Estimation of Greenhouse Gas Emissions Reduction Potential in Accordance with Reduction Target Scenarios

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Abstract

This study had intended to estimate greenhouse gas (GHG) emissions reduction potential using scenarios to set GHG emissions reduction target. To achieve this goal, this study has proceeded the following three stages. First, this study has reviewed literatures related to setting GHG emissions reduction target, estimating GHG emissions reduction potential, and methodologies to set GHG emissions reduction target. Second, this study has been set up GHG emissions reduction target scenarios. Third, this study has estimated the GHG emissions reduction potential in accordance with the scenarios by reduction. This study had found the following result: this study had estimated to reduction potential using scenarios for the setting of practical greenhouse gas emission reduction target. S1: 979,257 tCO_2, S2: 1,504,527 tCO_2, S3: 1,958,513 tCO_2, S4:2,480,784 tCO_2, and S5: 3,460,040 tCO_2. These results could be important indicators in setting feasible reduction goals in the context of the introduction rate of each section and the amount of reduction in other local government mandates.

Key Words: Reduction Potential, Greenhouse Gas, GHG Reduction Target, Scenario

1. Introduction

Determining greenhouse gas (GHG) reduction targets can create a new problem: rapidly growing global warming makes emission reduction efforts even more difficult (Huang et al. 2009). Emission reduction efforts influence the use of fossil fuels, which is the main GHG exhaustion reason. Further, emission reduction efforts influence the economy. Developed countries concerned about this influence, set voluntary GHG reduction targets lower than the reduction levels (25-40%) recommended by Intergovernmental Panel on Climate Change (IPCC) (LIM 2011). However, the effects of the implementation of voluntary targets among developed countries on GHG emissions and their respective economies differ from each other. These effects are determined by each country's reduction target and the industrial and economic structure of the country (Lim, 2011). For example, South Korea has targeted a 30% reduction in GHG; it is not the nation obligated to reduce GHG emissions. On the other hand, South Korea's total GHG emissions were the 9th highest among countries in 2009, and South Korea is the 15th largest economy in the world. It is therefore increasingly likely that, South Korea will be included among the nations obligated to reduce GHG emissions in 2020. The role of each municipality in South Korea in preparing for this eventuality is becoming important, and municipalities must strive for setting practical GHG reduction targets.

The aim of this study is to introduce a scenario technique for calculating feasible GHG reduction potentials, through the calculation of GHG reduction potentials for each scenario.

2. Literature review

2.1. Scenario technique

A scenario depicts an event that may happen in the future and the causes and effects of that event (Tser-Yieth et al. 2009). In addition, scenarios help in the creation of long term policies, strategies, and plans that can approximate possible future situations. Scenarios can expose an institution's limits, showing which futures are out of reach or impossible (Ryu, Cheongsan, 2011).

Used originally in World War II, the scenario is now used as a tool of business strategic planning and national future studies. Most recently, major private enterprises in developed countries are using scenarios as not only for management environment analysis (Seo et al. 2009) but also to aid future strategic planning for business strategies and the development of products.[i]

The scenario promotes stakeholder communication, and can be useful when establishing national strategies and deriving integrated opinions (Lim et al. 2010).

2.2. Reduction potential

A *reduction potential* refers to the amount of GHG that can be reduced when policies or technologies are introduced. Shin et al. (2009) created different alternative scenarios about power plants and used the reduction potential as the amount of GHG reductions which would occur in for each scenario. Jung et al. (2012) used reduction potential as the amount of GHG reduction that would occur from the introduction of renewable energy sources in a residential sector. Lee, and Park (2009) used reduction potential as the amount of GHG reductions that would occur due to increase in the extent of the natural sink owing to changes in land use. Jung et al. (2012) outputted the amount of energy consumptions by energy uses for individual house's heating, air conditioning, lighting, cooking, and appliance sectors, estimating the amount of GHG emissions from each, applying emission factors by energy types.

In this study, GHG reduction potential is defined as 'the target amount of GHG reduction, reflecting reduction measures in target year', regardless of current policies or actions.

2.3. Target GHG reduction method

Target GHG reduction methods have been discussed variously by Huang (2009), Aldy et al. (2003), Bondansky et al. (2004), Ott et al. (2004), Winkler (2006), and others. The complex

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[i] The examples of countries introduced by the scenario planning nation strategy are currently: "Trend: High Density Development in the Downtown," "Dispersion Development Scenario for Urban Planning in the Stuttgart of Germany," "Case Study of Village Change Diagnosis of an Executive Committee in the EU," "Nation Strategy Establishment Scenario of Mont Fleur Project in the South Africa," etc.(Im et al. 2009).

process of establishing reduction methods is characterized by *bottom-up* and *top-down* approaches. A bottom-up approach starts from each system and chooses a reduction target based on each available reduction technology and the affordability of the option to the sector. Duties to reduce GHG come mainly to companies, countries or regions, or through international agreement. Choices of national policies and tools are an example of a bottom-up approach. On the other hand, the top-down approach is based on scientific evidence. This approach begins with long-term targets—the stabilization of GHG concentrations and environmental protection—and uses these to allocate reductions to each sector with the duty to reduce emissions. Essentially, the top-down approach pursues environmental stabilization. The Kyoto Protocol is one such approach: it chooses a GHG reduction target for each sector. Top-down approaches are also called “Kyoto-style” approaches.

3. 3. Methods

3.1. Data

This study utilizes estimates of GHG emissions in Cheongju-si in 2020 (Cheongju-si 2011) as basic data. Estimates are obtained by applying “Greenhouse Gas Emission Estimation Guidelines” at a local level.[ii]. These estimates are then classified into three sectors: energy (residential, commercial, public, transportation, etc.), waste, and agricultural (livestock, forestry, and land use). For this study, estimates are reclassified into energy, transportation, and absorption sectors.

[Table 1] Estimates of GHG emissions in Cheongju-si in 2020

Sectors	Energy	Transportation	Waste	Absorption
Emissions (tCO2)	3,542,185	1,075,934	314,713	7,575

[ii] “Greenhouse Gas Emission Estimation Guidelines at a local level” (Korea Environment Corporation 2010) is a set of guidelines for the domestic application of the National Greenhouse Gas Inventory Estimation developed by the IPCC.

Data for estimating use in Cheongju-si in 2020 comes from populations, households, automobile ownership, and economically active population data, which are estimated in “Elementary urban planning of Cheongju in 2025.” In addition, the total floor area of buildings is computed by classifying the uses of buildings, which are classified in the building register of Cheongju-si into residential, commercial, public, and industrial units.

3.2. Methodology

This study desires to determine the amount of targets within each scenario using the bottom-up approach. The study begins by setting the GHG reduction targets of each scenario. After setting application rates of policies, which are targets by sectors, using top-down approach for setting of GHG reduction targets, this study collects the level of each target in each scenario, calculated by adding up reduction potentials by using previously set policy rates (the bottom-up approach).

National GHG reduction targets are 30% of Business As Usual (BAU) in 2020. This study intend to analyze reduction potentials according to various reduction targets, through reduction scenarios of 20%, 30%, 40%, 50%, and 70%.

Sectors and policies included in scenarios reflect quantitative estimates of measures in “Local Government Response to Climate Change Planning Support for a Comprehensive Plan to Reduce Greenhouse Gas Emissions Guidelines (ver.1),” a paper by the Ministry of the Environment and the National Institute of Environmental Research (2007). The calculation for GHG reductions also uses these guidelines. The resulting values that go through this course are defined as reduction potentials.

4. Results

4.1. Estimation of greenhouse gas emission reduction potentials by sector

4.1.1. Energy

In the energy section, we computed reduction potentials through 14 quantitative policies, “Supply of Green Homes”, “Insulation Equipment and Energy Efficiency Improvements”, “Renewable Energy Village Development Project”, “Supply of Solar Houses”, “Reuse of Rainwater”, “Installation of Sunlight Generation Equipment”, “Supply of Solar Water Heaters”, “Supply of Geothermal Energy”, “Cooling and Heating Using Sewage Water Heat and River Water Heat”, “Supply of High Efficiency LED Equipment”, “Supply of Business Use High Efficiency Air Handling Unit”, “Strengthening of Low-carbon Design Standards on New Building and Remodeling”, “Practice and Expansion of Turning Off Lights after Work” and “Worker Practice of Turning Off Lights at Lunch Time”.

The GHG reduction potentials of each scenario were: 617,899 tCO2(scenario 1), 947,444 tCO2(scenario 2), 1,235,796 tCO2(scenario 3), 1,565,342 tCO2(scenario 4), 99,185 tCO2(scenario 5).

[Table 2] Reduction Potentials in the Energy Section, Classified by Scenarios

Unit: tCO_2

Policy	Scenario1	Scenario2	Scenario3	Scenario4	Scenario5
Supply of Green Home	25,404	38,953	50,808	64,357	89,761
Insulation Equipment and Energy Efficiency Improvements	12,958	19,870	25,917	32,828	45,786
Renewable Energy Village Development Project	14,518	22,261	29,036	36,779	51,297
Supply of Solar Houses	14,518	22,261	29,036	36,779	51,297
Reuse of Rainwater	1,778	2,726	3,556	4,504	6,282
Installation of Sunlight Generation Equipment	14,722	22,574	29,445	37,296	52,019
Supply of Solar Water Heaters	18,904	28,986	37,808	47,890	66,794
Supply of Geothermal Energy	174,918	268,207	349,836	443,125	618,043
Cooling and Heating Using Sewage Water Heat and River Heat	278,375	426,841	556,749	705,215	983,590
Supply of High Efficiency LED Equipment	13,064	20,032	26,128	33,096	46,160
Supply of Business Use High Efficiency Air Handling Unit	2,217	3,399	4,433	5,615	7,832

Strengthening of Low-carbon Design Standards on New Building and Remodeling	35,012	53,685	70,023	88,696	123,708
Practice and Expansion of Turning Off Lights after Work	8,750	13,416	17,500	22,166	30,916
Worker Practice of Turning Off Lights at Lunch Time	2,761	4,234	5,523	6,996	9,757
Total GHG Reduction Potentials	617,898	947,444	1,235,796	1,565,342	2,183,240
Percentage reduction, compared with GHG emissions in energy Section in 2020	17%	27%	35%	44%	62%

4.1.2. Traffic

In the traffic section, we calculated reduction potentials through 16 quantitative policies: “Supply Expansion of CNG Cars”, “Promoting Self Carfree Day”, “Supply Expansion of Electric Cars”, “Supply Expansion of Hydrogen Fuel Cell Vehicles”, “Supply Expansion of Hybrid Cars”, “Supply Expansion of Plug-in Hybrid Cars”, “Regulating Car Idling”, “Regulating Bus Idling’, “Encouraging Manual Transmission Cars”, “Supply and Utilization Expansion of Light-weight Vehicles”, “Encouraging of Keeping an Economical Speed”, “Encouraging Refrain from a Quick Start”, “Encouraging Vehicle Weight Reduction”, “Encouraging Keeping Modest Tire Pressure”, “Introduction of Car-sharing & Carpool Systems”, “Expanding Introduction of Telework.”

The GHG reduction potentials of each scenario were: 321,707 tCO2(scenario 1), 493,294 tCO2(scenario 2), 643,414 tCO2(scenario 3), 814,991 tCO2(scenario 4), 1,136,699 tCO2(scenario 5).

[Table 3] Reduction Potentials in the Traffic Section, Classified by Scenarios

Unit: tCO2

Policy	Scenario1	Scenario2	Scenario3	Scenario4	Scenario5
Supply Expansion of CNG Cars	76	117	152	193	269
Promoting Self Carfree	19,680	30,176	39,360	49,856	69,536

Supply Expansion of Electric Cars	26,044	39,934	52,087	65,977	92,021
Supply Expansion of Hydrogen Fuel Cell Vehicle	11,872	18,204	23,745	30,077	41,949
Supply Expansion of Hybrid Cars	13,712	21,024	27,423	34,736	48,447
Supply Expansion of Plug-in Hybrid Cars	38,088	58,401	76,175	96,489	134,576
Regulating Car Idling	20,700	31,740	41,400	52,440	73,140
Regulating Bus Idling	191	293	383	485	676
Encouraging Manual Transmissions Cars	5,400	8,280	10,800	13,680	19,080
Supply and Utilization Expansion of Light-weight Vehicles	12,540	19,228	25,080	31,768	44,308
Encouraging Keeping an Economical Speed	13,800	21,160	27,600	34,960	48,760
Encouraging Refrain from a Quick Start	1,380	2,116	2,760	3,496	4,876
Encouraging Vehicle Weight Reduction	2,760	4,232	5,520	6,992	9,752
Encouraging Keeping Modest Tire Pressure	1,380	2,116	2,760	3,496	4,876
Introduction of Car-sharing & Car Pool Systems	137,940	211,508	275,880	349,448	487,388
Expanding Introduction of Telework	16,140	24,748	32,280	40,888	57,028
Total GHG Reduction Potentials	321,707	493,284	643,414	814,991	1,136,698
Percentage reduction, compared with GHG emissions in traffic Section in 2020	**30%**	**46%**	**60%**	**76%**	**106%**

4.1.3. Waste

In the waste section, we computed reduction potentials through two quantitative policies: “Reduction of Waste Generation” and “Activation of Waste Reuse.”

The GHG reduction potentials of each scenario were: 28,071tCO2(scenario 1), 43,042 tCO2(scenario 2), 56,142 tCO2(scenario 3), 71,114 tCO2(scenario 4), 99,185 tCO2(scenario 5).

[Table 4] Reduction potential in waste section classified by scenarios

Unit: tCO2

Policy	Scenario1	Scenario2	Scenario3	Scenario4	Scenario5
Reduction of Waste Generation	16,843	25,825	33,685	42,668	59,511
Activation of Waste Reuse	11,228	17,217	22,457	28,445	39,674
Total GHG Reduction Potentials	28,071	43,042	56,142	71,114	99,185
Percentage reduction, compared with GHG emissions in waste Section in 2020	**9%**	**14%**	**18%**	**23%**	**32%**

4.1.4. Absorption

In the absorption section, we computed reduction potentials through two quantitative policies: “Afforestation” and “Green Roof Systems.”

The GHG reduction potentials of each scenario were: 11,590tCO2(scenario 1), 17,756tCO2(scenario 2), 23,160tCO2(scenario 3), 29,337tCO2(scenario 4), 40,917tCO2(scenario 5).

[Table 5] Reduction Potentials in Absorption Section, Classified by Scenarios

Unit: tCO_2

Policy	Scenario1	Scenario2	Scenario3	Scenario4	Scenario5
Afforestation	10,748	16,481	21,497	27,229	37,978
Green Roof Systems	832	1,276	1,664	2,107	2,939
Total GHG Reduction Potential	11,580	17,756	23,160	29,337	40,917

Percentage reduction, compared with GHG emissions in absorption Section in 2020	30%	45%	59%	75%	104%

4.2. Calculation of Potential Reduction by Scenarios

<Table 6> shows reduction goals, the percentage of the policy introduction in each instance, and reduction potentials.

In scenario one, the percentage of policy introduction is 20% and potential reduction of greenhouse gases is 979,257 tCO2. In scenario two, the percentage of policy introduction is 30% and potential reduction of greenhouse gases is 1,501,527 tCO2. In scenario three, the percentage of policy introduction is 40% and potential reduction of greenhouse gases is 1,958,513 tCO2. In scenario four, the percentage of policy introduction is 50% and potential reduction of greenhouse gases is 2,480,784 tCO2. In scenario five, the percentage of policy introduction is 70% and potential reduction of greenhouse gases is 3,460,040 tCO2.

[Table 6] GHG Reduction Potentials by Scenario

Unit: tCO_2

Policy		Scenario1	Scenario2	Scenario3	Scenario4	Scenario5
Reduction Goal		20%	30%	40%	50%	70%
Percentage of the policy introduced		15%	23%	30%	38%	53%
Potential Reduction (in tCO_2)	Energy	617,898	947,444	1,235,796	1,565,342	2,183,240
	Traffic	321,707	493,284	643,414	814,991	1,136,698
	Waste	28,071	43,042	56,142	71,114	99,185
	Absorption	11,580	17,756	23,160	29,337	40,917
	Total	979,257	1,501,527	1,958,513	2,480,784	3,460,040

5. Conclusions and Implications

This study calculated GHG reduction potentials by scenarios, setting realizable greenhouse gas reduction goals using the scenario technique. To compute them, we set 5 scenarios and reduction goals for each scenario. Then, we fixed the application rate of policies to accomplish these reduction goals. Using these, we calculated GHG reduction potentials.

This study assessed reduction potentials. These results could be important indicators in setting feasible reduction goals in the context of the introduction rate of each section and the amount of reduction in other local government mandates.

Although this study computed GHG potential reductions classified by scenarios, it is limited to deductions of method in choosing adequate alternatives by each country or province. This limitation should be solved using conformity assessment by scenarios or a survey of related field experts.

Annotate

1) The examples of implementing scenario planning in setting national strategy are current trend · high density development in the downtown · dispersion development scenario for integrated city planning in Stuttgart German, case study of village change diagnosis by EU executive commission, and national strategy establishment scenario by Mont Fleur Project in South Africa. (Im, Hyun etc, 2009).
2) 『Local government's computation guideline of green-house gases emission is a guideline for applying calculating system, which is developed by IPCC, to domestic current situation.

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