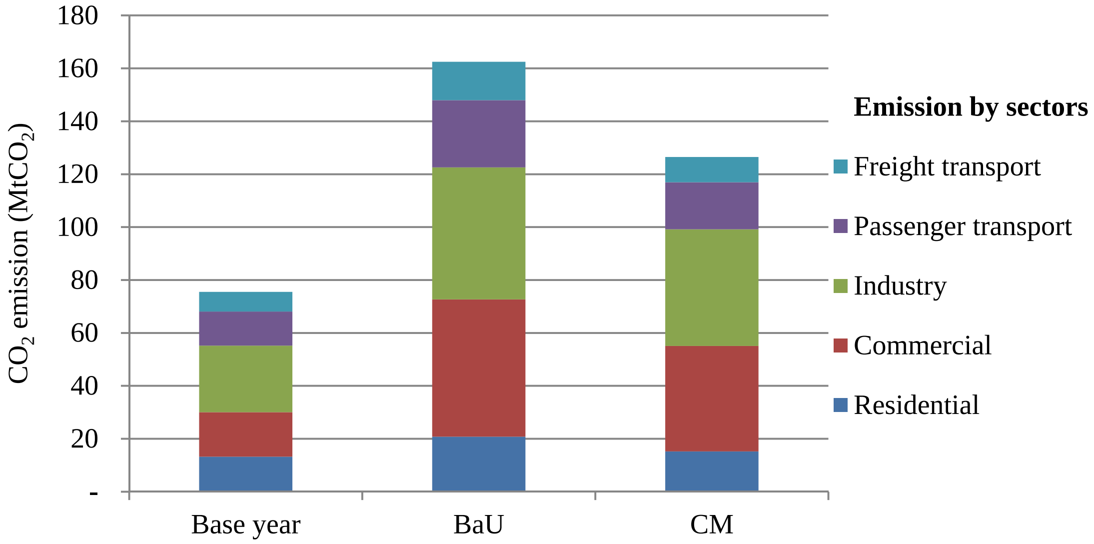

Figure 4 CO_2 emissions caused by energy use

After achieving reduction target, there will be a low carbonized society in 2030 except for passenger transportation sector, even if in CM scenario emit more carbon compared to base year emission.

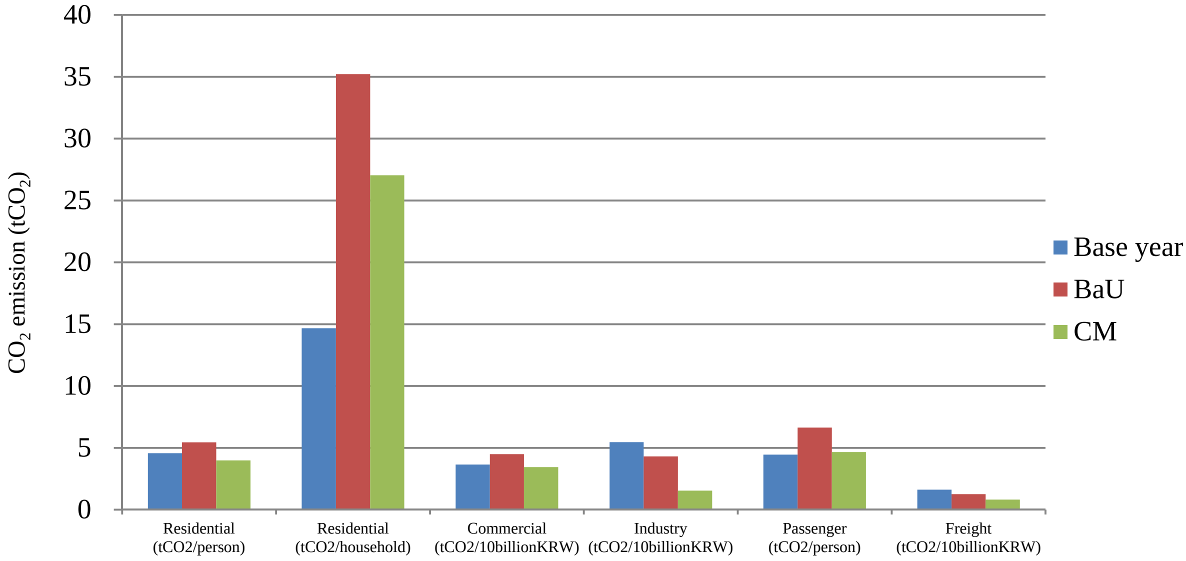

Figure 5 CO_2 emissions by each sector (per Capita or per GRDP)

In the transportation sector, carbon dioxide emissions will cause an increase in energy service due to the change in the industrial structure, increased freight transportation demand by economic growth, and increased travel transportation demand by population growth. Compared with the 2030 BAU in transportation sector, 32% of the emissions could be reduced by the changes in the structure of energy sources used, improvements in equipment efficiency, and subsidies for highly efficient equipment.

In the freight transportation sector, 5.0 $MtCO_2$ of carbon was analyzed to be reduced by improving the efficiency of energy equipment and transferring road-based transportation to railroad-based transportation. In the passenger transportation sector, through the reduction in the demand for car transportation by familiarizing the public with a low-carbon living style, activation of public transportation, utilization of bicycles and walking, 7.7 $MtCO_2$ of carbon can be reduced.

In the residential and commercial sectors, approximately 142% of the carbon dioxide emission increase is expected in 2030 due to increases in the size of equipment, the number of households, the average size of buildings per capita, and the hours of use and intensity. However, due to changes in energy sources to solar and other types of energy, energy efficient technology and changes in lifestyle, the emission in BAU was estimated to be reduced by approximately 24% in 2030 CM. In the residential sector, energy-saving behaviors and energy efficient technologies in the insulation ability can save 2.2 $MtCO_2$ of carbon. Although 3.5 $MtCO_2$ of carbon can be reduced by improvements in energy efficiency in the commercial sector, only 0.7 $MtCO_2$ of carbon can be reduced by energy efficient improvements in the residential sector. In the industrial sector, more efforts in improving processes appear to be needed to reduce GHG emissions.

When considering only the increasing demand side for energy services, carbon dioxide emissions are expected to increase. However, through the development of technology, changes in lifestyle and conversion in energy use in power generation sector at the national level, the emission in 2030 BAU can be reduced by 22%.

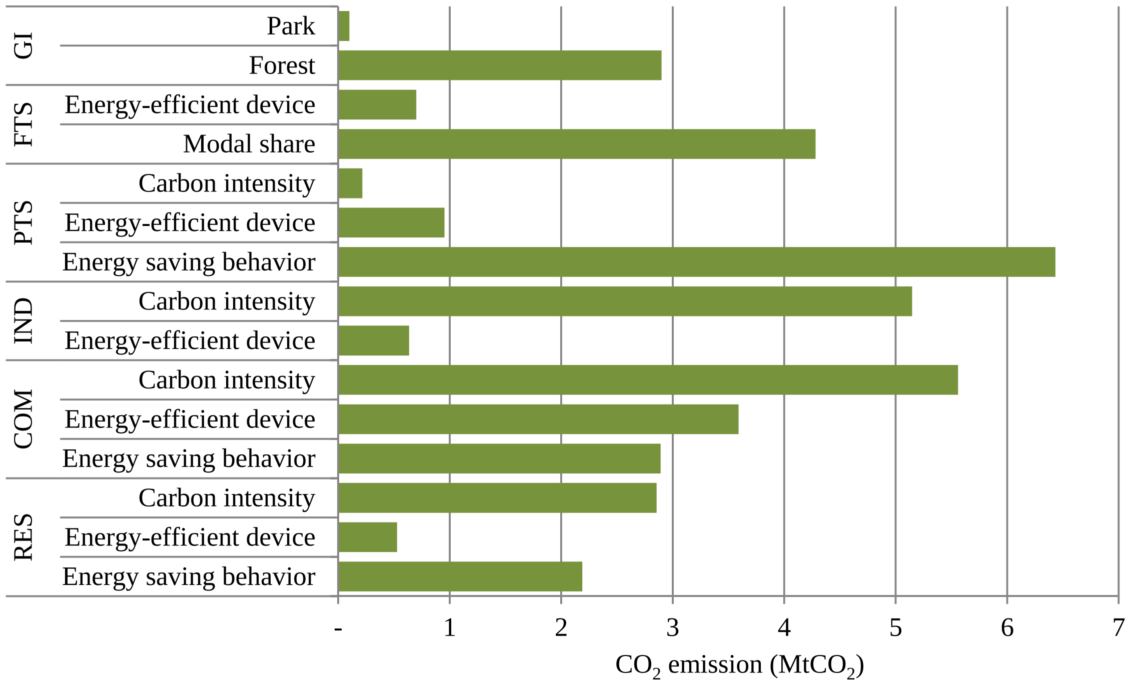

Figure 6 CO_2 emissions reduction potentials by each sector
(FTS: freight transport sector, PTS: passenger transport sector, IND: industry sector, COM: commercial sector, RES: residential sector)

In Gyeonggi province, changes in land use are expected to cause decrease of the amount of inorganic carbon in the soil compared with 2005, with 5.5 $MtCO_2$/year of GHG will be emitted into the atmosphere till 2030. In the Gyeonggi area, the decreases in the area of rice and other crop fields due to the development policy will result in the net decrease of inorganic carbon in the soil. If the changes in land use gradually occur until 2030, then carbon that has been accumulated in the vegetation will be released into the air, with the amount estimated to be 2.2 $MtCO_2$/year of carbon. Due to the growth in forest vegetation, in all of Gyeonggi province, 10.6 $MtCO_2$/year of carbon will be absorbed in 2030. In the case of the park system and grassland, 0.3 $MtCO_2$/year of carbon, which is approximately 3% of carbon absorption by forest vegetation, is expected to be reduced.

Methodology

A Procedure to create a local LCS scenario

(1) Setting framework

Framework of a LCS scenario includes; target area, base year, target year, environmental target, and number of scenarios. Among them, the base year is compared with target year. The target year should be far enough to realize required change, and near enough to image the vision for the people in the region.

(2) Assumptions of socio-economic situations

Before conducting quantitative estimation, qualitative future image should be written. It is an image of lifestyle, economy and industry, land use, climate change scenarios and so on. We could use the assumptions.

(3) Quantification of socio-economic assumptions

To estimate Snapshot based on future image, values of exogenous variables and parameters are set. Using those input, ExSS calculates socioeconomic indices of the target year such as population, GDP, output by industry, transport demand, and so on. CLUE (The Conversion of Land Use and its Effects) model is used to predict future land use.

(4) Collection of low-carbon measures and quantification measures

To collect counter measures which are thought to be available in the target year. For example, high energy-efficiency devices, transport structure change such as public transport, use of renewable energy, energy saving behavior and carbon sink. Technical data is required to estimate their effect to reduce GHG emissions. In this research we applied the quantified measures from Gyeongi province report and AIM-Korea results.

(5) Setting introduction of counter measures

Technological parameters related to energy demand and CO_2 emissions, in short energy efficiency, are defined. Since there can be various portfolios of the measures, one must choose appropriate criteria. For example, cost minimization, acceptance to the stakeholders, or probability of technological development.

(6) Estimation of GHG emission in the target year

Based on socio-economic indices and assumption of measures' introduction, GHG emissions are calculated including changes in CO_2 emission from energy use, and carbon dynamics in vegetation and soil under the impact of land use change and climate change.

Analytic Model

Changes in CO_2 emissions are analyzed by Extended Snapshot Tool (ExSS), the Conversion of Land Use and its Effects (CLUE), vegetation dynamic model.

Energy use by human activities that are directly related to carbon emission is considered in industrial, residential, commercial/public and transport (freight, passenger) sectors. The amount of carbon absorption by vegetation and soil includes the carbon in forest vegetation, park greens, grassland and soil.

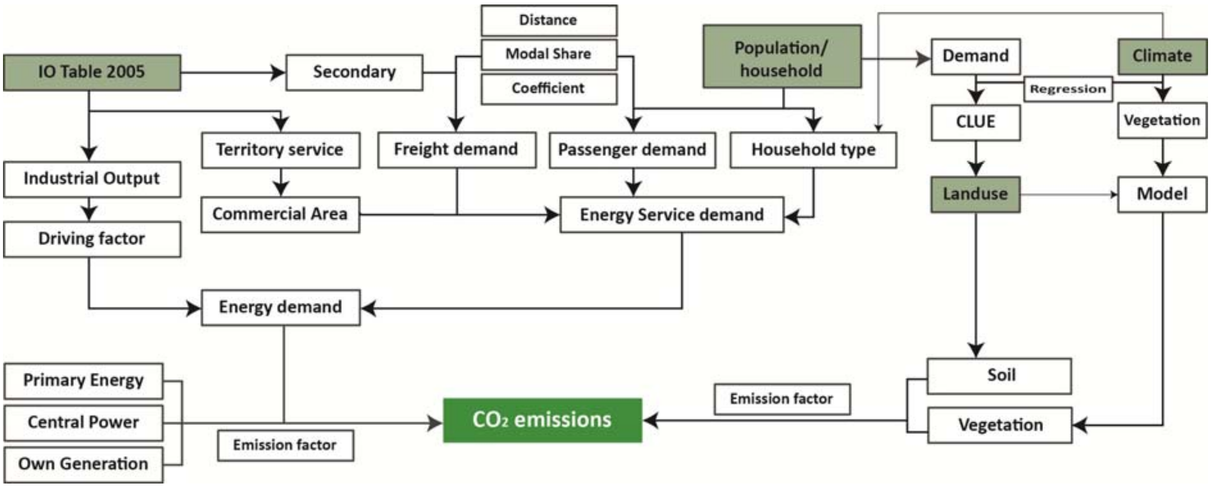

Figure 7 Analytic model of this research

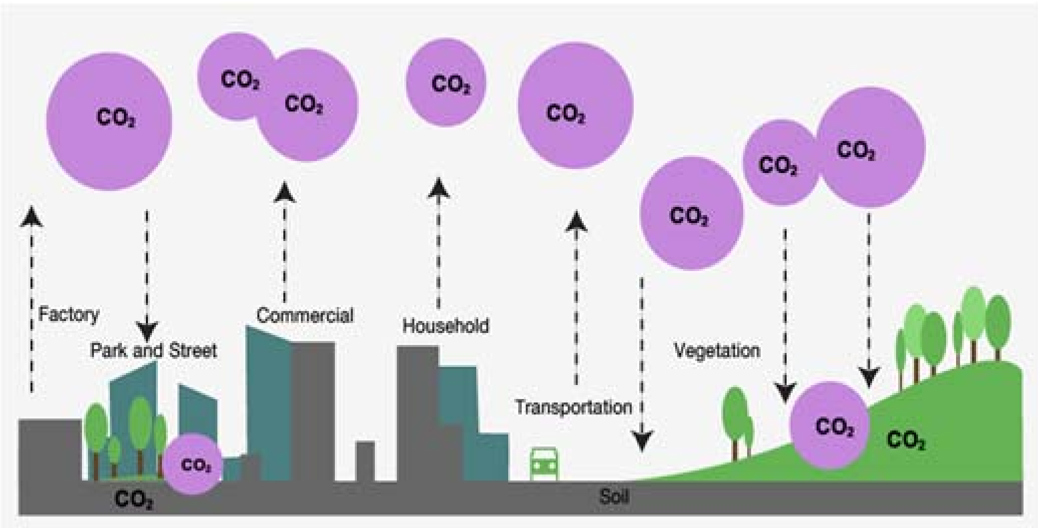

Figure 8 CO_2 emission related sectors

The structure of the Extended Snapshot Tool (ExSS)

Figure 10 shows the structure of the Extended Snapshot Tool (ExSS); main input parameters and endogenous variables. ExSS is a system of simultaneous equations. Given a set of exogenous variables and parameters, solution is uniquely defined. In many LCS scenarios, exogenously fixed population data are used. However, people migrate more easily, when the target region is relatively a smaller area such as a state, district, city or town. Population is decided by demand from outside of the region, labor participation ratio, demographic composition and relationship of commuting with outside of the region. To determine output of industries, input-output approach with "export-based approach" is combined in line with the theory of regional economics.

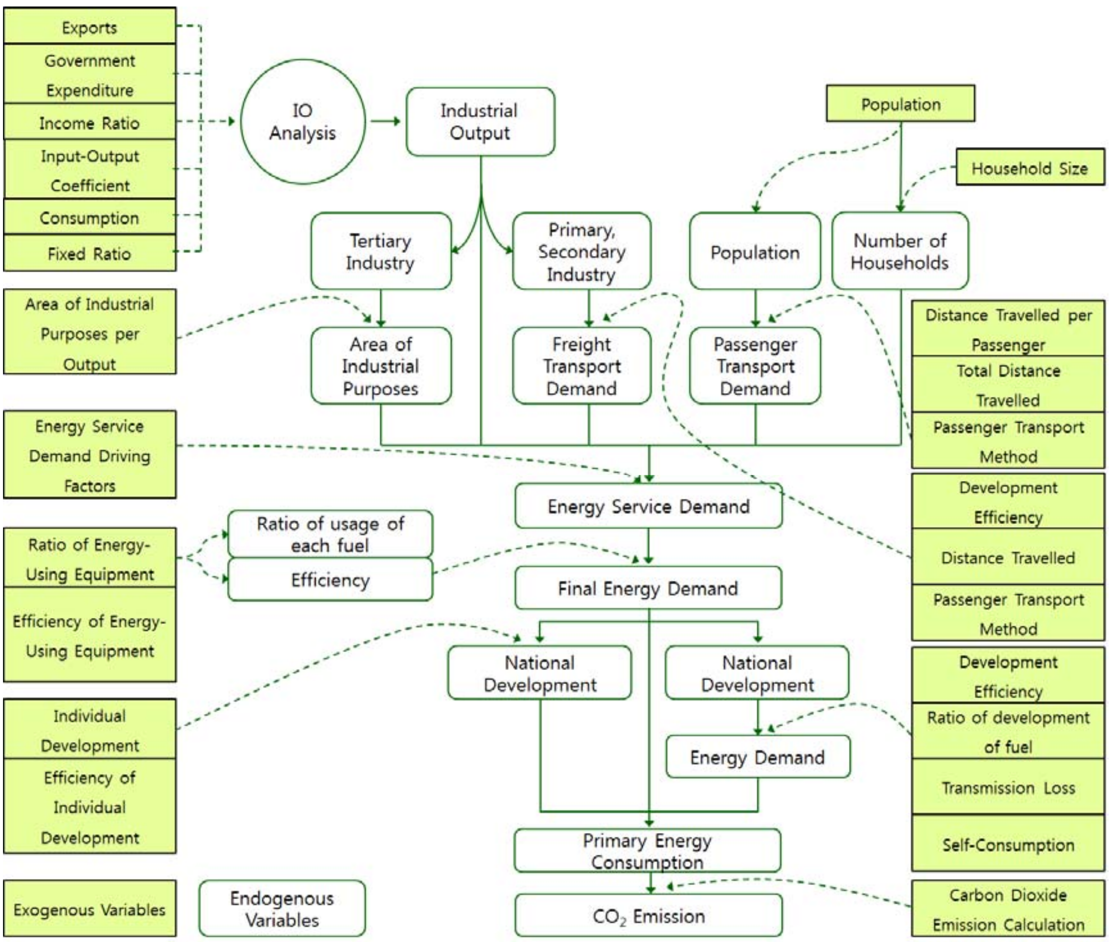

Figure 9 Overview of calculation system of Extended Snapshot Tool

Industries producing export goods are called "basic industry". Production of basic industries induces other industries i.e. non-basic industries, through demand of intermediate input and consumption of their employees. Number of workers must fulfill labor demand of those productions. Given assumptions of where those workers live and labor participation ratio, population living in the region is computed. This model enables us to consider viewpoints of regional economic development to estimate energy demand and CO_2 emissions. For future estimation, assumption of export value is especially important if the target region is thought to (or, desired to) develop led by particular industry, such as automotive manufacturing.

Passenger transport demand is estimated from the population and freight transport demand whereby it is a function of output by manufacturing industries. Floor area of commerce is determined from output of tertiary industries. Other than driving force, activity level of each sector, energy demand by fuels determined with three parameters. One is energy service demand per driving force, energy efficiency and fuel share. Diffusion of counter measures changes the value of these parameters, and so GHG emissions.

Greenhouse Gas Mitigation Measures

To analyze the reduction potential, the information from Gyeonggi research institute report related to mitigation policy was used. The introduction ratio of energy-efficient appliances was calculated by AIM-Korea. The followings are Gyeonggi province policies.

1) Building

Gyeonggi's existing reduction policies in the building sector can be divided into energy saving and improving efficiency for houses, energy-consuming buildings, low-carbon lifestyles and public institution.

- ✧ In the household sector, the policies for reducing energy include the generalization of high-efficient equipment, a carbon point system, the operation of a green call center, the promotion of a number of green campaigns for the citizens to bring awareness and voluntary action.
- ✧ In the commercial sector, the business for smart grids (green IT, generalizing smart measurements, etc.) and energy efficiency improvements and improves efficiency by investing and supplying highly efficient energy facilities and equipment. In the case of energy-consuming buildings, the expansion of a voluntary agreement (VA) will lead to energy savings.
- ✧ In the public sector, through the pilot project of the emission trading system for public institutions, the execution of public officials' green education and green

experience, public institutions leading businesses on energy saving, and so on, the plan to save energy by public institutions and develop more efficiency is being implemented. Additionally, the lighting equipment in the public sector will become more efficient through the expansion of the use of LED lighting in government office building in cities and counties, and a green compass movement to reduce energy consumption in colleges/universities is being promoted.

2) Industry

VA from energy-consuming establishments, energy management diagnostics by these establishments, and the management of the pollutants that are allowed to be emitted by the establishments are being considered to be put into practice.

3) Transportation (Traffic)

- ✧ The GHG reduction policies in Gyeonggi's transportation sector can be divided into the activation of public transportation use, the management of public transportation demand, the distribution of green transportation methods, and energy saving policies.

- ✧ For activating the use of public transportation, services such as expanding the alternative-day-no-driving system, establishing a bus rapid transit system (BRT) and strengthening the operation of the bus management system are being pushed ahead. As green transportation methods, services such as the dissemination of eco-friendly, low emission-vehicles, the activation of bicycle roads, and the trend of converting gas emission to low emission are being encouraged.

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Low carbon Society 2030