GREENHOUSE GAS EMISSIONS TRADING SYSTEM IMPLEMENTATION METHODOLOGY PROPOSAL AND A STUDY OF ITS FEASIBILITY AND EFFECTIVENESS THROUGH AHP AND REGRESSION

By

Bae, Deog Sang

THESIS

Submitted to
KDI School of Public Policy and Management
in partial fulfillment of the requirements
for the degree of

MASTER OF PUBLIC POLICY

2012

GREENHOUSE GAS EMISSIONS TRADING SYSTEM IMPLEMENTATION METHODOLOGY PROPOSAL AND A STUDY OF ITS FEASIBILITY AND EFFECTIVENESS THROUGH AHP AND REGRESSION

By

Bae, Deog Sang

THESIS

Submitted to
KDI School of Public Policy and Management
in partial fulfillment of the requirements
for the degree of

MASTER OF PUBLIC POLICY

2012

Professor Yoon Cheong CHO

GREENHOUSE GAS EMISSIONS TRADING SYSTEM IMPLEMENTATION METHODOLOGY PROPOSAL AND A STUDY OF ITS FEASIBILITY AND EFFECTIVENESS THROUGH AHP AND REGRESSION

By

Bae, Deog Sang

THESIS

Submitted to
KDI School of Public Policy and Management
in partial fulfillment of the requirements
for the degree of

MASTER OF PUBLIC POLICY

Committee in Charge

Professor Yoon Cheong CHO, Supervisor ______________

Professor Jinsoo LEE ______________

Professor Dongyoung KIM ______________

Approval as of December, 2012

ABSTRACT

Greenhouse Gas Emissions Trading System Implementation Methodology Proposal and a Study of its Feasibility and Effectiveness through AHP and Regression

By

Bae, Deog Sang

Counteraction against climate change is one of the biggest issues faced around the world today, and the increase in greenhouse gases (GHG) in the atmosphere caused by industrialization is identified as the most crucial reason for climate change. To address this global problem, developed nations such as the EU, the US, and Japan have adopted restriction policies to regulate the amounts of GHG emissions within their countries, and the EU firstly introduced the Emissions Trading Scheme (ETS) for the main policy mechanism for emissions control. Even though Korea is grouped with developing nations, which are not expected to reduce emissions, it faces tremendous pressure from international communities either to join groups of developing nations or to reduce GHG emissions voluntarily. The Korean government has declared that Korea will reduce its emissions by 30% before 2020 based on business as usual, and the Korean government has operated a GHG and Energy Target Management System to regulate emissions produced by businesses since 2011 and passed the Korean ETS law in 2012. With consideration for not only the EU ETS case studies but also Korean circumstances, this study proposed research questions about the issues of implementation diagrams for Korean ETS: i) Emissions allocation to distribute emissions credits to businesses efficiently under annual national emissions target; ii) A data interface to minimize burdens in data collection and verification between business and government; iii) Information Sharing to support SME through creation of synergy effect in sharing process; and iv) Trading to stabilize the price of emissions credit. The proposed system modules are confirmed by experts through the Analytic Hierarchy Process (AHP) for project feasibility test and regression for effectiveness after implementation.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

I. INTRODUCTION

The earth faces climate change risks such as an increase in sea level and unusual temperature. The most crucial cause is excessive greenhouse gas (GHG) emissions from industries. To reduce emissions, the United Nations (UN) designated advanced nations including European nations as compulsory reduction nations, and they are operating Emissions Trading Scheme (ETS) to comply with the international scheme.

To participate in the global movement and secure a leading position among developing nations, Korea, which is the 9th largest emission-producing nation in the world and a member of OECD, declared that it will reduce its business-as-usual emissions by 30% until 2020. To back up the plan, it enacted a law called “Low Carbon and Green Growth Law” in April 2010 and an administrative rule called “Greenhouse Gas and Energy Target Management System Regulation.” Furthermore, with the target of initiating emissions trading from 2015, it enacted the “Emissions Trading Law,” and the law is booming as a big issue for the government and industries.

To follow up on the situation, a variety of studies have been reported, such as an analysis of economic feasibility with the introduction of emissions trading, methodology of emissions allocation, and the introduction of carbon tax, but it is hard to find relevant theses related to the systems building of an emissions trading scheme and analysis of the effect even though research on implementation methodologies are necessary to support effective adaptation of the national emissions trading scheme. To help the successful adaptation of the ETS, whose purpose is to support governmental green growth policy, it is required to check the implementation methodologies of the IT system, because the working processes in data management such as data collection, verification, reduction, and trading and those in allowance allocation are mixed, those complications possibly cause inefficiency in ETS works without systemization. Thus, EU nations are already adopting and operating ETS-supported systems. Lastly, ETS systems could contribute to the development of GHG reduction opportunities. GHG and Energy Target Management Systems in Korea require that participating companies input an annual GHG reduction plan to the governmental system. If that information is shared with other participants, it would help not only to search reduction methodologies more easily than before but also to form a reduction market in which regulated companies would save on purchasing costs to introduce reduction technologies through group purchase. Its mechanism would also support the governmental green-growth goal. Therefore, research is required regarding implementation methodologies of governmental IT support systems to ETS.

To illustrate the importance of system management necessity and propose implementation methodologies, this study will research the importance of GHG, analyze the international movement of ETS management such as EU ETS and Korean circumstances of GHG management, review possibilities for application of Keynesian theory to this study in the field of governmental interruption on the effect of economic growth, explain implementation methodologies, build hypotheses to evaluate proposals, propose evaluation methodologies of AHP and regression, and provide a conclusion.

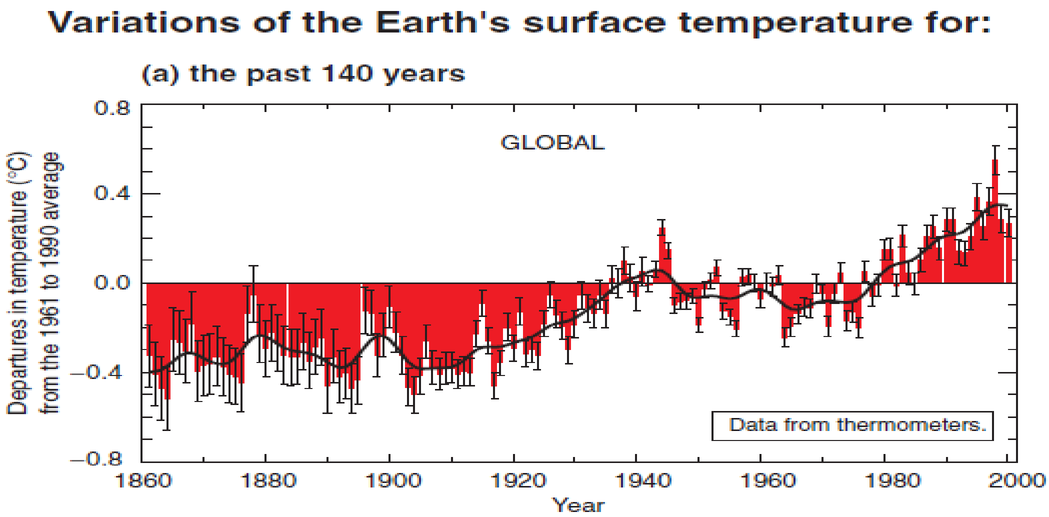
II. BACKGROUND OF STUDY

2.1. Why is Climate Change a Global Issue?

2.1.1. Background

Global warming refers to the continual rise of the Earth's average atmospheric temperature and ocean levels. Figure 1 shows that surface temperature has shifted up to 0.74 °C from its average temperatures between 1961 and 1990, and the trend is not thought to be slowed soon (As shown in Figure 1). More than 90% of scientists are certain that most of the up-shift is caused by increasing concentrations of GHG. These findings are recognized by all of the major industrialized countries.

Figure 1: Global Temperature Variation



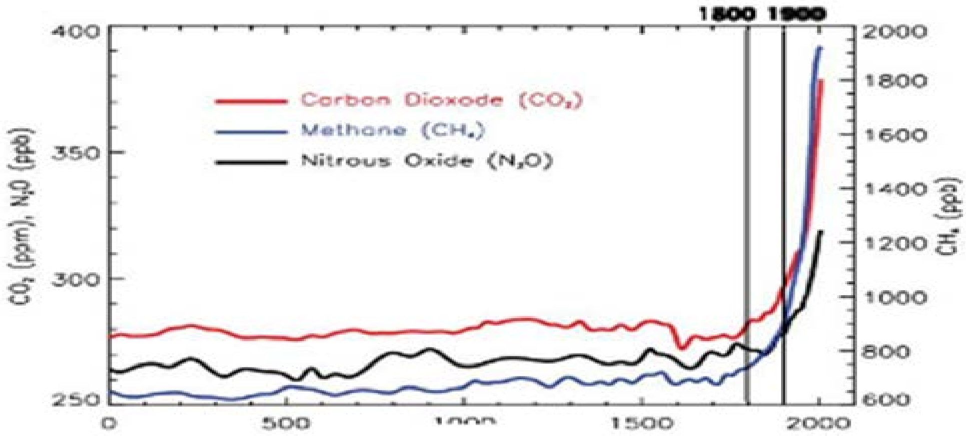
Source: http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/figspm-1.htm

Climate model estimations are researched in the 2007 Fourth Assessment Report (FAR) by the Intergovernmental Panel on Climate Change (IPCC, 2001). This report indicated that, during the 21st century, the global surface temperature is likely to rise a further 1.1 to 2.9°C based on their lowest emissions scenario and 2.4 to 6.4°C according to their highest. The ranges of these estimates arise from the differing sensitivity of the models to GHG concentrations.

An increase in global temperature will cause a rise in sea level, change patterns of precipitation, and affect ecological and geological systems. Why does the shift happen? Scientists indicate that there are three main criteria to cause the up-shift.

Firstly, GHG[1] density in the air is a major attributor. Since the Industrial Revolution, human activity has increased the amount of greenhouse gases in the atmosphere, because industrial development accompanies energy consumption and smoke emission. Figure 2 describes the increase in the concentration of GHG since the 18th century, when manufacturing industry expanded. Those levels are much higher than the figures produced at any time during the last 800,000 years, regarding which reliable data has been extracted from ice cores (Petit, 1999). Fossil fuel burning has produced about three-quarters of the increase in CO2 over the past 20 years. The rest of the increase is caused mostly by changes in land use, particularly deforestation through urbanization and industrialization (IPCC, 2001).

Figure 2: Main Greenhouse Concentration in the Atmosphere



Source: http://www.epa.gov/climatechange/science/causes.html

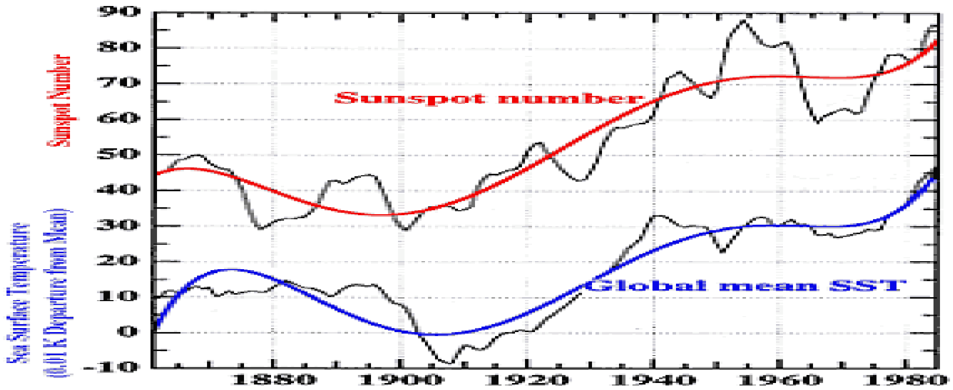
Secondly, aerosols such as smoke also affect global warming. As industrial development has expanded further, those gases from smokestacks interact with other components in the air and help to form cloud through chemical utilization. Global warming can be diminished through the cloud, because the cloud usually prevents solar radiation to the land and sea by absorbing or reflecting it. However, the phenomenon contributes to heating unbalance between areas. In rural India, as much as 50% of surface warming by spot heating was covered by atmospheric brown clouds (Ramanathan, 2008).

Thirdly, the sunspot cycle would be effective in the fluctuation of temperature.

[1] GHG consists of 6 major gases: CO2, CH4, N2O, PFCs, HFCs, and SF6; these gases respectively influence the Global Warming Potential (GWP). GWP of CO2 is 1, CH4 is 21, N2O is 310, HFCs is 1,300, PFCs is 7,000, and SF6 is 23,900.

Sunspots are generated when huge magnetic power is formed and disappears simultaneously after internal nuclear fusion occurs, radiating huge solar energy outward in the process (Viereck, 2001). Thus, scientists argue that the variance of global temperature on the globe has been synchronized with the number of sunspots that occur.

Figure 3: Variance Relationship between Sunspots and Temperature



Source: www.oar.noaa.gov/spotlite/archive/spot_sunclimate.html.

The climate changes of the 20th century may have a significant solar component. Figure 3 shows comparisons of globally averaged temperature and solar activity. Many scientists find that these correlations are convincing evidence that the sun has contributed to the global warming of the 20th century. Some say that as much as 1/3 of the global warming may be the result of an increase in solar energy. So, while it is becoming clear that human activity is changing the climate today, solar activity may also be contributing to climate change and has probably changed the climate in the past.

Even though some natural aspects influence global warming, it is generally accepted that human activity expansion is a leading contributor. To manage GHG emissions without hampering economic development and form international cooperation for collective counteraction has become a compelling issue.

2.1.2. International Cooperation

In the Rio Declaration in 1992, the climate change issue brought to the board table, and participating nations agreed that each party should strive to minimize its own emissions production. However, the declaration did not define conditions to restrain emissions.

To specify conditions and requirements, the Kyoto protocol was enacted in 1997 and ratified in 2005 by member nations. Each advanced nation named as part of Annex I is applied to the specific reduction targets, which is around a 5.2% reduction by 2012 based on the 1990 emissions of GHG, and developing nations named as part of Non-Annex I, such as China, India, and Korea, were not included (As shown Table 1), because member countries agreed that advanced nations have mainly caused global warming on their economic scale and highly developed levels and placing an emissions cap on developing nations would restrain their individual industry expansion. For supportive policies to achieve the targets, the protocol is incorporated with flexible measures such as Emissions Trading (ET), Clean Development Mechanism (CDM), and Joint Implementation (JI).

Table 1: Comparison between Non-Annex I and Annex I in the Kyoto protocol

Category	Non-Annex I (Developing Nations)	Annex I (Developed Nations)
Member	- Developing nations such as India China, and Korea	- 37 developed nations such as USA, Japan, France, and Germany
GHG statistics documentation	- Annual GHG emissions and absorption amount reporting	
Reduction target	- No	- Reduction target specified around 5%
National Strategy implementation	- National program implementation and execution for climate change adoption	- Implementation of national program to meet the target.
Collaboration	- Development, distribution, and expansion of GHG reduction technology - Conservation and expansion of carbon absorption areas - Apply climate change issues to national policies	- Financial and technology support to developing nations to reduce emissions - Joint implementation with other nations available

Source: Modified from Shin (2010).

ET provides a legal background of trading emissions allowance[2] in Annex I. In ET, the nation that has a surplus of allowance over the target emissions can sell its allowance to other nations that lack the allowances to meet their targets. Therefore, ET provides cost-effective and economic measures to meet the national emissions cap through a market

[2]Usually, emissions allowance is a property right to emit GHG gas. Unit of allowance is one ton of CO2 (equivalent). CO2 (equivalent) is calculated based on GWP potential of each regulatory GHG gases such as CO2, N2O, CH4, PFCS, HFCS, and SF6.

mechanism, because the marginal reduction cost of each party is varied (Kim and Jung, 2007).

In addition, CDM and JI are also effective tools for Annex I. CDM provides a methodology that Annex I nations can earn a carbon allowance from carbon abatement projects invested in non-Annex I nations, contributing to both Annex I nations that need allowance and non-Annex I nations that pursue sustainable development. The mechanism of JI is the same as that of CDM, but its difference is that investor and investee nations belong to Annex I.

However, the Kyoto protocol has a limitation to manage global warming, because it does not state any code of punishment when an Annex I nation does not meet its target. In spite of the non-penalty defined, the flow of GHG reduction has been positioned on the center of world political issues since a specific target was settled, as the world concentrated on the management of GHG for collaboration between civil society and the environment.

2.1.3. Carbon Reduction Policies in Developed Nations

As the Kyoto protocol was initiated, reduction of GHG emissions was accepted as part of the mandatory international rules for developed nations. They have prepared the activation of the ETS. Even though ETS has not perfectly landed on the policy in Annex I, preceding nations have operated it well. The Japanese Voluntary Emissions Trading Scheme (JVETS), Regional Greenhouse Gas Initiative (RGGI), and the EU European Emissions Trading Schemes (ETS) are representative of these efforts.

Compare to the other schemes, EU ETS are equipped with regulations of compulsory participant and penalty endowment when its members do not satisfy annual allowance limits. EU ETS has been actively operated through positioning as the No.1 market share in the global allowance trading market. Even though some may argue that EU ETS has not been adopted well to pursue a reduction target due to the relaxed distribution of allowance, it is the most successful policy, because the allowance market has been expanded and successfully settled. Thus, Korea, which declares a voluntary plan of GHG reduction, should gather some insights from EU ETS (Shin, 2010).

2.2. ETS Policy in EU

As evaluated as the most effective tool to reduce emissions in the world, the EU ETS includes a 'cap and trade' mechanism, covering about 70% of the market share of GHG allowance trading in the world (Kim and Jung, 2007). As the most significant policy for GHG control in EU, it was proposed by the European Commission in October 2001 and ratified by the European Council in October 2002. Under the scheme, each member is able to implement its own policies for emissions management. EU ETS consists of three phases: Phase I from 2005 to 2007, Phase II from 2008 to 2012, and Phase III from 2013 to 2020. Phase I was a pilot test period. Applicable GHG type was CO2 only in Phase I, N2O was newly included in Phase II, and all six GHG types will be covered in Phase III. The penalty, endowed by mismatched target emission, is 40 euro per ton in Phase I; in Phase II, the penalty is 100 euro per ton. Core mechanisms to support EU ETS are emissions allocation, MRV, SME support, and trading system.

2.2.1. Allocation

Each nation in the EU ETS provided allowances to the participating companies through auctioning and free providing policy in Phases I and II, but the proportion was different. In Phase I, 95% of allowances were distributed for free, and the remaining proportion was auctioned. However, because of the economic burden from auctioning distribution, which will lead to a loss in price competitiveness on products, just four states (Denmark, Hungry, Island, and Lithuania) adopted the auctioning allocation scheme. Only Hungry auctioned 5% of its national allowance to participating companies, the highest figure.

Not only was the auctioning system malfunctioned, but also allowances were over distributed. The initial purchase price of one allowance was about 20~25 euro, but it plunged to 0.6 euro as the deadline of Phase I came. With the exception of some states that allocated their allowances to companies with less-than-expected emissions such as Austria (-3%), Italy (-4.1%), Greece (-0.2%), Spain (-6.3%), and the UK (-17.7%), other nations allocated more allowances than expected, such as Belgium (29%), Denmark (25.9%), Estonia (24.6%), and Lithuania (51.1%) (Shin, 2010). The reason for the reduction gap between nations is that each nation could allocate its allowance itself, and the EU council did not have any control and supervising power in the distribution. In addition, banking policy, which permits savings of perennial allowances in an account, was not included in Phase I, so participating companies should sell all extra allowances before the deadline.

In Phase II, the EU council controlled an allocation plan of each nation to prevent exceeding of allowance and decided to cut whole emissions around the EU by 10.4% based on BAU, and 9 nations distributed their allowances through the auction. With those efforts, emissions price was stabilized at about 20 euros, and after the financial crisis in 2008, the price has been stabilized at 10 to 15 euros (Shin, 2010).

To calculate the expected (BAU emission) and reduced emissions amounts, each EU member nation adopted its policy between top-down and bottom-up approaches, because EU ETS policies do not regulate methodologies. Representatively, Germany adopted a bottom-up scheme, but UK adopted a top-down scheme.

The German government presumes its annual total emissions through data collection of expected emissions amount measured by each participating company. It also draws a compliance factor, which is calculated through the formula of national target emissions divided by total submitted emissions, and finally allocates each company allowance in the formula of "expected emissions multiplied by the compliance factor." If a company takes an early action[3], the government would provide extra allowance. Even though its distribution policy is well accepted by participating companies with precise allocations because they are able to claim their quotas on the expected business growth or business change, Germany should devote significant administrative power to the complicated methodology.

However, the UK requires less administrative power than Germany. Based on the portion of baseline emissions of a participating company against the national annual emissions in the past year, the government distributes the next year allowance to the company. With the GHG inventory reporting system in which participating companies report their annual emissions, the government easily executes the policy, and the government is able to concentrate on supportive policies such as the reduction of technology development and prevents civil claims against allowance distribution. Despite those benefits, the policy could hamper the economic growth of the UK more than that of Germany, due to uniformed allocation not reflecting the business growth plan of each company.

Therefore, to guarantee the success of the ETS, the government should build distribution standards of allowance allocation to the participating companies and decide to provide the allowance with fee collection such as auction or provision for free.

2.2.2. MRV

For successful ETS, monitoring, reporting, and verification (MRV) are properly and exactly executed by all parties such as government, company, and verifier. If a third party does not admit the figure of emissions amount, emissions trading would not be transacted. An

---

[3]Voluntary trial to reduce emissions before GHG regulatory law is applied to a company.

MRV directive in the EU ETS states that a participating company should apply a verification service to ensure its annual emissions report. Then, an independent verification body registered in the EU authority checks any possibility of errors from the organization boundary of the company for data collection and calculation. After verification, the company submits the verified report to the government. Finally, the government endorses the report and screens for whether the reported emissions amount is bigger than the annual allocated amount. Therefore, the government should examine the operation of MRV.

Because allowances provided to participating companies by each nation are able to be circulated in the EU, the operation of standardized policy is very important. However, MRV rules were different in each nation when the EU ETS started. In Phase I, because MRV rules were regarded as an initial step of policy standardization, they allowed each nation to set up its regulation and policy, enlarging the policy gap between nations and causing confusion in ensuring the absolute value of emissions amount. To minimize confusion during policy application, in Phase II, member nations agreed to standardize MRV rules, and the EU council is revising MRV rules (Shin, 2010).

2.2.3. SME Support

Most scientists and policy makers think that EU ETS is one of the most successful mechanisms to control GHG emissions in an economic way due to the minimized GHG abatement costs by trading, but some are skeptical whether it contributes to small and medium enterprises (SME) also. Administrative and financial costs in MRV and trading are burdensome to SMEs. In 2005, the EC reported that its administrative cost was about 10,000 euro annually, and further cost would be charged for financial advisory in emissions trading (As shown Table 2). Furthermore, it is hard to participate in the trading market because the minimum transaction amount is 1,000 CO2 ton.

Table 2: EU-ETS Administration Cost for SME

Nation	Administration Cost (euro per site)
Germany	12,000 ~ 20,000
Netherlands	5,700 ~ 21,500
Denmark	4,300 ~ 7,000
UK	3,700 ~ 4,400

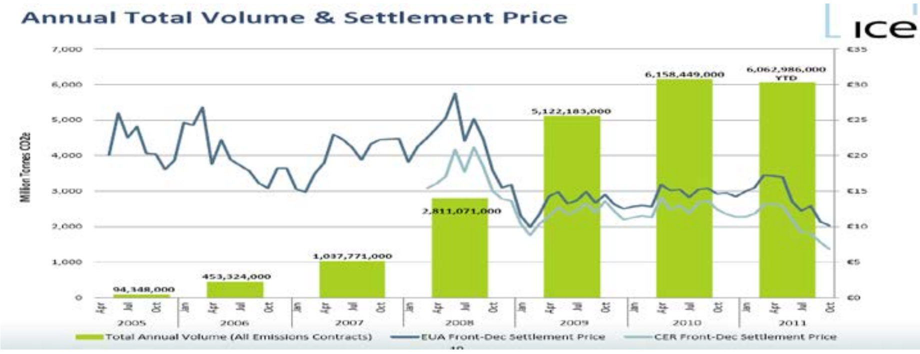
Source: EC, 2006.

However, in spite of those disadvantages, governments should encourage participation of SME. Liquidity would be more affluent when all relevant companies participate in the market than when only specific companies trade allowances. Also, exclusion of SME in ETS would be regarded as unfair, and carbon leakage would occur. So, the EU ETS includes SME with supporting policies such as providing subsidy to administrative and financial costs.

2.2.4. TRADING System

There are five trading systems in the EU ETS, of which the European Carbon Exchange (ECX) is the biggest. Thus, this study will research mainly ECX. As a subordinate company of Climate Exchange Plc, ECX is specialized to exchange carbon credits based on the EU ETS, and the market share of ECX in the emissions trading market has been expanded sustainably since 2005, with an 82% increase in transaction amount from 2008 to 2009 (As shown in Figure 4). The main products of ECX are EU Allowance (EUA) from allowance distribution and Certified Emissions Reduction (CER) from the CDM project, and financial derivatives of carbon credits are also exchanged. Thousands of traders daily access the exchange system through brokers and banks.

Figure 4: Annual Data in ECX



Source: https://www.theice.com/publicdocs/futures/ICE_ECX_presentation.pdf.

As ECX is allied with ICE, ICE[4] is supervising all transacting credits in ECX through its own trading system, and ECX is developing and marketing products. All of the

[4] ICE Futures Europe is a future exchange, located in the UK, supervised by the UK financial Supervisory Agency
(FSA). As a representative future exchange, ICE covers all European future transactions

trading results in ECX are settled through LCH Clearnet[5] (London Clearing House Limited and Clearnet).

However, operation of ETS accompanies transaction costs such as an exchange and clearing fee (0.004 euros per ton) and a broker fee (approximately 1% of the total transaction value). Based on the annual transaction amount in ECX in 2011, the total transaction cost will be about 388 million euros[6]. However, the benefit of the transaction in the market is greater than the cost. In 2006, the EC estimated that the total cost of carbon reduction through ETS would be less than 0.1% of the total EU GDP, 3 billion euro, but the total direct reduction cost without the market mechanism would be 7 billion euro, double the cost in ETS (EC, 2006). Economic feasibility through ETS is derived from the positive economic effect in exchange. Without the exchange market, social inefficiency would occur, because all parties have different marginal costs of carbon reduction. Consequently, ETS is an effective tool to minimize cost in emissions reduction.

2.3. GHG and Energy Target Management System Introduction

2.3.1. Korean Circumstances

Korea joined the United Nations Framework Convention on Climate Change (UNFCCC) in 1993 and ratified the Kyoto Protocol in 2002. Currently, its annual GHG emissions are ranking 10th, followed by China and the United States in 2009, emitting 520 million CO2 tons, or 1.7% of the world's emissions. The expansion rate of emissions between 1990 and 2004 was 124% (IEA, 2011) (As shown Table 3). It is generally agreed that international communities have indirectly pressed Korea either to join Annex I or to express differentiated paths in non-Annex I as an member of the Organization for Economic Cooperation and Development (OECD).

Table 3: GHG status of Korea

Criteria	Korea	Ranking	Remark
Emissions('09)	0.52 billion CO2ton	10th	1st China (6.8), 2nd USA (5.2)
Growth rate ('90~'09)	124%	41th	1st Benin (1,535%), 18th China (208%)

[5] Clearnet is one of major clearing houses of the futures in UK.

[6] Transaction amount(6,062,986,000, 2011 expected) * CER price(6 euro) * 0.01(Broker fee 1%) + Transaction amount * 0.004

Emissions per GDP ('09)	0.45 CO2ton/$1000	46th	1st Iraq (3.14), 45th USA (0.46), OECD average (0.38)
Emissions per capita ('09)	10.57 CO2ton/person	20th	1st Qatar (40.12), 11th USA (16.9), OECD average (9.83)

Source: CO2 Emissions from Fuel Combustion, 2011 edition, IEA, Paris.

To counteract international claims and pursue sustainable development, in August 2008, the Korean government declared a new national development paradigm of low carbon and green growth, with sustainable development including the reduction of greenhouse gas and environmental pollution and securing of new growth potentials armed with green technology and clean energy. In 2009, the government reported a GHG-reduction mid-term plan through which Korea will reduce its BAU emissions by 30% until 2020 (As shown Table 4). The target is the most recordable figure among developing nations.

Table 4: The Midterm Plan of Greenhouse Gas Reduction

Category		Emissions (CO2 Million ton)		Reduction Rate (%)			
		2007	2020 (BAU)	2012	2013	2015	2020
Power	**Power Generation, LNG Supply**	190.7	255.44	1.5	3.0	6.1	26.7
Industry	**Oil refinery**	12.8	17.1	0.4	0.6	2.8	7.5
	Mining	1.0	0.68	0.4	0.4	0.6	3.9
	Iron	86.0	121.35	0.1	0.2	2.1	6.5
	Cement	42.2	41.48	0.5	0.9	3.0	8.5
	Petroleum & Chemical	50.7	63.47	0.4	0.6	2.8	7.5
	Paper & Wood	8.7	7.73	0.4	0.5	2.4	7.1
	Cloth &Leather	11.9	9.81	0.4	0.6	1.1	6.3
	Glass & Ceramic	4.5	5.50	0.4	0.5	0.7	4.0
	Nonferrous Metal	5.4	5.02	0.4	0.5	0.7	4.1
	Machine	10.2	13.10	0.45	0.7	1.2	7.6
	Electricity & Electronic	27.7	41.34	0.9	2.2	32.3	61.7
	Electronic device	6..3	71.65	2.4	3.4	26.3	39.5
	Semiconductor	8.4	14.53	1.0	1.8	17.3	27.7
	Car	9.7	12.34	0.5	1.1	15.2	31.9
	Shipbuilding	1.8	3.79	0.5	0.6	1.3	6.7
	Other manufacturing	17.6	16.91	0.2	0.2	0.3	1.7
	Beverage & Food	6.8	6.16	0.5	0.6	0.9	5.0
	Construction	2.5	3.22	0.2	0.5	3.2	7.1

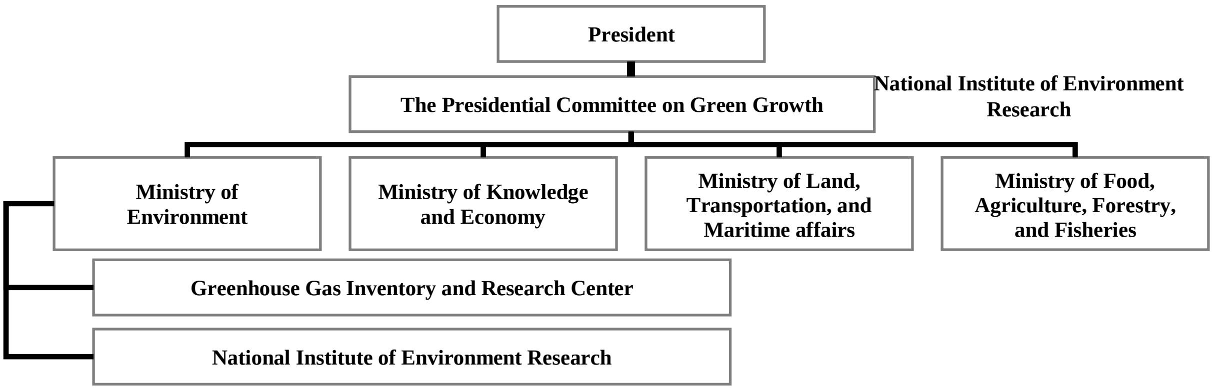
Transportation		87.7	107.25	2.0	4.2	9.6	34.3
Building	**Home**	70.5	87.44	1.8	5.0	8.9	27.0
	Commercial	67.6	91.52	1.9	4.4	8.8	26.7
Public		16.2	18.85	5.2	8.6	15.7	25.0
Agriculture & Fish		30.0	29.10	0.0	0.1	1.7	5.2
Waste		17.1	13.84	1.3	2.0	9.0	12.3
Total		**610.5**	**813**	**1.6**	**3.3**	**10.0**	**30.0**

Source: Korean Governmental Press (2011). National Greenhouse Gas Reduction Plan.

To legally support the government vision and show willingness, the Low Carbon and Green Growth Law (Green Law) was enacted in Jan 2010 and the Greenhouse Gas and Energy Target Management System Regulation" was enacted in Mar 2011. The Green Law consisted of two parts: low-carbon green growth national strategy including 2020 national vision and institutional background of the presidential committee on green growth, which is the control tower of national green growth.

The Presidential Committee on Green Growth is the highest governmental agency. As a supervising governmental department to line ministries, it establishes national regulations and designs national green growth budgets. Line ministries in green growth consist of the Ministry of Environment (ME); Ministry of Knowledge and Economy (MKE); Ministry of Land, Transportation, and Maritime Affairs (MLTM); and Ministry of Food, Agriculture, Forestry, and Fisheries (MFAFF). ME is responsible for waste and public buildings, MKE for manufacturing industries and power generation, MLTM for private buildings and transportations, and MFAFF for agriculture and fishery; ME also controls the Greenhouse gas Inventory & Research center (GIR) and third-party GHG validation bodies (As shown in Figure 5).

Figure 5: Government Organization for National Green Growth



Source: Low Carbon and Green Growth Law (2010). Korea.

GHG and Energy Target Management System Regulation is designed to control businesses that emit over the government emissions cap. The government can endow penalties or incentives to businesses upon their compliances to the scheme. The scheme is a crucial frame to the reduction mid-term plan of the government.

2.3.2. GHG and Energy Target Management System Regulation

GHG and Energy Target Management System Regulation has a process cycle, "Designating regulated business (June) >> Allocation of the GHG cap to the business (September) >> Reduction plan submission from the business (December) >> Emitting GHG and executing reduction activities on the reduction plan (for one year, January to December in next year) >> Emissions inventory and reduction report submission by the business.

1) Designating Regulated Business and Allocation of GHG Cap to the Business

The regulated business in the GHG and Energy Target Management Scheme are selected if its average emissions amount during the previous three years is over the governmental emissions cap. In 2011, which is the first year of GHG and Energy Target Management Scheme Regulation, 375 businesses are designated. Until 2011, the company emitting over 125,000 CO2 tons or the manufacturing plant emitting over 25,000 CO2 tons is to participate in GHG and Energy Target Management Scheme Regulation, and the standard is enforced year by year. So, after 2014, the standard of the company is over 50,000 CO2 tons or for the manufacturing plant over 15,000 CO2 tons, and the number of the company and manufacturing plant is expected to increase (As shown in Table 5).

Table 5: Participating Company Designation Criteria

Category	Until 2011.12.31		After 2012.1.1		After 2014.1.1	
	Company	Plant	Company	Plant	Company	Plant
CO2ton	125,000	25,000	87,500	20,000	50,000	15,000

Source: Ministry of Environment (2010). GHG and Energy Target Management Regulation, Korea.

After completion of the designation process, the government allocates emissions caps to all participants. In the allocation process, participants provide all relevant data to emissions, such as business growth rate, new facility installation plant, emissions trends of existed facility emissions, and any changes in business boundary (As shown in Figure 6). After deep consideration of validation on submitted data and establishment of national emissions target in the following year, the government allocates GHG caps to each participant. If a business is not imposing a satisfactory emissions cap, it can submit a formal objection to the government decision. The total allocation amount for each business is the sum of the allocated emissions amount for each facility.

Figure 6: GHG Emissions Quota Allocation Methodology

1. Allocation methodology

$$EA\_company_{i,j} = \sum_k EA\_inst_{i,j,k} + \sum_k EA\_new\_inst_{i,j,k}$$

i : Industrial category

j : Business

k : Emissions facility type

$EA\_company_{i,j}$: (*i*) Industrial category (*j*) business *emissions quota* (tCO_2eq)

$EA\_inst_{i,j,k}$: (*i*) Industrial category (*j*) business *(k) pre*-installed facility emissions quota (tCO_2eq)

$EA\_new\_inst_{i,j,k}$: (*i*) Industrial category (*j*) business *(k) new*-installed facility emissions quota (tCO_2eq)

2. Pre-installed facility emissions quota

Pre-installed facility is defined as one whose facility was already installed before the first participating year under the regulation.

$$EA\_inst_{i,j,k} = HE_{i,j,k} \times (1 + GF_{i,j,k}) \times CF_i$$

$EA\_inst_{i,j,k}$: (*i*) Industrial category (*j*) business *(k) pre*-installed facility emissions quota (tCO_2eq)

$HE_{i,j,k}$ (*i*) Industrial category (*j*) business *(k) pre*-installed facility baseline emissions amount (tCO_2eq)

$GF_{i,j,k}$: (*i*) Industrial category (*j*) business *(k) pre*-installed facility growth rate

CF_i: (*i*) Industrial category reduction coefficient ($CF \leq 1.0$)

3. N*ew*-installed facility emissions quota

New-installed facility is defined as on for which the facility is newly installed after the participating year.

$$EA\_new\_inst_{i,j,k} = C_{i,j,k} \times t_M \times RD \times EV_{i,j,k} \times CF_i$$

EA_new_inst*$_{i,j,k}$* : (*i*) Industrial category (*j*) business *(k) new*-installed facility emissions quota (tCO_2eq)

C*$_{i,j,k}$* : (*i*) Industrial category (*j*) business *(k) new*-installed facility designing capability(MW, t/h)

t*$_M$* : (*i*) Industrial category (*j*) business *(k) new*-installed facility *daily maximum operation hours* (hr/day)

RD : (*i*) Industrial category (*j*) business *(k) new*-installed facility *operation days in a year* (days)

EV*$_{i,j,k}$* : (*i*) Industrial category (*j*) business *(k) new*-installed facility average emissions amount per manufacturing goods (tCO_2/t, tCO_2/TJ)

CF*$_i$* : (*i*) Industrial category (*j*) business *(k) new*-installed facility emissions reduction rate ($CF \leq 1.0$)

4. Emissions reduction rate (*CF$_i$*)

$$CF_i = \frac{EA\_Sector_i}{\sum_{j,k}[HE_{i,j,k} \times (1 + GF_{i,j,k})] + \sum_{j,k}[C_{i,j,k} \times t_M \times RD \times EV_{i,j,k}]}$$

EA_Sector*$_i$* : National emissions quota of (*i*) industrial category based on the midterm green growth

Source: GHG and Energy Target Management Regulation, Ministry of Environment, Korea, 2010.

Even though the allocation methodology is set up for effective and scientific emissions distribution process to each participant, it was not applied effectively in the 2012 allocation plan, because all governmental officers collect data from businesses and allocate emissions quota to businesses by hand. Also, the number of participating businesses is over 300, so handwritten approaches are not appropriate for operating the regulation. Therefore, the government should introduce implementation of the IT allocation system to manage data, apply methodology efficiently, and monitor the annual allocation to the national plant to be matched with the mid-term green growth plan.

2) Reduction Plan Submission by the Business

The participating business should submit a reduction plan by December. The reduction plan covers whole processes of emissions reduction from data measurement to a reduction plan, such as a data monitoring plan, QA and QC plan, reduction-item introduction plan. The business submits the plan electronically to the government via the governmental web site (As shown in Figure 7).

Figure 7: GIR System Screen Capture

Source: GIR (2011). GIR system capture, Korea.

The most difficult part of this process is to write a reduction item introduction plan. The International Energy Agency (IEA) reported that the reduction potential amount for the Korean industry is small, because most Korean industries have already installed high-efficiency facilities (As shown in Table 6). So, to counteract the emissions quota, a business should share reduction item information with other businesses, and the government should actively develop reduction technologies and support information sharing. However, not only has the national sharing system not begun operating yet, but also a business has no willingness to participate in the sharing scheme, because there is no incentive. To make a synergistic effect with information sharing and derive cost minimization, the government should implement a sharing tool that is lucrative to both the government and to industries.

Table 6: Reduction Potential Amount when Best Available Technology is applied

Category	Korea	Japan	EU	China	World
Energy reduction potential amount (GJ/ton)	0.92	0.83	2.12	5.57	3.90
CO_2 reduction potential amount (CO_2ton/steel ton)	0.08	0.07	0.22	0.48	0.30

Source: IEA, Energy Technology Perspective 2008: Scenarios & Strategies to 2020.

3) Emissions Inventory and Reduction Report Submission by the Business

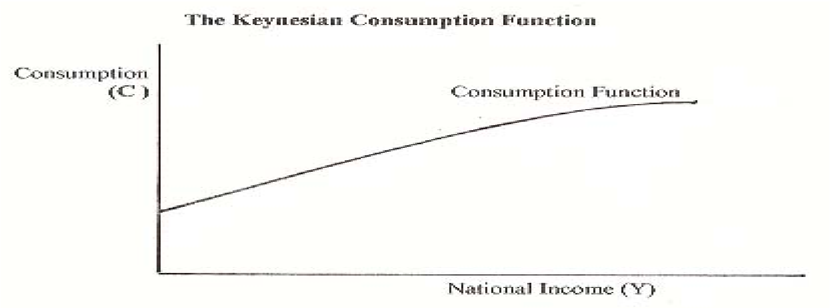
After submitting the reduction plan, a business should reduce its emissions under the quota from January to December and submit emissions performance records, which are validated by a verification body, to the government via a governmental web site by next March 31. In the submission process, collection of emissions activity data is crucial. The emissions inventory covers direct emissions such as diesel usage in emissions facilities and Per-Fluorinated Compound (PFC) gas usage in semiconductor facilities and indirect emissions, such as externally purchased power like electricity and steam. All data should be proved with objective papers such as invoices, bills, and legal records.

To observe the submission deadline, a business prepares a GHG inventory by February and requests data validation to a verification body. Because of the complexity in collecting and verifying data registered on the GHG inventory, the social work burden for preparation and verification is significant. The ETS provides more burdensome regulation to businesses than the Energy and GHG Target Management Scheme. Not only to alleviate working load to businesses but also to secure accurate data, the government should implement a data management system that facilitates data interface between the governmental GHG system and the energy provider such as electricity and gas. IT infrastructure of data interface is already prepared as energy providers implement automatic billing systems. Emissions from energy and gas usage represent more than 60% of total emissions. Some argue that data interface is fragile to system attacks, but it would be safe if the government set up the latest technologies for defense, because the Albaro system, which is a governmental waste management system to facilitate data interface between governmental and corporate systems, has been effectively operational without any system interruption by hackers.

2.4. Keynesian Theory Application

Keynesian theory argues that individual microeconomic-level action leads to economic insufficiency, which means that aggregate demands are below the potentiality of aggregate outcomes, even though classical models assert that aggregate demand is equal to aggregate supply and there is no inefficiency in economy. Keynes explained the gap between demand and outcome with individual spending activities: "In the fundamental psychological law, upon which we are entitled to depend with great confidence both a priori from our knowledge of human nature and from the detailed facts of experience, is that men are disposed, as a rule and on the average, to increase their consumption as their income increases, but not by as much as the increase in their income" (Keynes, 1997). He maintained that the Great Depression came from those deviations (Figure 8).

Figure 8: The Keynesian Consumption Function



Source: http://www.stchas.edu/faculty/gbowling/survey/DerivationoftheExpenditureMultiplier.html.

To solve economic depression, he argues that government intervention in the market is necessary, and he proposed two methodologies to draw investment; 1) Lessened interest rates and 2) Government investment in social infrastructure. To make an investment, business owners, who are the most crucial attributors to decide ranges of investment in the economy, consider two factors: interest rate and return expectation. If the interest rate is more than the potential profitable ratio after an investment, entrepreneurs will just keep their deposits in banking accounts, and the situation will not contribute to boosting the national economy. Thus, he argues that the government should decrease interest rates to overcome the downturn in the economy. Secondly, government spending to construct infrastructure is required to boost an economy. Figure 8 describes the marginal consumption level along with income decreases, meaning that relatively poor people have greater propensity to consume goods of value as great as their incomes than rich people are. Because construction employees are mainly from poor populations, he argues that governmental projects would help to overcome the downturn through prompting consumption.

Some studies apply Keynesian theory to green growth issues. Greer argues that emissions restriction policy will be contributable to economic growth as applying Keynesian theory to emissions control issues (Greer, 1995). For example, as expansions of investment and aggregate demand are crucial to economic growth through product and process innovation, the policy stimulates new investment to create clean technologies for compliance with the regulation and to minimize the cost among power industries, which are not only the biggest users of fossil fuels but also the biggest emitters. Some works of research back up Greer's argument. Jin and Kim argue that it is expected that national GDP will grow by 0.1% through the development of unvalued industries caused by horizontal financing (Jin and Kim, 2011). Cheon maintains that ETS is the verified tool to achieve national GHG emissions targets when successful case studies in the US Acid program, which are operated under the emissions trading mechanism to reduce sulfur oxides and nitrogen oxides, are considered (Cheon, 1999). Also, Choi maintains that the implementation of a supporting IT system to Korean ETS is required for effective emissions allocation and trading, monitoring and reporting, record management, and penalty policy control (Choi, 2009).

There are also discussions regarding an environment policy that will be more effective in regulating GHGs with a minimum economic impact. Carbon tax and ETS are mainly discussed. Applied to fossil fuel consumption, carbon tax does not restrict reduction methodologies. So, polluters can make decisions in terms of their own best choices (Jin and Kim, 2011). In ETS, the government issues tradable emissions rights under a national target, and polluters emit emissions by purchasing the rights or acquiring government allocation. The price of the rights is decided on the market mechanism. Many experts argue that ETS not only contributes to the minimization of marginal reduction cost theoretically but is also derived in GHG reduction effect through the control of national total emissions amount (Hanley and Moffat, 1993; Fisher, Barnett, and others, 1996; Chang and Cho, 2000; Johansson, 2006; Montgomery, 1972).

However, there are some counter arguments. Strict management of GHG to restrict emissions amount to businesses could hamper economic growth, because the restriction can be ultimately reached with replacement of current technologies, such as fossil fuel combustion to new types such as utilization of renewable energy or repression of manufacturing growth (Manne and Richels, 1990). To minimize economic impact, they suggested two alternatives: green R&D into industries must be pursued on the manufacturing side, and high energy efficiency in energy consumption side must be achieved.

Thus, Greer agreed that there will also be an adjustment cost in the short term and recommended that the government activate emissions cap regulation slowly and implement supporting policies to lead sustainable development and minimize the adjustment cost (Greer, 1995).

III. HYPOTHESIS

3.1. System Designing

3.1.1. Allocation Module

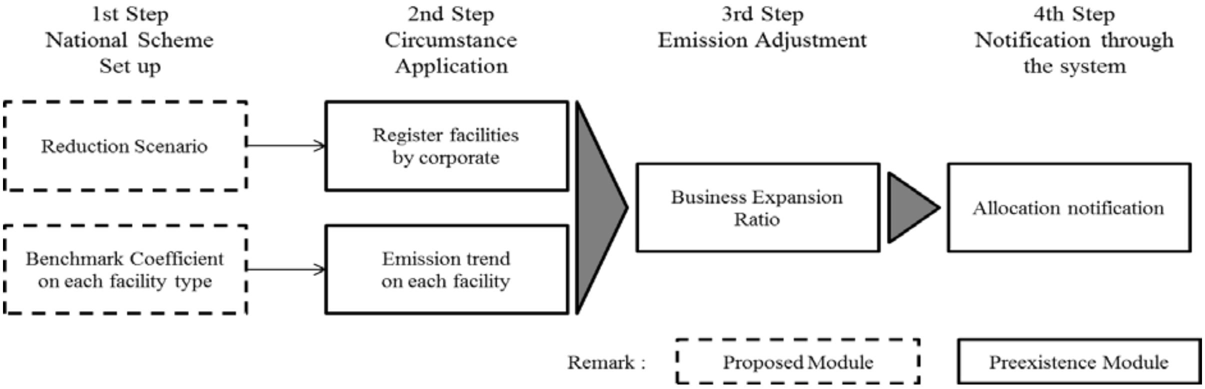
The most crucial point in ETS is how to allocate allowance to each participating company. In the case of EU ETS of Phase I, distribution of excessive allowance to business over actual emissions resulted in a drop of allowance price up to 0.6 euro/CO2ton. However, strictly limited allowance will cause economic collapse. Currently, the Korean government has adopted German allocation methodologies and once distributed allowances in 2011. However, the government has prepared a benchmark methodology for 2012 in which the emissions quota of each company is calculated based on combination of between past trend of emissions amount, the benchmark coefficient[7] on each facility, and the national target of emissions in each industry sector. So, more precise allocation than that of the past methodology is possible, but the administrative burden on the government side will be hiked up.

To achieve the allocation plan, the government should implement an effective GHG system, but the current government GHG inventory system is restrictedly activated to notify an annual emissions cap for each company. To minimize the public burden, this study proposed an emissions allowance allocation framework (As shown in Figure 9). Firstly, as with the improved government methodology, the system should include the reduction scenario on each industry and the benchmark coefficient on each emissions facility. Secondly, based on the past year's emissions amount for each facility already registered in the GHG system, the government allocates a total emissions quota to a corporation, which is the sum of the emissions allowance on each facility. Lastly, business expansion ratio is incorporated to the calculated result for final adjustment.

Without those improvements, the government is able to cut workforces, and the distribution processes will be more apparent to business participants than before.

[7]The most optimized emissions rate on each facility type after reduction facility installation.

Figure 9: Proposed Allocation Process in the GHG System



3.1.2. Data Interface Implementation and MRV Improvement

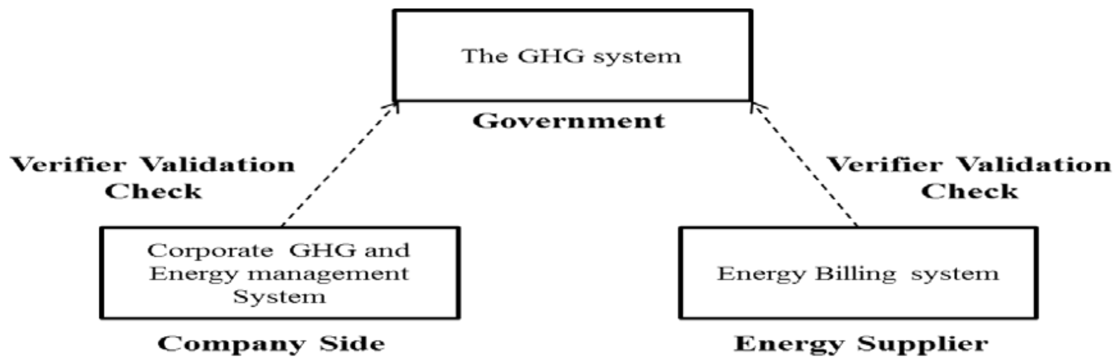
The government should look at the working loss in the data registration process. Business needs to submit relevant sources from more than 10 categories, such as company organization boundary, procedure of data monitoring and QA, emissions facilities categorized upon governmental standard, and general business information such as sales revenue and business plan for expansion. The most challenging task is registering facilities and GHG data on those facilities, due to the excessive numbers of facilities and GHG data sources.

However, the time can be minimized if the government implements a data interface module, which facilitates data transaction between systems (As shown in Figure 10). Most of the extensive manufacturing sites are equipped with energy monitoring system to store energy consumption trends on each piece of heavy facility equipment, such as a boiler or air compressor. So, if the recorded data in the corporate system is transmitted to the GHG system automatically, working time to register data registration would be innovatively improved. Albaro, which is a governmental system for national waste management, is an example of a successful case of data interface between the public system and corporate operating systems. Korean waste management law regulates that the company that disposes of industrial waste should report its waste type and amount to the system within 24 hours, and the system allows only handwritten documents to register the data. Due to its huge burden in terms of data input, a business association requested data interface, and the government accepted the proposal. Therefore, these days, a corporate waste management system is able to transmit waste data to the government system on a daily basis, reducing working time in data registration.

Also, data interface between the government system and billing systems of utility companies would contribute to the shortened working time. The billing papers, which include energy cost and usage, are legal evidence for GHG MRV. Currently, reporting employees gather all energy usage data from the energy monitoring systems, check and revise those data against the records of the bill, and register confirmed data to the governmental GHG system. Because billing process is systematized, the government can easily approach implementation of data interface.

Finally, the MRV process will be simplified after the data interface. As handwritten data is replaced by automatic transmitted data in the GHG system, the government can request specific GHG information such as daily or monthly emissions data, thus enhancing GHG management level and giving diversified selection options in emissions trading by checking monthly or daily data. The improvement will also contribute to the foundation of a sophisticated verification process. These days, verifiers should check between numbers in all receipts of energy billing papers and data in the GHG system and examine whether data collection and reporting are executed on the procedure according to corporate standards. After the improvement, verifiers can concentrate more on macro perspectives such as the corporate GHG system design and data flow and the technological structure of the GHG reduction scheme through spending saved time in data collection and reporting the check-in time limit of verification.

Figure 10: Proposed Data Interface Diagram



3.1.3. Reduction Item Management through Information Sharing

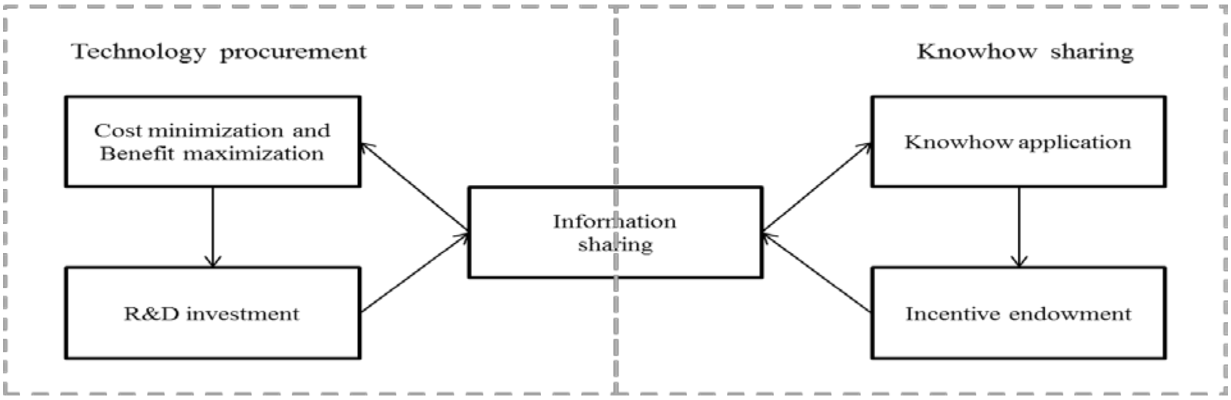
After an appropriate emissions allowance is endowed to a company, the company should build a GHG abatement plan and execute the plan with priority. When a carbon market in which carbon allowance is traded by participating companies is implemented, the company will execute either allowance purchase or reduction technology introduction. So, if costs of both purchase and technology introduction are shortened, business burden will be reduced to achieve the emissions target. How does the government support both with cost minimization?

Firstly, the government should operate GHG information-sharing communities between participating companies (As shown in Figure 11). If a reduction technology that is effective in terms of energy saving and can be applied to relevant companies is shared with all participants, marginal reduction cost would be lessened, resulting in enlarged reduction options and minimized demand of allowance purchase. Group purchase in the community also contributes to cost minimization. For example, Samsung electronics could have reduced energy costs by more than 100 thousand dollars and reduced emissions by 1,000 tons in 2009, by introducing one energy-saving item, which was implemented in just one manufacturing site, at all sites. Without the expansion of the application, this action would save less than 10 thousand dollars in just one site, and implementation at other sites will save more energy cost than before. Its result of the synergy effect implies that sharing information is beneficial to all members. Khanna corroborates that the positive synergy effect is accrued through information sharing between affiliated firms (Khanna and Rivkin, 2001).

Secondly, the community should include not only emissions-producing business but also GHG reduction technology makers and environmental consultants (As shown in Figure 11). One of the most crucial challenges to GHG reduction is that nobody has sufficient information. There are many cases in which technology developers possessing good reduction technology in both economy and environment went bankrupt due to the difficulty finding customers. Also, GHG emitters spend more money to renovate facilities for GHG reduction than expected in budget, due to a lack of information in the reduction technology market. So, if the community allows information sharing between buyer and seller, asymmetry will be broken, and positive synergy circulation will be secured as R&D organizations concentrate on engineering and production and emitters adopt reduction technology adaptable with their circumstances. Furthermore, group purchasing will maximize social efficiency by minimizing cost in procurement and maximizing benefit in production.

Thirdly, the government should seek incentive standards for sharing. In many cases, GHG reduction is achieved by simply changing the manufacturing process innovation. To share knowhow, relevant information should be registered in the GHG system, but nobody will succeed without incentive. So, if the government operates an incentive scheme when the knowhow is shared by many ETS participants, a virtuous cycle of sharing will be composed, reducing social reduction cost.

Figure 11: Proposed Information Sharing



3.1.4. Trading Module

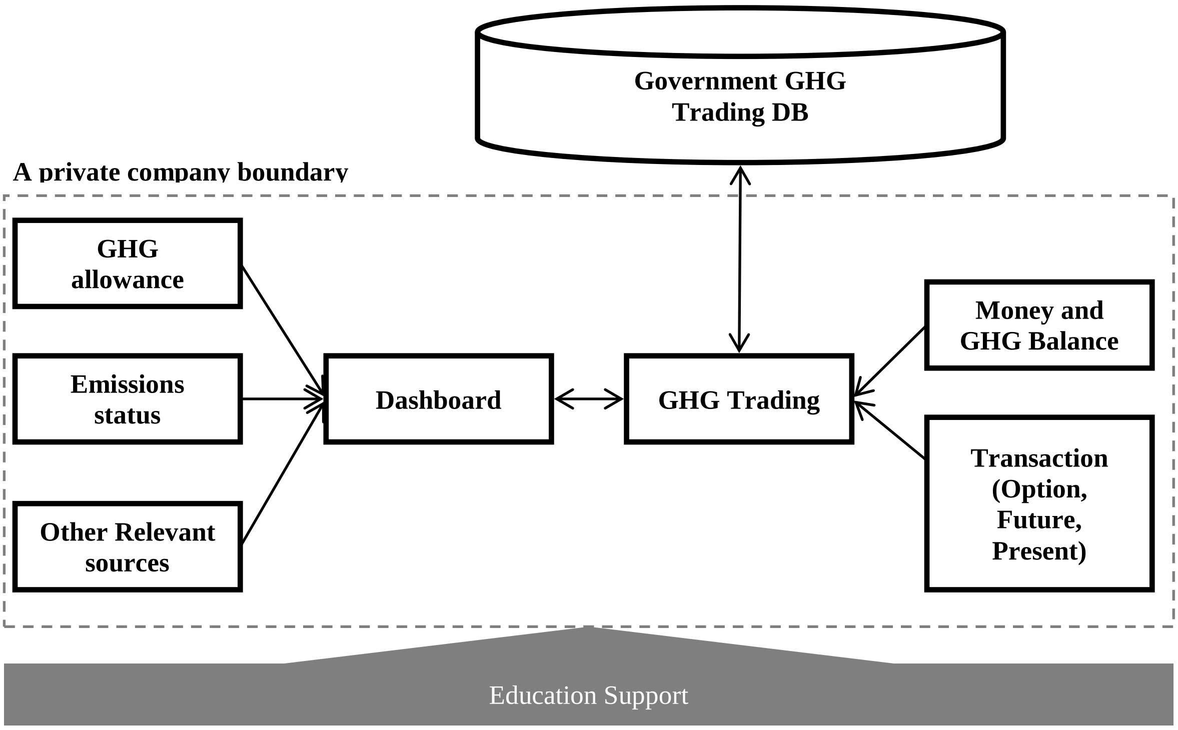
If all conditions to introduce ETS are satisfied, the government can propel the implementation of a trading module in which companies can trade allowances for their selling or purchasing through the market price. Those companies would optimize their reduction burdens through either allowance purchase or reduction technology introduction. So, it is very important to secure sufficient and relevant information on the business side, and the government should provide such information to minimize social burden.

For successful establishments, firstly, the government should include a dashboard module in the GHG management system (As shown in Figure 12). Dashboard, which is a visual board to indicate current circumstances for GHG, such as annual cumulative GHG amount, selling and purchasing balance, and reduction technology development, would contribute to precise and rapid decision making through data transactions with other modules. The trading scheme should be incorporated in the GHG system (As shown in Figure 12). A major cost of exchange is the payment of broker fee and exchange commission in the EU ETS. So, if the trading scheme is incorporated in the GHG system and controlled by the government, companies would save costs.

Secondly, not only spot exchange but also option and future exchanges should be incorporated into the GHS system, and the government should allow allowance banking in which the expiration date of purchased allowances does not exist, such as money. In contrast to stock exchange, emissions trade exchange has a settling day when the company declares that its possession of allowance is greater than or equal to the allocated allowance after verification. So, allowances prices would fluctuate if the government does not introduce futures and options. As futures and options are tools to distribute risks evenly during a given period, three financial mechanisms would help to sell and purchase allowances. Also, futures and options exchange would serve to expand financial options of securing investment money to introduce reduction technology. Also, the banking of allowances will contribute to activated trade and lessened price fluctuation. In the EU ETS, allowance price plunged to 0.6 euro through not only excessive allocation but also lack of permitted banking, because companies that possessed more allowances than were mandatory had to sell them for almost nothing as the final date of allowance clearing approached.

Thirdly, the government should educate employees of participating companies for allowance trading (As shown in Figure 12). Background information is required to understand concepts of futures, options, and spot exchanges. SMEs face difficulty finding employees who are familiar with concepts of both GHG and financial management. So, if the government supports their training, they would not face the harsh task of carbon management.

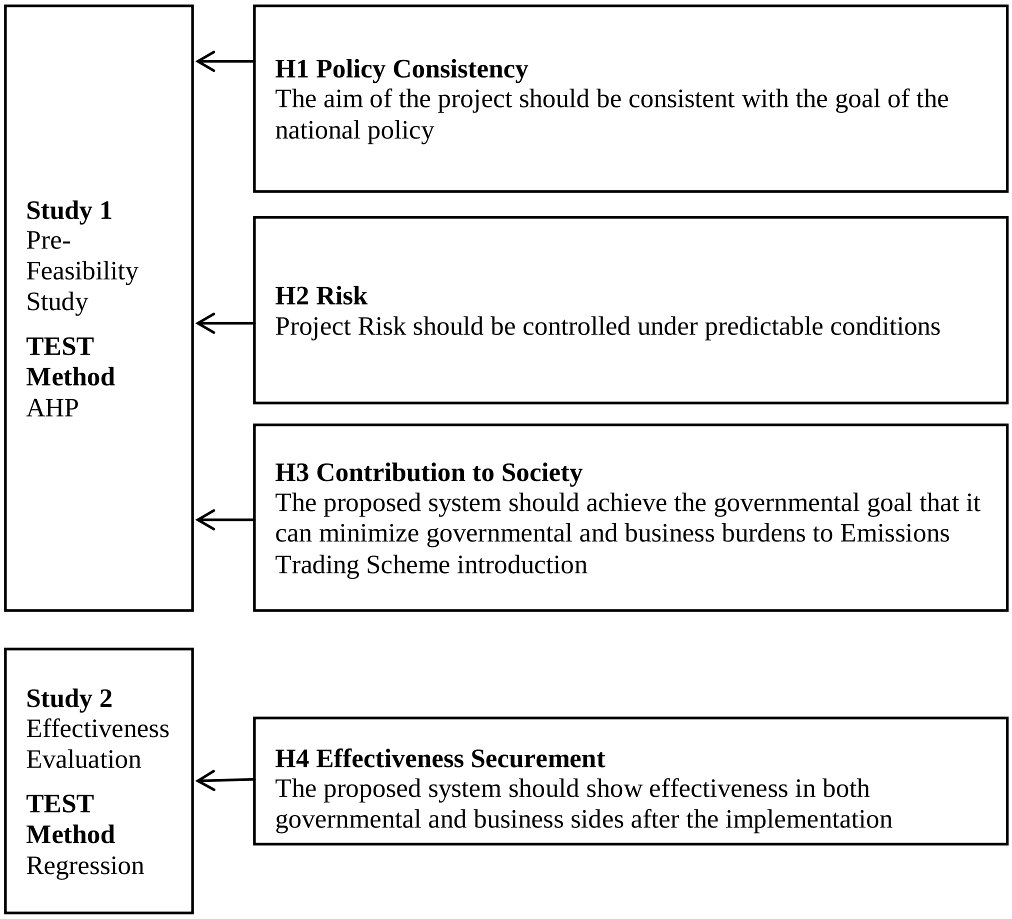
Figure 12: Proposed Trading Module



3.2. Hypothesis Development

In the case of Korea, a department that pursues a certain investment project should perform AHP policy analysis processes of a prefeasibility study carried by the Korea Development Institute (KDI). KDI policy analysis scheme consists of three categories: policy consistency, risk control plan, and project-specific goal-achieving possibility. About ten people who are professors, researchers, accountants, and lawyers participate in the analysis. Because the proposed system on the study is a governmental system, it has to be considered based on the KDI pre-feasibility study. Because the main users of the system are governmental officers as well as business employees, effectiveness after system implementation should be checked. So, the pre-feasibility study of the system will be tested in Study 1, and effectiveness after the implementation will be tested in Study 2 (As shown in Figure 13).

Figure 13: Hypothesis Development Diagram



3.2.1. Study 1: Pre-Feasibility Study

- H1: [Policy Consistency] The aim of the project should be consistent with the goal of the national policy

Policy consistency is implemented as the government declares that the aim and willingness of the project do not conflict with other project interests. The consistency is divided into two parts: time-sequential consistency and collaborating consistency (Jeon and Lee, 2004). Time-sequential consistency means that a policy is consistent with the past policies and collaborating consistency and that a policy is supplemented with other policies (Roh, 1995). However, if the policy does not maintain consistencies or is conflicted with other policies, there will be some problems (Jeon and Lee, 2004).

Firstly, the execution of the policy will be varied and lose consistency in the same space and time. Secondly, the policy accomplishment will fail if policy makers and executors do not have any willingness to pursue them, even though the policy maintains consistency (Lee, 1989). For example, in a case of failure, Allison (Allison, 1999) indicated the policy of the US regarding Cuba. President Kennedy directed the US Navy to isolate all coasts of Cuba; the Navy rejected the direction. Because of policy conflicts, perfect isolation was not executed, and some Soviet ships gained access to Havana. Therefore, if the governmental project is not preceded without any consideration for consistency, it faces a lot of barriers. A pre-feasibility study by KDI includes a policy consistency test, which consists of policy direction consistency, project pursuance of willingness and preference, and project preparation (KDI, 2010). Because the proposed system framework on this thesis is to support the national green growth agenda, the framework should be tested on the pre-feasibility study by KDI.

- H2: [Project Risk] Project Risk should be controlled under predictable conditions

As the GHG management IT system belongs to a national project area, national budget financing possibility should be checked. Financing sources are varied. Government financing origins are separated into three parts: national tax such as income tax, local government tax such as property tax, and other government source such as public funds (Choi, 2008). Without any specification for financing methodologies, a governmental project cannot be pursued, so KDI checks for possibilities of financing for a project on pre-feasibility test (KDI, 2011).

For example, when KDI evaluates the “Improvement project of IT system in National Tax Service (NTS),” it checks the annual IT budget. NTS has usually spent 9% of its total budget on IT infrastructure operation and includes IT improvement project budget in its mid-term budgetary plan. So, it confirms that NTS project can be pursued without financing risks (Jeong and Jo, 2010).

This proposed project is in the conceptual stage, so it is hard to define cost and benefit in the project and to discuss possibilities of financing specifically. However, the national mid-term budgetary plan includes some positive signs of IT infrastructure development for GHG management. For example, the IT budget amount in the Ministry of Environment (ME) increased from 14 million USD in 2011 to 16 million USD in 2012 (2012 Budget planning, Ministry of Environment, 2011), and the presidential committee on green growth indicated that 107 billion USD from 2009 to 2013 will be invested in the national green growth plan (Green financing for green growth, Presidential Committee on Green Growth, 2010).

Also, project management risks should be defined. Because the proposed system includes all credential data to the government and business such as business sales amount, emissions amount, national green growth plan, and so on, data security is crucial. Risk management is also necessary to prevent software interruptions such as hacking and physical interruptions such as electricity blackouts in information systems implementation, and operation is becoming more important than before (Kim and Kim, 1995). So, KDI checked data interface risks and system developer proficiency risks in an improvement project of the IT system at the National Tax Service (NTS) and decided that risk points are high.

Because the purpose of the proposed system on this thesis is similar to the purpose of the NTS improvement project from the perspective of data integration management, the proposed system will be hard to pursue without solving IT risks.

- H3: [Contribution to Society] The proposed system should achieve the governmental goal of minimizing governmental and business burdens to Emissions Trading Scheme introduction

The introduction of ETS accompanies governmental burden for GHG allocation and management and business burden for GHG reduction and report. From allocation to report and emissions trading, a huge amount of data is generated and managed. To minimize burdens, system implementation is required. Choi suggested that financial system supplementation and IT management system implementation are required (Choi, 2008).

The purpose of the proposed system is to minimize social burdens during the introduction of ETS by providing a GHG allocation management module, data interface between government and energy provider for convenient data collection and effective and efficient data verification, item sharing to create synergy effects, and emissions trading for transaction cost minimization. If the purpose of the system is defined as unhelpful, pursing of the project will be difficult. However, it is difficult to define whether the system is supportable to the introduction of ETS to the government and business sides, due to the shortage of experience and research, which covers less than ten years, to check the utilities of the ETS IT system worldwide.

3.2.2. Study 2: Effectiveness after the implementation

- H4: [Effectiveness Securement] The proposed system should show effectiveness on both governmental and business sides after implementation

Study 1 is designed to evaluate the feasibility of implementation on the government side in terms of macro perspectives. Contrary to Study 1, Study 2 checks its effectiveness among governmental and business users in terms of micro perspectives.

(Business) Labor hours reduction and utilized working process with optimization of emissions trading processes

The method that brings the greatest effectiveness to businesses when the system is implemented is a reduction of working hours. Kim suggests that system effectiveness is measured by the process of working lead time reduction and minimization of purchasing costs in Enterprise Resource Planning (ERP) implementation (Kim, 1999). The proposed project is expected to contribute to working hour reduction by allowing data interface, which replaces handwriting input. As information sharing creates synergistic effects such as economic scale effects through enlarging knowledge (Goold and Campbell, 1998), reduction of item sharing enables minimization of emissions trading costs through expanding selection options and leads to purchasing cost reduction if businesses purchase the same emissions reduction items at once. However, item sharing would be negative if the sharing is operated in unclear trading methodologies. Thus, to maximize synergy effects and to minimize negative effects, the government should lead item sharing of positive signals (Williamson, 1993).

The government should also introduce the present and the future transactions in the ETS to minimize business burdens. ECX allows the present, the future, and the option transactions in the emissions market to stabilize emissions credit price. As 85% of total emissions transaction amounts are generated in future transactions, Choi argued that the Korean emissions trading market should be implemented to allow for a variety of credit transaction functions (Choi, 2008).

(Government) Achieving efficiency in administration and observing a national reduction plan

It is not a new idea to pursue an effective administration process and achieve the goal of the administration through IT implementation (Kim and Kim, 2008). Since 1990, the Korean government has implemented an electronic government system to counteract against circumstance changes, to improve administration powers, and to build clean governmental affairs, and the electronic government system is highly sophisticated, ranked first in the UN electronic governmental system evaluation[8]. So, newly implemented governmental systems of GHG will have side effects as a result of unskilled official uses. Through the GHG management system, the government can achieve the national emissions target through effective emissions quota allocation and minimize business burdens.

[8] http://www.mopasblog.net/11810158

IV. METHODOLOGY AND ANALYSIS

4.1. Methodology for Hypothesis Validation

4.1.1. Study 1 – AHP

AHP, which was developed by Satty in 1970, was designed to support qualitative and multi-standard decision making and is an appropriate tool for the study, which requires deep consideration for a variety of parts. Governments are using AHP for public project evaluation, in addition to other uses. For example, Lee evaluated the feasibility of implantation of a heating power supply system on AHP analysis, and the evaluation criteria were technology adaptation, economic achievement, environmental impact, and social contribution (Lee and Park, 2003). AHP was also used for ERP implementation assessment (Oh, 2007). In Study 1, H1, H2, and H3 are tested based on AHP.

To decide the preference between alternatives, AHP responders use dual comparison methodology. The preference point is decided from one to nine (As shown in Table 7); one point means that preference between the choices is the same (As shown in Table 8). Nine points means that the preference for the choice recorded with the point is nine times preferable to the alternative (Satty, 1980), and the other choice gets the inverse number of scoring, such as 1/9.

Table 7: AHP Score Definition

Score	Definition
1	Equal Importance
3	Moderate Importance
5	Strong Importance
7	Very Strong Importance
9	Extreme Importance

Source: Modified from Satty (1980).

Table 8: Dual Comparison Table Example

Evaluation Criteria	Extreme Importance		Very Strong Importance		Strong Importance		Moderate Importance		Equal		Moderate Importance		Strong Importance		Very Strong Importance		Extreme Importance	Evaluation Criteria
Consistency	⑨	⑧	⑦	⑥	⑤	④	③	②		②	③	④	⑤	⑥	⑦	⑧	⑨	Risk

Source: Modified from Satty (1980).

Thus, the scores of dual comparisons are shown in the matrix below.

Dual Comparison Matrix

$$\text{Dual comparison matrix} = \begin{bmatrix} 1 & A12 & A13 \\ A21 & 1 & A23 \\ A31 & A32 & 1 \end{bmatrix}$$

$$Aij = 1/Aji,\ Aii = 1,\ \forall i$$

I,J = The number of alternatives. (Up to N)

Source: Modified from Satty (1980).

With the matrix, preference weight for each alternative is calculated. To earn each weight, all factors are summed up with the column base ($\sum_i^j \mathrm{Aij}$), and each alternative score is divided by the column sum. The results are shown to the matrix below.

The Number of Alternatives Divided by the Column Sum

$$\text{The number of alternatives divided by the column sum} = \begin{bmatrix} \frac{1}{\sum_i^j \mathrm{Ai1}} & \frac{A12}{\sum_i^j \mathrm{Ai2}} & \frac{A13}{\sum_i^j \mathrm{Ai3}} \\ \frac{\mathrm{A}_{21}}{\sum_i^j \mathrm{Ai1}} & \frac{1}{\sum_i^j \mathrm{Ai2}} & \frac{A23}{\sum_i^j \mathrm{Ai3}} \\ \frac{\mathrm{A}_{31}}{\sum_i^j \mathrm{Ai1}} & \frac{A32}{\sum_i^j \mathrm{Ai2}} & \frac{A33}{\sum_i^j \mathrm{Ai3}} \end{bmatrix}$$

Source: Modified from Satty (1980).

All factors are summed up with the row base, and the summed number is divided by the number of columns, which is same as the number of j on the matrix. Finally, preference weight on each alternative is decided. Refer to the matrix below.

Preference Weight

$$\text{Preference weight} = \begin{pmatrix} \grave{}\mathrm{A}_1 \\ \grave{}\mathrm{A}_2 \\ \grave{}\mathrm{A}_3 \end{pmatrix} = \begin{pmatrix} (\frac{1}{\sum_i^j \mathrm{Ai1}} + \frac{A12}{\sum_i^j \mathrm{Ai2}} + \frac{A13}{\sum_i^j \mathrm{Ai3}})/3 \\ (\frac{A21}{\sum_i^j \mathrm{Ai1}} + \frac{1}{\sum_i^j \mathrm{Ai2}} + \frac{A23}{\sum_i^j \mathrm{Ai3}})/3 \\ (\frac{A31}{\sum_i^j \mathrm{Ai1}} + \frac{A32}{\sum_i^j \mathrm{Ai2}} + \frac{A33}{\sum_i^j \mathrm{Ai3}})/3 \end{pmatrix}$$

Source: Modified from Satty (1980).

Logical consistency for preference weights should be checked. To derive the consistency, all alternative factors are multiplied by preference weights with the same sequence, and all multiplied factors are summed based on row base. Refer to the matrix below.

Logical Consistency

$$\begin{pmatrix} ``A_1 \\ ``A_2 \\ ``A_3 \end{pmatrix} = \begin{pmatrix} (1 * `A_1 + A_{12} * `A_2 + A_{13} * `A_3)/`A_1 \\ (A_{21} * `A_1 + 1 * `A_2 + A_{23} * `A_3)/`A_2 \\ (A_{31} * `A_1 + A_{32} * `A_2 + 1 * `A_3)/`A_3 \end{pmatrix}$$

Source: Modified from Satty (1980).

To calculate the Eigen Value (τ), all calculated numbers are summed up and the figure is divided by the number of alternatives. Refer to the formula below.

Eigen Value

Eigen Value(τ) = ($``A_1$ + $``A_1$ + $``A_1$) / 3 (the number of alternatives)

Source: Modified from Satty (1980).

To utilize CI (Constancy Index) = (τ– n) / (n -1) formula, consistency index can be calculated. To utilize the CR (Consistency Ratio) = CI / RI (Random Index) (As shown in Table 9) formula, constancy ratio can be calculated (n is the number of alternatives).

Table 9: Random Index

n	1	2	3	4	5	6	7	8	9	10
Random Index	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Source: Satty (1996).

If a CR value is "0", it means that the AHP responder did a perfect AHP dual comparison. If the CR value has less than "0.1", it means that the dual comparison result has a reasonable consistency, and if the CR value is less than "0.2", it means that the dual comparison result has an acceptable consistency (Satty, 1980; Kwon, 2010).

4.1.2. Study 2 − Regression

H4 in Study 2 checks the effectiveness of users on the proposed system. Because the system consists of four modules, system satisfactory levels of each module will be different, and user type of either governmental or business will influence the satisfactory level. The GHG emissions amount of each business should be checked, because the emissions amount influences GHG counteraction working load to the business and GHG allocation complexity to the government. So, it is necessary to check governmental and business working satisfactory level change before and after the system implementation with consideration for the GHG amount (As shown in Tables 10 and 11).

Table 10: Simple Linear Regression Model

Criteria	Simple Linear Regression
Company	X: GHG emissions from the company -> Y: Improvement score in the company
Government	X: GHG emissions from the company -> Y: Improvement score in the government

Table 11: Regression Survey Question Example

Company Name	Emission (CO_2ton eq)	Criteria	Company					Government				
			Total	Allocation	Data I/F	Idea Sharing	Carbon Exchange	Total	Allocation	Data I/F	Idea Sharing	Carbon Exchange
A	50,000	Before	40	15	5	15	5	30	10	5	10	5
		After	75	20	10	20	25	85	25	15	20	25

4.2. Sampling Methodology

AHP scores vary depending on responder answering qualities. So, AHP responders of the study should have a profound knowledge of GHG policies or business approaches to GHG counteraction (As shown Table 12).

Table 12: Study 1 and 2 Survey Respondent List

Name	Occupation	Remark
A	Business Consultant	More than 10 years' working experience in the Green Industry
B	Manager	GHG Counteraction in a big emissions-producing company
C	Accountant	KICPA, Registered GHG Verifier in Korea
D	Accountant	AICPA, Registered GHG Verifier in Korea
E	Manager	PhD in Environment, working in an environment research institute
F	Accountant	KICPA, working with the government for GHG strategy

G	Assistant Manager	Government employee of Korea Energy Management Corporation
H	Accountant	KICPA, working with the government for GHG strategy
I	Accountant	KICPA, working with the government for GHG strategy
J	Accountant	AICPA, working with the government for GHG strategy

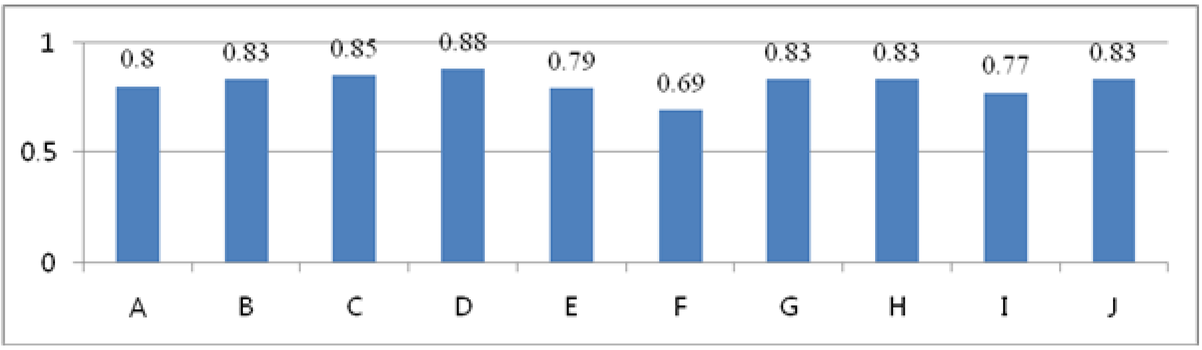
According to the demography of the sample, six men and four women participated in the AHP survey, and their average age is 35. Responder A is an environmental consultant and has participated in biomass energy development in China and a governmental GHG project of emissions allocation methodology researches. B is an employee in the GHG counteraction department in a big emissions-producing company, which emits more than 8 million CO_2 tons per year. C and E are accountants and GHG verifiers and have participated in GHG verification of more than 10 companies. E is a PhD in environmental engineering at Purdue in the US and currently designs GHG counteraction policies in a big company. G is a governmental employee and supervises budgetary plans for national GHG counteraction. F, H, I, J are business consultants and participate in a governmental GHG project of emissions allocation methodology research. Therefore, it can be confirmed that survey responders to Study 1 are qualified, and their answers will secure logical consistencies and authorities. They also participate in the Study 2 survey, because their responses are expected to be truthful, and they know the working circumstances and situations through business consulting experiences or participation in GHG working processes directly.

V. ANALYSIS

5.1. Study 1

The average preference point, which is calculated with the exclusion of the lowest and the highest scores, is 0.82 (As shown in Figure 14). Normally, if the point is over 0.5, the project is defined as feasible. So, the proposed project is regarded as feasible for pursuance. The consistency ratio value is less than 0.2, so we can assume that responder answers are logically consistent.

Figure 14: Responder Preference Answer



Survey responders evaluate the weights of policy, risk, and project as 0.438, 0.214, and 0.348 (As shown Table 13). The reason for the highest weight point in policy is that policy control and management are the basis of pursuing governmental projects. If the project is not consistent with the national goal or policy framework, driving forces of the project will not be secured easily, and governmental budgetary department asks the project pursuing department to severely cut or reduce the project budget. The project weight is scored as the second. If the policy basis is secured, the project should achieve the aim of its goal after implementation. For example, these days, the Korean government has implemented a four-river project, which constructs river-dams on four great rivers on the Korean peninsula, and it declared that the main purpose of the project is to improve water quality. However, water quality has not been improved, and the government faces social conflicts. So, the test of the project specialties is crucial. The last element is risk. After policy consistency and project specialties are validated, the IT risks in terms of system security and project management in the implementation remain, and those risks are crucial to pursuing projects. However, those risks are usually solved well within the introduction of advanced firewalls and qualified management skills. This scoring pattern is general. System improvement project by the National Tax Service determines the weights of policy, risk, and project to be 0.23, 0.12, and 0.65 (Jeong and Jo, 2010), and Postal service management system implementation project by National Postal Service has 0.55, 0.06, and 0.39, respectively (Jang, 2008).

Table 13: AHP Weight Analysis

Category	A	B	C	D	E	F	G	H	I	J	Avg
Policy	**0.69**	**0.14**	**0.24**		**0.69**		**0.63**	**0.25**	**0.21**	**0.65**	**0.44**
Policy consistency	0.14	0.11	0.05		0.51		0.47	0.22	0.03	0.52	0.26
Willingness of project pursuing and preference	0.55	0.04	0.19		0.17		0.16	0.03	0.17	0.13	0.18
Risk	**0.08**	**0.14**	**0.09**		**0.21**		**0.11**	**0.09**	**0.72**	**0.27**	**0.21**
Financing	0.02	0.11	0.02		0.04		0.08	0.01	0.62	0.05	0.12
Project risk management	0.06	0.04	0.07	**Highest score**	0.18	**Lowest score**	0.03	0.08	0.10	0.21	0.10
Project specialties	**0.22**	**0.71**	**0.67**		**0.10**		**0.26**	**0.66**	**0.07**	**0.08**	**0.35**
Systemization of GHG allocation	0.06	0.22	0.03		0.03		0.05	0.23	0.04	0.05	0.09
Data I/F	0.02	0.03	0.37		0.06		0.14	0.21	0.02	0.02	0.11
Reduction item sharing	0.01	0.07	0.22		0.01		0.02	0.02	0.00	0.00	0.04
Carbon credit exchange	0.14	0.40	0.06		0.01		0.04	0.20	0.01	0.01	0.11

5.2. Study 2

Seven experts responded from 19 businesses (Shown as Table 14). Even though some of those experts are not employees of their responding companies, they can give reliable answers to evaluate effectiveness of the proposed system in the eye of business and the government because they have consulting or verification experience with the responding company.

Table 14: Company List

Company background information					Business side utility change		Government side utility change	
Business Name	Business Category	Responder	GHG emissions(CO2ton)	GHG Emissions standardization (MAX 100)	Before (MAX 100)	After (MAX 100)	Before (MAX 100)	After (MAX 100)
AA	Electronics	B	9,608,920	99.82	75	90	30	85
BB	Oil-chemical	D	7,187,170	97.95	70	80	50	85
CC	Oil-chemical	D	5,784,110	93.81	65	80	50	85
DD	Steel	F	1,743,638	53.52	55	85	45	70
EE	Transportation	F	690,187	38.59	50	90	45	50
FF	Telecommunication	C	567,349	36.92	50	90	55	100
GG	Electronics	E	531,481	36.43	50	95	60	40
HH	Oil-chemical	C	474,048	35.66	60	90	50	95
II	Building	A	401,512	34.69	55	105	25	90
JJ	Electronics	C	294,873	33.29	60	90	50	100
KK	Oil-chemical	C	250,254	32.71	50	80	55	85
LL	Oil-chemical	F	193,175	31.97	45	100	45	65
MM	Food	J	185,018	31.87	45	100	45	79
NN	Machinery	C	166,591	31.63	45	90	45	100
OO	Cement	C	161,139	31.56	40	95	35	55
PP	Paper	C	95,593	30.73	45	90	65	95
QQ	Paper	C	51,553	30.18	40	90	35	75
RR	Oil-chemical	A	42,134	30.06	50	100	30	90
SS	Building	F	27,571	29.88	40	100	45	55

As GHG emissions amounts are greatly different among companies from 9 million CO2 tons to 27 thousand CO2 tons, all business amounts are standardized through z-value standardization methodology, and the amount range is adjusted to 100 scales, from 0 to 100. Refer to the formula below.

Standardization of Emissions Amount in responding Businesses

Standardized value of 100 scale = Probability from z-value in normal distribution X 100

In the survey, an increase in utility after the implementation is reported, when GHG emissions amounts, which are crucial to GHG counteraction to both business and government sides, are not considered. Generally, the systemization of the working process to the IT system contributes to an increase in working efficiency for users. The difference between before and after implementation is about 40 points, an almost 80% improvement from the current status on the business side (As shown in Table 15). The most contributable category to the increase is trading. Even though the law of the ETS is enacted, the government has not yet provided any specific information regarding how to operate ETS to businesses, and businesses have learned that transaction costs of emissions trading are significant in the EU ETS, where emissions trading is mainly operated by private financing firms. So, businesses earn benefits from the minimization of unexpected risks from governmental system operation. However, an increase in effectiveness on the governmental side was not as great as the increase on the business side (As shown in Table 16). The reason is that, even though governmental user burdens decrease with the systemization that replaces handwriting working procedure, businesses will make greater requests of IT, such as resolution of system errors, than before.

Table 15: Utility Change before and after the Implementation on the Business Side

Category	Total (Max 100)	Allocation (Max 25)	Data I/F (Max 25)	Item sharing (Max 25)	Trading (Max 25)
Before	52.11	11.32	14.74	16.58	9.21
After	91.58	21.32	24.47	24.47	21.32

Table 16: Utility Change before and after the Implementation on the Governmental Side

Category	Total (Max 100)	Allocation (Max 25)	Data I/F (Max 25)	Item sharing (Max 25)	Trading (Max 25)
Before	45.26	11.32	12.63	10.53	10.79
After	78.89	20.53	20.37	17.89	20.11

The survey result including consideration for the GHG amount to each business on the business side indicates that the emissions amount is directly correlated with the preparation level of GHG counteraction (As shown in Figure 15) and is conversely correlated with a utility increase before and after the implementation (As shown in Figure 16). The regression line of between emissions amount and utility level before the implementation shows a strong positive relationship, and as R^2 value is 0.7085, the line is acceptable.

An increase in utility level before and after the implementation is not well detected in big emissions companies. They have prepared counteraction measurements, such as operation of its own voluntary ETS in their business areas, for the introduction of ETS. So, even though they need to collect huge amounts of data for the governmental regulation, company systems are adjusting all data requirements to help users. For example, British Petroleum, Shell, SK energy, and LG chemical have introduced their ETSs for Corporate Social Responsibility and regulation counteraction (Kim, 2009). However, small companies are not equipped with the company system, because system implementation is expensive. Thus, the level of convenience in the governmental system is directly impacted on the utility change on small companies. The regression line is then negatively correlated, pointing out the R^2 value, 0.6999, to be acceptable.

Figure 15: Emissions (X-axis) VS Utility (Y-axis) before the Implementation in Business Side

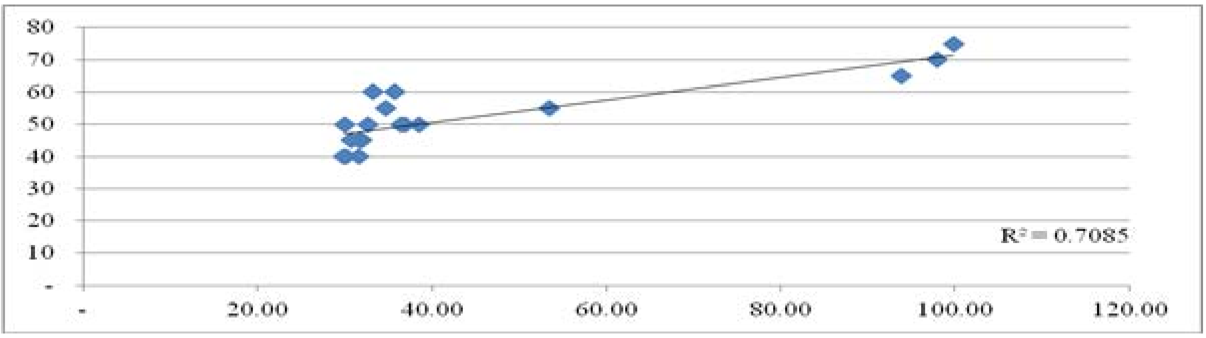
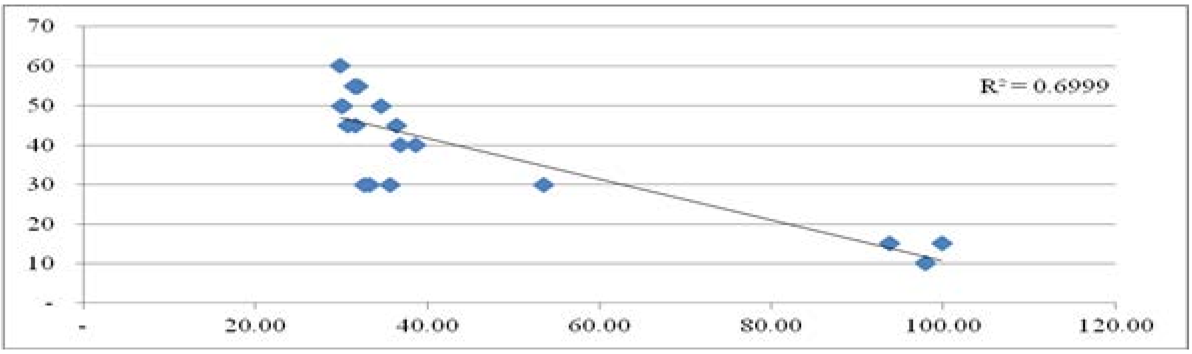


Figure 16: Emissions (X-axis) VS Utility Changes (Y-axis) in Business Side



However, there are no relationships between emissions amount and utility level on the governmental side. R^2 values of regression lines are 0.0139 (As shown in Figure 17) and 0.006 (As shown in Figure 18). The reason for this is that governmental efficiency is hard to be measured. Because there are hundreds of participants in ETS, it is unknown which problems and side effects will occur as a result of allocation to carbon credit trading. Also, even though laboring utility increases with the total management of data through the system, other administrative demands such as IT requests will be generated and compensate for working convenience.

Figure 17: Emissions (X-axis) vs. Utility (Y-axis) before the Implementation on the Governmental Side

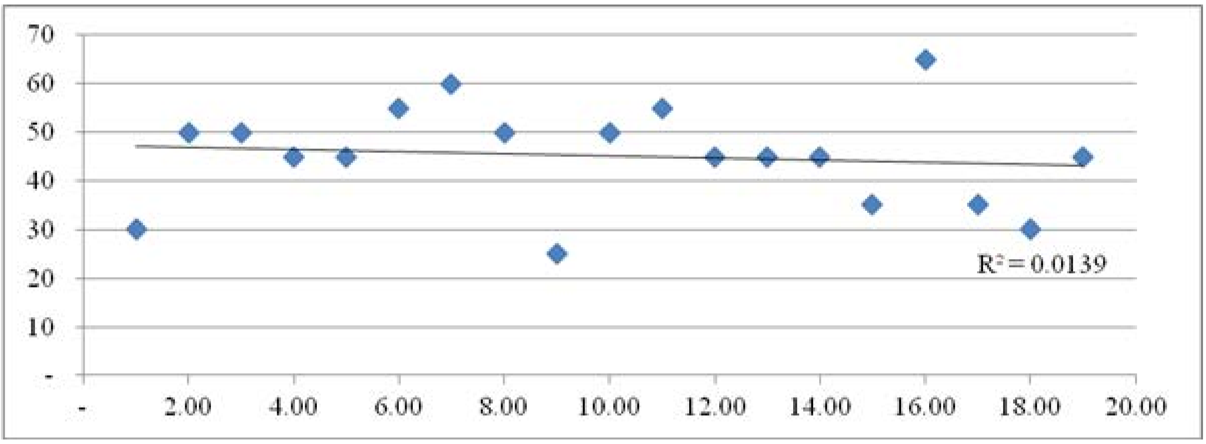
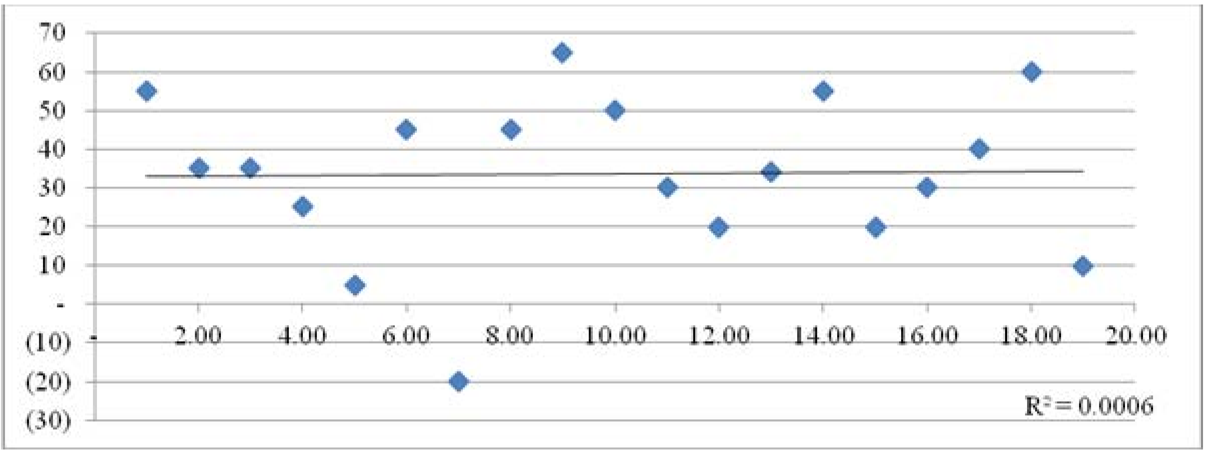


Figure 18: Emissions (X-axis) vs. Utility Changes (Y-axis) on the Governmental Side



VI. CONCLUSION

The world is experiencing severe natural disasters due to climate change. The main reasons include periodic fluctuation of sun spots, cloud reflection against sunlight, and an increase in GHG due to rapid industrialization. However, IPCC argues that the extension in the amount of GHGs is the most plausible reason. The international community founded the UNFCCC to counteract against environmental risk and pursue sustainable development, and developed nations such as the EU and the US are regulated regarding GHG emissions. Specifically, the Kyoto protocol, which was enacted in 1997, provides policy schemes such as the ETS, Clean Development Mechanism (CDM), and Joint Implementation (JI). The EU firstly introduced ETS throughout the world for sustainable growth. The EU ETS consists of four parts: emissions allocation, MRV, SME support, and emissions trading.

The Korean government declared the National Low Carbon and Green Growth Plan in 2008 to participate in global emissions reduction approaches, even though Korea does not need to reduce its emissions output. The core content of the declaration is that Korea will voluntarily reduce its GHG emissions amount by 30% based on business as usual, the highest reduction target among the developing nations. To comply with the target, the Korean government is operating a GHG and Energy Target Management System, which includes emissions cap allocation to each business and monitors emissions amounts. The ETS law will be applied in 2015.

Despite the fact that such a policy trend can be supported theoretically by relevant theses whose topics are emissions trading methodology development, SME support policy, economic effects after ETS introduction, and so on, it is hard to find GHG management system implementation methodologies.

This study suggests IT system methodology for ETS introduction and checks the feasibility of its implementation. When case studies of the EU ETS are reviewed, four major modules should be constructed. The first module is emissions allocation. In the Korean ETS and GHG and Energy Target Management System, the government adopted emissions trend methodology that reflects previous emissions amounts, and each site for emissions quota is decided by previous emissions amounts based on existing emissions-producing facilities, growth rate, and emissions amounts from newly installed facilities. As such data represents a huge amount and is managed in writing, without system support, it is hard to allocate effective emissions caps to business. To solve the problem, this study suggested integrated data management between the national emissions target and the emissions status of those facilities.

The second module is Monitoring, Reporting, and Verification (MRV). The business, which is regulated under law, should comply with the emissions quota, and the government should supervise emissions activities. To satisfy those responsibilities, emissions data from each facility should be managed under zero defects. So, the business spends about one or two months for data reporting to the government, and the government also spends a few months verifying the reporting data. To improve such a situation, this study proposed data interface. The greatest portion of GHG emissions is from the consumption of energy such as electricity, steam, and LNG, and energy consumption records are saved electronically in energy provider systems for billing. If an energy provider billing system is connected with the government system, businesses do not need to collect energy usage data, saving human resources for data collection and verification, and the government minimizes administration powers for data validation. Also, if GHG inventory systems managed by businesses are connected with the government system, the improvement effects will be amplified.

The third module is SME support. SMEs would face more severe risks than conglomerates if ETS is introduced without administrative supports, because it is difficult to develop emissions reduction technologies during a financial shortage. To overcome these problems, the study proposed sharing of reduction technologies. One of the greatest difficulties in reducing emissions is in finding adaptable reduction technologies. Under GHG and Energy Target Management System Regulation, all businesses should enforce an annual reduction plan. If all reduction technologies saved in governmental database are shared with all participants, social synergy effects aroused by information sharing are expected. Also, the sharing information is able to derive a group purchase mechanism. Group purchase mechanisms can provide a cost minimization effect to introduce such technologies and ensure environmental market sustainability to technology providers.

The last module is emissions trading support. Emissions credits are traded in future and present markets in the EU ETS. Even though commercial markets contribute to stabilization of trading amount and credit price, there are also side effects, such as an increase in transaction costs caused by financial brokerages. This study proposed that trading functions be incorporated to other GHG management modules implemented on the governmental side to minimize economic burdens to participants. As GHG processes from

GHG allocation to emissions trading are controlled in one site, the business workforce could increase its working efficiency. Even though the quality of emissions trading can be minimized due to a lack of participation from financial brokers in the market, such problems can be improved with governmental education support to the business sector.

The feasibility and effectiveness of the proposed system implementation methodologies are analyzed through AHP and regression. Before pursuing the government projects, Korean government analyzes the feasibility of the project through AHP. The AHP score on this project is 0.82, which is over the standard point of 0.5, and the project is decided as feasible for pursuing. Regression checks the GHG amount of each business, correlated with utility change before and after the system implementation. In the research, on the business side, utility change is conversely correlated with the GHG amount. However, on the government side, there was no correlation between utility change, which occurs through administration burdens to businesses along with GHG work procedures and GHG amount. However, the average utility is higher after the implementation than before. Thus, the study defines that pursuing the project is ensured with effectiveness.

This IT platform would contribute to the national green growth policy. As a benefit of data collection and verification through data interface, support of systematic allowance allocation to participating companies through in-house allocation mechanisms, the soft-landing of ETS adoption to participating companies through reduction technologies sharing and group purchases, and reduction of transaction costs through the trading system, the system will provide advantages to the government.

Theoretically, the study can support Greer's argument that green regulation can be contributable to economic growth when the Keynesian theory is applied (Greer, 1995). In transaction time of introducing emissions control regulations, the proposed system is able to play a role as a buffer through an increase in working efficiency between business and government sides and minimize side effects such as soaring cost in data management and reduction of technology application.

However, the study has limitations. Firstly, reliability of the data used in checking effectiveness in AHP and feasibility in regression would be questioned because of a short number of survey respondents, even though they are all qualified experts in the green industry. Secondly, figures of working utilities are subjective. Because the ETS has not been yet introduced to Korea, it is impossible to check utility change before and after the implementation of the proposed ETS IT system practically. So, utility records from respondents would vary depending on personal perspectives, even though they look at the same situations. Thirdly, the proposed system is just tested under Korean circumstances. The IT system should be widely used to minimize implementation costs. Even though each nation has a different rule for emissions control, the basic principles are same; allocation, data collection and verification, and emissions trading are mainframes to ETS. So, if the proposed system is tested internationally, the validity of system implementation will be increased beyond where it is now.

Furthermore, it is required that the proposed system be tested to examine the cost minimization effect with objective data, if the system is actually implemented. Ultimately, GDP contribution rates from ETS introduction should be tested to check the validity of Keynesian theory application to the introduction of new environmental regulation. To enhance system efficiency, the proposed model should be modified to reflect GHG figures within other nations.

VII. APPENDIX

VII. APPENDIX

Survey Questions

Topic: Feasibility test of implementation of Greenhouse-gas Management IT System

The purpose of the survey is to check the feasibility of a Greenhouse-gas Management IT system. Currently, the Emissions Trading Scheme of Carbon Credit has been passed in Congress, and the government should persuade businesses to adopt the scheme as well as minimize risks from side effects such as an increase in manufacturing cost due to credit purchase. For preparation, the implementation of supportive system is necessary, and the thesis will introduce the methodology of implementation and provide a feasibility score for its relevance. Contact Info +82-10-7689-7758, agentbae@naver.com, Bae, Deog Sang

1. Background information for the implementation scheme

- Before starting the survey, respondents should read carefully the articles listed below to understand the implementation scheme.

Survey Criteria	Check point	Reference
Policy Consistency and Willingness		
Consistency	· Consistency of the upper-level plan · Consistency of the line ministry's plan	. The government is executing an agenda for green growth and passed ETS Law, May 2013. . The government declared spending of 10 billion dollars, which is 2% of the annual GDP, from 2009 to 2013. (Presidential Committee on Green Growth)
Willingness	· Willingness of central or local government	
Risk Management		
Financing	· Financing possibility	. The government declared spending of 10 billion dollars, which is 2% of the annual GDP, from 2009 to 2013. (Presidential Committee on Green Growth) . Climate Change Counteraction, which is one of three mainstreams on green growth, includes efficient greenhouse gas management policy . ETS law includes operation of a registration system on Carbon Credit.
Project Risk	· Information Control, etc.	. Because the system proposes data interface between systems from the government and businesses, system security management is crucial.

Uniqueness		
Allowance Allocation Systemization	· National Carbon Reduction management . Easy access to allocation information	. Methodologies to allocate allowances are complex, because they include baseline and benchmark coefficients for allocation. . As systemized, it can provide easy access to allocation information.
Data I/F	. Increase in efficiency in the work	. Carbon emissions from LNG and electricity, which produce more than 50% in total national emissions, are reported and verified by hand. . If those data are registered on the government reporting system automatically via data I/F, working efficiency will be improved.
Carbon Reduction Item sharing and collaborated purchasing market for the item opening	. Item sharing can contribute to minimize carbon reduction costs. . Green market can be activated through collaborated market opening.	. If carbon reduction items are shared, synergy effects can occur and contribute to cost minimization. . Collaborated procurement on the market to introduce carbon reduction items can contribute to not only expansion of the green market but also cost minimization.
Carbon Credit Exchange	. Integrated information management for the exchange	. As the exchange is implemented in the system, users can check whole working processes from allocation to exchange. . The government can check carbon reduction performance through continual monitoring on the exchange amount.

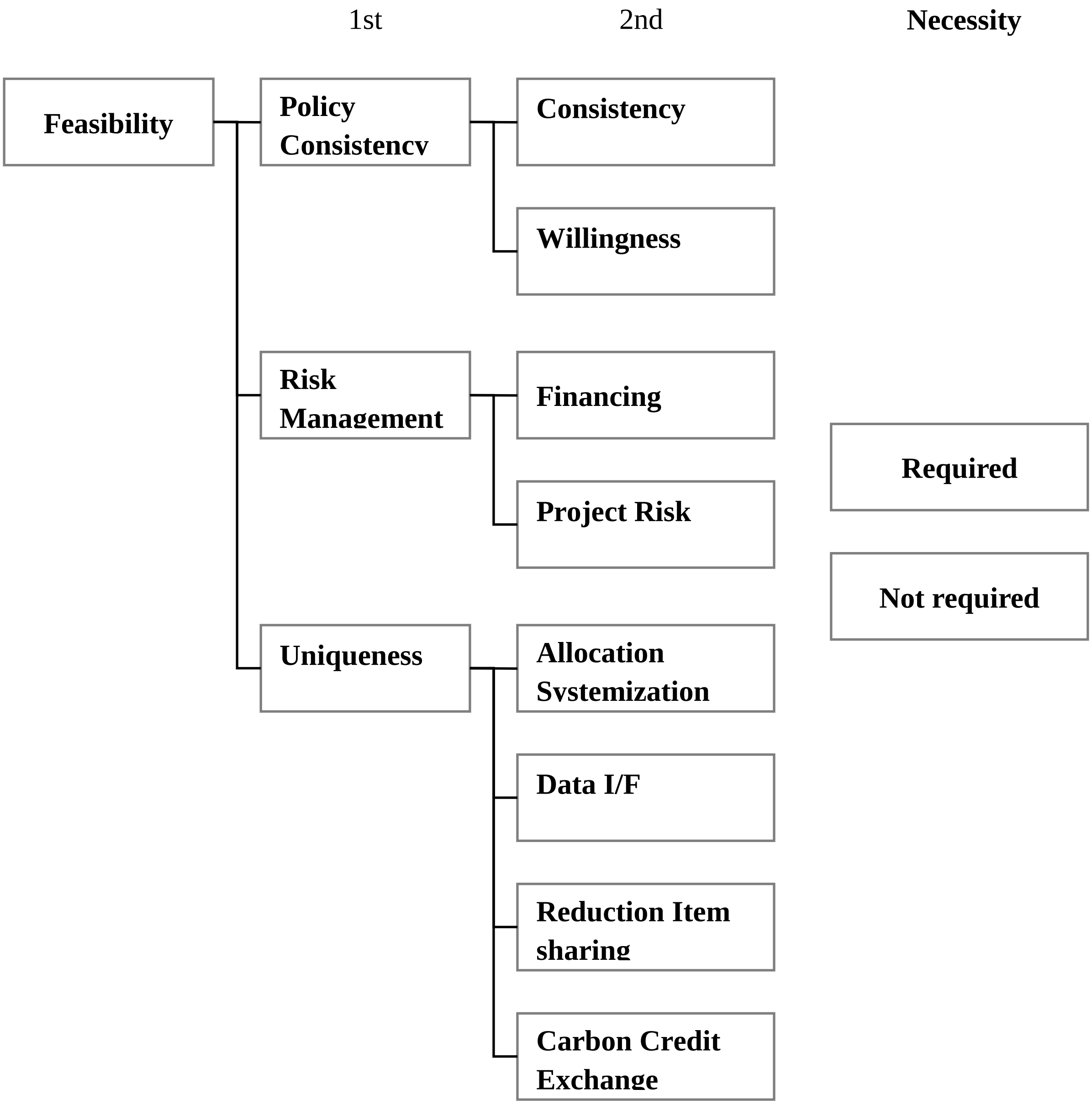
2. Survey questions

- As survey respondents are restricted to professionals in the green industry, and all answers will be tested to check reliability; please carefully respond to the questionnaire.
- Survey process:

Analyze weights on each criterion >> Check necessity of each criterion

2.1 Analyze weights on each criterion

<Hierarchy to Feasibility Test>



2.1.1 Analyze weights on 1st hierarchy criterion

Please write weight on each criterion (Sum of weights is 10)

Policy Consistency : Risk Management : Uniqueness = ____ : ____ : ____

2.1.2 Analyze weights on 2nd hierarchy criterion

2.1.2.1 Policy Consistency

Please write weight on each criterion (Sum of weights is 10)

Consistency : Willingness = ____ : ____

2.1.2.2 Policy Consistency
Please write weight on each criterion (Sum of weights is 10)
Financing : Project Risk = ____ : ____

2.1.2.3 Policy Consistency
Please write weight on each criterion (Sum of weights is 10)
Allocation : Data I/F : Item Sharing : Exchange = ____ : ____ : ____ : ____

2.2 Check Necessity on each criterion (Please check your answer on the chart)

Criteria (2nd Hierarchy)	**Required <<**			**>> Necessary but not now <<**			**>> Not required**		
Consistency	⑨	⑧	⑦	⑥	⑤	④	③	②	①
Willingness	⑨	⑧	⑦	⑥	⑤	④	③	②	①
Financing	⑨	⑧	⑦	⑥	⑤	④	③	②	①
Project Risk	⑨	⑧	⑦	⑥	⑤	④	③	②	①
Allocation Systemization	⑨	⑧	⑦	⑥	⑤	④	③	②	①
Data I/F	⑨	⑧	⑦	⑥	⑤	④	③	②	①
Reduction Item Sharing	⑨	⑧	⑦	⑥	⑤	④	③	②	①
Carbon Credit Exchange	⑨	⑧	⑦	⑥	⑤	④	③	②	①

3. Regression Analysis
- Measure utility change before and after implementation
- Each criteria max point is 25, and total max is 100. There is no maximum number of the company that you respond

Company	Change	Business					Government				
		Total	Allocation	Data I/F	Idea Sharing	Trading	Total	Allocation	Data I/F	Idea Sharing	Trading
(Example) A	Before	40	15	5	15	5	30	10	5	10	5
	After	75	20	10	20	25	85	25	15	20	25
	Before										
	After										

4. Personal Info collecting
To contact you when some inquiries to your responses on the survey occur and to analyze your answers, the researcher needs your personal information.
4.1 What is the name of your company and your grade?
(Name)__________________________ (Grade)__________________________

4.2 What is your specialty within the green business?

① Registered charters (CPA, Lawyer, etc.) ② PhD in the green industry

③ More than 5 years' work experience in the green industry

4.3 How old are you?_______ 4.4 What is your gender?_______

Thank you very much!

VIII. BIBLIOGRAPHY

VIII. BIBLIOGRAPHY

1. IPCC, Third Assessment Report (TAR), 2001.

2. Petit, J.R., *Climate and atmospheric history of the past 420,000 years from the Vostok ice core, Antarctica*, Nature, 1999.

3. Ramanathan, V., *Atmospheric Brown Clouds: Regional Assessment Report with Focus on Asia*, United Nation Environment Program (UNEP), Kenya, 2008.

4. Kim, Young Duk, and Jung, Ho Jin, "A Study on the EU Emissions Trading Scheme (EU-ETS) and Implication for Korea," *The International Association of Area Studies (IAAS),* 2007.

6. Shin, Chong-Sik, A Study on the Introduction of Greenhouse Gas Emissions Trading Scheme in Korea, Keimyung University, Korea, 2010.

7. Kim, Hyun and Lee, Gwang Hoon, "Empirical Analysis of the effect of EU ETS on the CO2 Emission," *Environmental and Resource Economics Review,* 2010.

8. EC, EC Survey among Member States, 2006.

9. IEA, Energy Technology Perspective 2008: Scenarios & Strategies to 2050, 2008.

10. Khanna, Tarun and Rivkin, Jan W., "Estimating the performance effects of business groups in Emerging Markets," *Strategic Management Journal Vol.22*: 45-74, 2001.

11. Jeon, Gi Jeong and Lee, Jeong Un, Researches on governmental innovation and policy execution, Korean Association for Policy Sciences (KAPS), Korea, 2004.

12. No, Hwa Jun, *Policy Principle,* Parkyoungsa, Korea, 1995.

13. Lee, Sang An, Researches on Policy Failure, Seoul National University, Korea, 1989.

14. Allison, Graham T., Essence of Decision: *Explaining the Cuban Missile Crisis*, Longman, New York, 1999.

15. Jeong, Yong Gwan and Jo, Suk Jin, Pre-Feasibility Study on System Implementation of Tax Management of National Tax Service (NTS), KDI, Korea, 2010.

16. Choi, Yong Han, *Budget Practice*, Chungnok press, Seoul, Korea, 2008.

17. Kim, Ki Yun and Kim, Yong Gyum, “Risk Management for Information System”, *The Journal of Risk Management*, Korea, 1995.

18. Choi, Seung Pil, Legal review on Carbon Emissions Trading Scheme, Hankuk Univeristy of Foreign Studies, Korea, 2008.

19. Kim, Jae Jin, Researches on ERP Configuration Management and Performance Improvement after ERP introduction, Kukmin University, Korea, 1999.

20. Goold, M. and Campbell, A., Desperately Seeking Synergy, *Harvard Business Review Sept.-Oct.*, 1998.

21. Williamson, O. E., Transaction Cost Economics and Organization Theory, Vol. 2: 207-256, Oxford University Press, 1993.

22. Kim, Il Hwan and Kim, Myeong Sik Kim, Researches on Administrative Information Management Legal Affair Improvement, Sungkyunkwan University, Korea, 2008.

23. Lee, Duck Gee and Park, Su Uk, “Energy Management System Evaluation through AHP”, *Environmental and Resource Economics Review* Vol. 12: 611-635 (2003), Korea.

24. Oh, Sang Young, “Calculation of Hotel R’s Investment Effects of ERP System Implementation”, *The Korea Contents Society* Vol. 12: 611-635 (2007), Korea.

25. Satty, T.L., *The Analytic Hierarchy Process*, McGraw-Hill, New York, USA, 1980.

26. Satty, T.L., *Fundamentals of decision making and priority theory with the AHP*, RWS Publications, Pittsburg, USA, 1994.

27. Kwon, Ki Joon, A Study on Relative importance and Priority of Physical Environment for the Successful Small Business Restaurants: Using AHP Method, Sejong University, Korea, 2010.

28. Cho, Geun Tae, Cho, Yong Gon, and Kang, Hyun Su, *Analytic Hierarchy Process Application to Leaders*, Donghyun Press, Seoul, Korea, 2003.

29. Jang, Tae Woo, "Pre-Feasibility Study on Postal Service System Implementation," *Entrue Journal of Information Technology*, Korea, 2008.

30. Kim, Jeong Un, Researches on Greenhouse Gas Trading Scheme Introduction to Businesses, Korea University, Korea, 2009.

31. Manne, Alan S. and Richels, Richard G., "CO2 Emissions Limits: An Economic Cost Analysis for the USA," *Energy Journal* Vol. 11 Issue 2: 51-74, 1990.

32. Greer, Mark R., "Aggressive Greenhouse Gas Policies: How They Could Spur Economic Growth," *Journal of Economic Issues* Vol. 29 No.4, 1995.

33. Jin, Hyung-Joung and Kim, Jeong-In, "Comparison of the Economic Effects of Carbon Taxation and Emissions Trading System in South Korea," *GRI Researches* Vol. 13 No.1: 29-47, Gyeonggi Research Institute, Korea, 2011.

34. Hanley, Nick and Moffat, Ian, "Efficiency and Distributional Aspects of Market Mechanism in the Control of Pollution: AN EMPIRICAL ANALYSIS," *Scottish Journal of Political Economy* Vol. 40 Issue I: 69-87, 1993.

35. Fisher, Brian S., Barnett, Scott, Bohm, Peter, Shah, Anwar, Kuroda, M., Stavins, Robert, Mubazi, J. K. E., *An Economic Assessment of Policy Instruments for Combatting Climate Change, Climate Change 1995: Economic and Social Dimensions of Climate Change,* Cambridge University Press, 1996.

36. Chang, H. J. and Cho, G. L., Auction vs. Grandfathering in Emissions Trading: A Test on Korean Economy, Energy and Environment: Striking the Right Balance in Korea, Korea Energy Economics Institute, 2001.

37. Johansson, Bengt, "Climate Policy Instruments and Industry—Effects and Potential Responses in the Swedish Context," *Energy Policy,* p2344-2360, Elsevier Ltd, 2006.

38. Montgomery, W. David., Markets in Licenses and Efficient Pollution Control Programs, *Journal of Economic Theory* Vol.5 Issue 3: 395-419, 1972.

39. Choen, Woo Dong, Research on Policy Efficiency on Emissions Trading System, *Social Science Researches*, p. 277-306, Donga University, Korea, 1999.

40. Choi, Seung Pil, Legal and Institutional Study on Greenhouse Gas Emissions Allowance & Trading -With a focus on the study of the European Emissions Allowance & Trading, Vol.31 No.2, Environmental Law Association, Korea, 2009.

41. Satty, T. L., *Fundamentals of decision making and priority theory with the AHP*, Vol. VI of the AHP Series, RWS Publications, 1996.

42. IEA, CO2 Emissions from Fuel Combustion, Paris, 2011

43. Keynes, J. M., *The General Theory of Employment, Interest, and Money, Great Minds Series*, Page 96, Prometheus Books, 1997.

Other Sources

1. Rodney Viereck, NOAA Space Environment Center, www.oar.noaa.gov/spotlite/archive/spot_sunclimate.html, 2011.

2. ICE, https://www.theice.com/publicdocs/futures/ICE_ECX_presentation.pdf.

3. Korean Governmental Press, National Greenhouse Gas Reduction Plan, Korea, 2011.

4. Ministry of Environment, GHG and Energy Target Management Regulation, Korea, 2011.

5. Ministry of Environment, 2012 Budget planning, Korea, 2011.

6. Presidential Committee on Green Growth, Green financing for green growth, 2010.