The Impact of Environmental Regulations on the South Korean Materials Industry: Effect Analysis of GHG Emissions-related Regulations

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1. Background & Objectives

The materials industry is largely divided into the sectors of metal, chemicals, textile, rubber and plastics, papermaking, and non-metallic mineral product manufacturing, providing basic materials essential for the production activities of the entire manufacturing industry and accounting for approximately 30 percent of total industry output. Industrial policy in South Korea, including the "Fourth Basic Plan for the Development of the Materials and Component Industries" (2016), has shifted the focus to the materials industry. However, as this industry is considered the business of large companies, it has often been neglected in major policy support and consideration. On the other hand, the industry has been subject to stringent environmental regulations and their application, which has raised concerns that the base for strengthening the industry's long-term growth potential will be weakened.

Meanwhile, to reach the targeted reduction of greenhouse gas

(GHG) emissions by 2020, as proposed at the United Nations Climate Change Conference of the Parties held in Paris in December 2015, swift moves have been taken to improve environmental and energy policies for industry. The South Korean government has been implementing a GHG emissions and energy target management system since 2012 and introduced a GHG Emission Trading Scheme (ETS) in 2015. As a result, the South Korean materials industry, which takes up the greatest share of the total emissions by the entire manufacturing industry, needs to promptly adjust itself to drastically changing internal and external conditions as well as face the new challenge to cut these emissions.

This study examined the applicable current regulation conditions regarding GHG emissions for the materials industry, analyzed the impact of implementation of emission permits subject to the ETS on the materials industry, and attempted to seek a desirable future direction for the system. We hope this study will provide an opportunity to identify effective and sensible procedures and ways to implement the ETS, which was introduced as an effective means of cutting GHG emissions. In addition, it was also anticipated that this study would be used as a basic foundation to predict and eliminate factors hampering expansion of the industry and effectiveness of South Korea's climate change and industrial policies, as well as to establish strategies to promote industrial innovation.

The scope of this study includes steel, petrochemicals, nonferrous metal, paper, and cement. Although the authors focused only on these five materials sectors due to the limitations associated with using basic data, these sectors constitute 15.5 percent of total manufacturing industry output and 58.4 percent of total GHG emissions. Therefore, it is deemed suitable to analyze structures and characteristics of energy consumption and GHG emissions. In terms of geography, the analysis focused on South Korea, but regarding ETS-related institutions and competitiveness by industry, analytic focus was limited to major economies including the EU and the US.

This study is largely divided into four parts: the first part discusses current conditions of ETS at home and abroad, and backgrounds and grounds for the institution of ETS in other countries, and seeks a suitable direction for the ETS in South Korea; the second part examines the routes of GHG emissions and reduction tools in the five basic materials sectors, and then reviews major issues pertinent to emissions permits and permit markets; the third part analyzes characteristics of corporate responses to institutional changes regarding energy and GHG emissions under the Energy Target Management System introduced in 2012, a measure currently being used to achieve GHG reduction goals; the fourth part makes policy recommendations that should be implemented in tandem with environmental regulations so that the materials industry remains competitive.

2. Current Domestic & Foreign Conditions of GHG Emissions-related Institutions

(1) Background of Introduction and Current Condition in Foreign Countries

The Emissions Trading Scheme (ETS) is a system in which

GHG emitters (companies, establishments, facilities) are allocated emission permits and allowed to discharge GHGs within specified emission permits; under this cap-and-trade system, emitters holding a deficit can purchase emission permits from other emitters while those with an excess of emission permits can sell. During this process, emitters in accordance with their reduction capacity can cut emissions or buy emission permits from others, thus complying with the emissions cap; they can also opt for reduction amounts and methods voluntarily.

In addition, under the ETS, which recognizes individual emitters' varying marginal costs of reduction, emission permits can be traded among emitters. As the system encourages emitters to cut GHG emissions voluntarily and flexibly without hampering economic efficiency, it is safe to say the ETS is the most cost-effective way of achieving reduction goals. The anticipated effects of the system are the output and substitution effects. The output effect decreases the amount of emissions as emitters reflect the expenses incurred from discharging greenhouse gases in the cost of products, which leads to a price increase and then lower demand. For its part, the substitution effect is a resulting benefit in which emitters are encouraged to use input materials or production technologies emitting less GHGs, thereby reducing emissions.

The Emissions Trading Scheme, a regulatory system aimed at greenhouse gases, was first instituted by the European Union in 2005, and since then the US, South Korea, China, Japan, and Canada have followed suit. Turkey, Russia, Mexico, Thailand, and the Ukraine are now planning to adopt the system nationwide, whereas China and Japan are now considering a nationwide implementation of the scheme.

The EU-ETS had 31 member countries as of 2016, and forms the world's largest permit market, trading 74 percent of total emission permits. In the first phase, which began with 25 member countries, the EU-ETS (2005-2007) ran test operations focusing on energy-intensive sectors and set the paid allocation below 5 percent. According to the phase-end total, however, the paid allocation was only 0.12 percent. Meanwhile, the EU, with over-supplied emission permits, banned the carryforward of remaining emission permits to the second phase, which caused the average price of permits to plunge from EUR 18.40 per ton in 2005 to EUR 18.20 per ton in 2006 and EUR 0.70 per ton in 2007. In the second phase spanning from 2008 to 2012, the EU set the emissions target to 8 percent below 1990 levels by the end of 2012 and the paid allocation at below 10 percent. However, in effect, only 3.07 percent of total permits were allocated for payment. During the corresponding period, the average price of emission credits also fell from EUR 25.80 per ton in 2008 to EUR 15.40 in 2010 and EUR 7.50 in 2012. Despite the first phase experience, the reason for the falling permit prices lay in the fact that the European debt crisis and unstable economic conditions led to a decrease in demand for the permits.

The EU applied different allocation methods to each member country until 2012 when an unfair competition issue arose. To resolve the issue and improve efficacy of the system, the EU changed its method to a single allocation rule beginning from the third phase spanning from 2013 to 2020. The single allocation rule which replaced the National Allocation Plans that had awarded emission permits to each sector or each place of business separately, represented a positive method of allocation in which carbon credits are granted to member states that reach the annual reduction goal of 1.74 percent by the end of the second phase from the average amount of carbon dioxide emitted.

California, the second largest GHG emitter in the US, established its First Climate Change Action Plan in 2008, which included a variety of strategic recommendations, direct regulatory instruments, market-friendly policies, and voluntary measures. The resulting introduction of the cap-and-trade system aims to reduce emissions to 1990 levels by 2020, and 80 percent below 1990 levels by 2050. California set the emission cap for 2015 at 394.5 million tons of carbon dioxide equivalent and awarded 450 firms annual emission permits of at least 25,000 tons, which accounted for 85 percent of total emissions. The price of the emission permits for the first quarter of 2015 reached USD 12.21 per ton.

(2) Current Conditions in South Korea

The South Korean government submitted its “Reduction Roadmap for 2030” to the Paris Agreement in December 2015 after going through a review of national GHG reduction scenarios and collecting a series of extensive opinions, including a public-private joint review process, public hearings, and discussion at the National Assembly, and adding to Scenario 3 a reduction goal of 11.3 percent, a reduction which would be achieved through the international trading market, thereby setting the reduction target of the Roadmap at 37 percent below business as usual (BaU) levels by 2030. The reduction target will be applied to an extensive range of industries, from energy, industrial processes, agriculture, and waste treatment. Whether the land use issue will be added will be decided later. The government included carbon dioxide, methane, nitrogen oxide, hydrogen fluoride, perfluorocarbons, and sulfur hexafluoride into the list of greenhouse gases to cut, and has revealed a plan to employ international carbon market mechanisms.

The GHG and Energy Target Management System is a direct regulatory method used by the government to manage and support GHG emitters in their efforts to achieve pre-determined energy use and emission goals. The South Korean government prepared the Framework Act on Low Carbon, Green Growth in 2010 and adopted the same act in 2012. Under the GHG and Energy Target Management System, companies are allowed to independently implement their own reduction plan at their places of business within the prescribed periods so as to achieve the set goal. Therefore, there will be no incentives for companies that emit less than the allocated cap, whereas a fine not exceeding KRW 10 million will be imposed on companies that emit more than the target goal.

After two years of preparation, South Korea adopted the ETS in January 2015. Twenty-three areas in the selected five industrial sectors (power generation and energy, commerce, buildings, transportation, and waste) were targeted. Firms that discharge over 125,000 tons of CO_2 on an annual basis, and places of business which emitted more than 25,000 tons of CO_2 between 2011 and 2013 were selected as target companies. This made for a total of 525 companies subject to the Target Management System at the beginning phase. Phase 1 of the trading system mainly focused on successful establishment of the system; beginning from Phase 2, the system aimed at effectively reducing GHG emissions. Although the South Korean ETS was a five-year plan, Phase 1 and 2 are prescribed by law to operate for three years in order to resolve issues arising during its infant stages. Regarding permit allocation, the share of free allocation was 100 percent for Phase 1 and 97 percent for Phase 2, a relatively higher percentage. The South Korean government awarded 100 percent free allocation to sectors sensitive to the effects of the implemented regulations. Both grandfathering and benchmark-based allocations were used for firms.

However, from the beginning, industrial circles raised a wide range of issues regarding institutional design and operation of the K-ETS, including over BaU projections, fairness of allocating emission permits by sector and by industry, and allocation methods. Specifically, some argued that as the estimation of BaU was made during the economic recession, the projection for industries was underestimated. Others insisted that nothing was wrong with the total amount of emission credits, but the fairness principle was not fully reflected in allocating the emission permits to each sector or each industry. Meanwhile, application of the grandfathering method led to underestimated allocation, further driven by unfavorable business conditions surrounding individual industrial sectors. Due to the application of adjustment coefficient ill-suited to sector characteristics and individual places of business, excessive burdens have been imposed on target companies. In addition, some also opined that target companies have become forced to shoulder a double burden due to the addition of indirect emissions into the K-ETS; measures to compensate for damage inflicted by the imposition of double burdens have not been put in place. Others have long argued that policy uncertainty remains high due to a lack of specific action plans pertinent to a variety of institutional measures designed for market stabilization, which include use of allowance reserves, setting the top to bottom pricing for buying and selling emission permits, and borrowing/holding/offsetting limit adjustments.

On the other hand, policy research institutes and academic circles have expressed critical opinions that due to institutional design and operation of allocation methods in favor of industrial sectors, it would be impossible to achieve the national reduction target. Such critical opinions came when based on the BaU estimation up to 2020 proposed by the Roadmap for 2014 and Allocation Plan for Phase 1, and when diverse climate change-related policies and the K-ETS were implemented as well as when the BaU projection up to 2030 was disclosed after the government submitted its Intended Nationally Determined Contribution (INDC) to the United Nations. As a result, voices in opposition have been raised that the basic direction of the objective and fair allocation, presented in the National Allocation Plan for Phase 1, and the principle of sharing fair reduction burdens between target and non-target companies or sectors were all broken.

3. Structure & Current Condition of GHG Emissions in the South Korean Materials Industry

This study analyzed five materials sectors in South Korea: steel, petrochemicals, nonferrous metal, paper, and cement. These sectors constitute around 55 percent of total energy consumption and

GHG emissions, especially in comparison to their share of total output. In addition, energy consumption and emissions by the materials industry are highly concentrated on a particular phase of production processes and the upstream process which manufactures intermediate goods out of basic materials.

In the steel industry, blast furnace steel-making is employed to produce intermediate goods used in high purity, functional steel products. The steel-making process requires a lot of coal, which means the industry makes up a higher share of total GHG emissions. As of 2014, the steel industry used 29.86 million tons of oil equivalent (TOE) of energy and emitted 113 million tons of GHGs, accounting for 22.3 percent and 31.5 percent of the industry's totals, respectively. The reason the share of emissions is higher in comparison with energy consumption lies in the fact that much of the coal (bituminous coal) used during the production process has a higher CO_2 emission coefficient. Energy consumption generally occurs in the upstream areas including iron and steel-making as well as manufacturing of hot rolled products, and it is in this phase that most GHGs (98.2%) are emitted.

The steel industry's energy consumption and GHG emission units were on a steady decrease in the 2000s, but returned to an upward trend in 2010 when new facilities went into operation. Since 2012, GHG emission units of the steel industry have risen again, which is attributable to the decrease in crude steel production using electricity (which results in a lower emission coefficient); on the other hand, blast furnace steel production using coal (which results in a higher emission coefficient) increased again. As a result, carbon intensity in the industry rose slightly to 3.79 in 2014 from

3.77 in the 2000s.

GHG emissions by the nonferrous metal industry continued to fall between 2011 and 2014. Unlike the period 2011-2013 when emissions grew by 3 to 4 percent, the growth rate in 2014 dropped sharply to 0.4 percent. For the total amount of output and added-value produced by the industry in 2014, the shares held by paper-making amounted to 51 percent and 44 percent, respectively (as of 2012). However, the shares held by the smelting sector of total energy consumption and emissions were 70 percent and 72 percent, respectively. These figures show that the smelting sector is an area with a higher share of energy consumption and GHG emissions in comparison to its share of production. As of 2012, the amount of GHG emissions by subdivided process was greater in the order of zinc and lead (59%), copper (17%), aluminum (12%), and nickel (12%); the amount of energy consumption also showed a similar ranking order. During the production process of zinc and lead, GHGs are released in the first smelting phase (100%). On the other hand, in copper production, more GHGs are released in the rolling or compression phases, as well as in the finished goods production phase (73%) than the first smelting phase (37%). As for aluminum, more GHGs are emitted into the atmosphere in the manufacturing phase of intermediate goods (22%) and rolled products (72%).

Energy consumption and GHG emission units in the nonferrous metal industry remained low in the 2000s but have risen slightly since 2010. This is due to output growth in zinc, which makes up some 50 percent of total energy consumption and GHG emissions. In addition, units of zinc production have also been on an upward trend, which is attributable to an additional use of energy during the process of extracting precious metals (such as gold and silver) and rare metals, by using residues resulting from zinc production. Carbon intensity in the nonferrous metal industry has been on a steady decrease. Again since 2010, the fact that outputs have continued to increase, whereas carbon intensity has continued falling, indicates that a growing number of new eco-friendly facilities have replaced outdated carbon-emitting facilities.

Total outputs from the petrochemical industry in 2014 were recorded at KRW 6.2 trillion, with KRW 10.4 trillion in added value; energy consumption was at 3.2 million TOE and GHG emissions at 5.993 tons of CO_2. As the upstream process including the naphtha cracking center (NCC) generates products using the reaction of high temperature and high pressure, the petrochemical industry uses relatively more energy and emits more GHGs into the atmosphere. In addition, the industry's upstream process has a higher share of direct emissions due to a higher proportion of fixed, mobile, and fugitive emissions, and direct emission sources, whereas in the downstream process, the share of indirect emissions is higher because of a higher proportion of power and steam consumption, resulting from the employment of lower-temperature and lower-pressure energy.

The share of basic oil and intermediate raw materials accounted for more than 86 percent of production, whereas their GHG emission share was over 89 percent. This means the production process for these petrochemical goods is a major source of total GHG emissions generated by the entire petrochemical industry. In addition, as the petrochemical industry has continued to make facility investments to secure economy of scale, energy consumption during the process of producing basic oil and intermediate raw materials has increasingly risen on a year-on-year basis. On the other hand, the production share of three major derivatives, main products of the industry, stood at 15 percent and their share of GHG emissions at 11 percent, representing a relatively small scope of production and share of emissions. Energy consumption and GHG emission units for the industry were on the upward trend between 2010 and 2014. This can be interpreted that although the industry has made constant effort to improve energy efficiency at its production facilities in preparation for high oil prices, strong investment has been made into the upstream process where larger GHG emissions are released into the air.

Energy consumption and GHG emissions for the cement industry stood at 4.64 million TOE and 18.03 million tons of CO_2, representing 3.6 percent and 5 percent, respectively, of the entire manufacturing industry's totals. The cement sector's higher share of emissions in comparison with its share of energy consumption within the manufacturing industry is due to the decarboxylation process included in the basic cement manufacturing process. The key process in cement production is when lumps of clinker are generated in a furnace, which is where at least 90 percent of energy consumption and GHG emissions occur.

Energy consumption and GHG emission units for the cement industry have been on a steady decrease since 2011. Considering that there was little change in clinker production during this period, it can be judged that efforts made to improve energy efficiency and reduce GHGs have paid off to some extent. However, when conversion is made based on the amount of clinker produced, energy consumption and GHG emission units did not show striking improvement. This means that while the effects of energy efficiency and GHG reduction have been realized, this has occurred primarily in processes other than clinker production. Simultaneously, this also suggests that in order to maximize the effect of cutting GHG emissions, technology is urgently needed to reduce GHG emissions during the main process of producing clinker.

GHG emissions from the paper-making industry reached their peak of 7.66 million tons in 2011 and have since returned to a downward path. As of 2014, the industry's GHG emissions were recorded at 7.04 million tons. Energy consumption and GHG emission units from the industry were negligible and on a downward trend, which is attributable to changes in the consumption structure of releasing less GHG into the air; for instance, less B-C oil, which emits greater amounts of GHG, was consumed, whereas the use of LNG, an energy with lower GHG emissions, increased.

Examining emission structures by production process, during the pulp production process, a small amount of CO_2 is generated in a calcination furnace where chemicals used for pulp making are retrieved; in doing so, indirect emissions resulting from the use of power and direct emissions from boiler combustion take place. In the paper- or cardboard-making process, emissions do not occur during the product manufacturing phase; instead, most emissions take place during energy combustion (direct emission) to produce steam and during equipment operations, when power is consumed (indirect emissions). Sources of fuel used for steam production include fossil fuel or waste (solid refuse fuel).

□ Challenges to application to individual materials industries

As for the steel industry, when a benchmark is applied, the limited number of companies or types of processes would make it difficult to extract and apply a benchmark-based allocation method. Applying a benchmark to its steel industry enabled the EU to derive a benchmark coefficient by comparing emission factors for specific processes, which was possible because there are many steel companies within the region. In South Korea, however, there are only two firms releasing a great amount of GHGs even in the blast furnace process. Therefore, estimating a benchmark coefficient would likely be difficult. As for the electric furnace, as equipment and products vary by company, products are further segmented in processing phases, and movable equipment is diverse, it would be difficult to extract a benchmark after investigating many specimens from products and processes. Considering such difficulties, standards for appropriate levels of products and equipment should first be established.

In the event a benchmark is applied to the nonferrous metal industry, it seems appropriate to take the alternative approach recommended by the EU-ETS guidelines. This is because for the copper, zinc, and lead manufacturing processes employed in South Korea, even flagship products are produced in monopolistic or oligopolistic structures. For instance, regarding lead smelting products, South Korea Zinc is the only lead smelter in South Korea and copper smelting products are manufactured only by LS Nikko Copper and South Korea Zinc. However, as there is a huge gap in output between the two smelters, it is hard to apply a benchmark.

Zinc is produced by two manufacturers only – South Korea Zinc and Youngpoong – and the difference in output is relatively small. However, considering South Korea Zinc is a subsidiary of Youngpoong and the characteristics of the manufacturing process employed by South Korea Zinc as a producer of both zinc and lead, it would be impossible to derive an independent and representative benchmark value for zinc smelting. Taking into account the structural characteristics of the South Korean aluminum industry in absence of the smelting sector, it also seems difficult to develop a reliable benchmark coefficient for the industry.

In the cement industry where the benchmark-based allocation method is already in use, the issue of reverse discrimination between different companies and sectors has been raised in the application of adjustment factors, which coordinate the disparity between authorized emission quantities and emission permits, and are currently applied by industry. Additional authorized emissions are awarded to new facilities, which leads to a lowering of the adjustment factors for sectors which have a lot of new facilities. As a result, sectors with relatively fewer new installations tend to be allocated fewer emission permits than their counterparts.

When the same benchmark-based allocation method is applied to other industries, companies with fewer new facilities will be allocated fewer emission credits than their counterparts, like the cement industry. For this reason, chances are high that this allocation method will probably be a constant source of problems in connection with the issue of choosing between allocation by company and allocation by industry in designing an emissions trading system down the road. Meanwhile, issues to be taken into account so as for the cement industry to achieve the goals of the Post-2020 Roadmap by Industry include: revision of South Korean standards to increase the use of cement admixture; unification of diverse estimation methods for emissions generated from the use of alternative fuels with a BaU-based method; government-led support for technology development and introduction of advanced technologies to a cement industry facing a worsening profit structure.

In introducing benchmark-based allocation to the South Korean paper-making industry, issues to resolve have to do with GHG emissions and reduction methods. This is because the industry has already introduced many highly-efficient facilities which have improved production, as well as shifting to a less GHG-emitting energy consumption structure. In addition, the number of business places subject to application of a benchmark method exceeds 1,000 firms in the EU, whereas the number is around 50 in South Korea. As the number of establishments by product is too small, an issue can occur over the effectiveness of such an application. There is another issue to be noted: while companies using waste energy (waste incineration heat) contribute to cutting fossil fuel consumption under a government-led promotion campaign for resource recycling, they are still a larger source of GHG emissions, and therefore would tend to face negative consequences from BaU allocation.

In order to cut its own GHG emissions, the paper industry is planning to introduce boilers using liquefied natural gas (LNG) and biomass instead of expanding the use of high-efficiency equipment. In particular, considering the installation year of equipment held by companies and global technological advancements, the introduction of state-of-the-art energy-efficient equipment is expected to begin in 2025 and be in full swing by 2030 to 2040. Therefore, a majority of GHG reduction technologies reviewed by the paper industry need time to prove their effectiveness and that they will not lower product quality before they can be applied industry-wide.

4. Analysis of the Impact of GHG Emission-related Regulations on the South Korean Materials Industry

Analyzing the effects of ETS-related policies requires the lapse of sufficient time after policy implementation as well as availability of basic data to sense any changes at the corporate or industrial level. However, as the Emissions Trading System in South Korea remains in the infant stage of implementation, no basic data has yet been accumulated to assess policy impact. Against this backdrop, this study attempted to conduct a quantitative analysis of the impacts of policies related to GHG and Energy Target Management, a GHG reduction policy implemented in 2012 as a direct regulatory means. The study conducted by Sonnenschein and Mundaca (2016) points out that despite the South Korean government's strong commitment to introducing environmental regulations, including both the GHG and Energy Target Management System and Emissions Trading System, quantitative assessment on the impacts of such policies has not been made. Although limited to only a few major materials sectors in South Korea, it is meaningful in that the analysis conducted by this study is the first to assess the achievements of the GHG and Energy Target Management System using actual data on GHG emissions. In addition, identification of the results of the target management system is expected to provide meaningful implications for institutional improvements to Phase 2 of the Emissions Trading System (spanning from 2018 to 2020).

This study employed "Energy Consumption and GHG Emissions in Industrial Sectors (Mining & Manufacturing)," a statistics database built by the South Korea Energy Agency (KEA) as a main resource to examine the effects of the target management system. The KEA database was constructed with data collected on the amount of energy used and GHG emission structures. In this study, 2010 to 2014 was analyzed so as to utilize continuous time series data. Corporate information data used for this analysis was extracted from the company data database of NICE evaluation information. Information on the companies directly subject to the GHG emission target management system was obtained from the GHG Information Center. In fact, the criteria used in selecting target companies have changed every year since 2012. However, as this study needed to understand the development of changes in the same company over the entire period, the companies designated as target companies in 2012 were defined as target companies for the analysis period.

The first step in the analysis was to combine data on energy consumption and GHG emissions, collected from the KEA database, and collect the company information variables, which include sales, operating profit, and company size (small, medium, and large), etc., from NICE evaluation information. Information on GHG management target companies, which is included in the emission statement statistics created by the GHG Information Center, was added to the first combined data. Using this additional data, target companies and non-target companies were sorted out. Consolidating all the data for analysis was conducted by company or by place of business. However, the final data used for quantitative analysis was that compiled in accordance with subdivided sectors and company size due to a variety of constraints, such as security restrictions on corporate information.

Policy effectiveness of the target management system was examined by applying the dual difference method, a representative methodology for policy evaluation analysis. The analysis period was 2010 to 2014; based on information compiled in 2012 when the target management system was introduced, target companies and non-target companies were selected; then from 2010 to 2014, company emission trends and business activities were examined in target and non-target groups. Results of the basic analysis were reexamined by using a double difference method in addition to group-specific fixed effects, yearly fixed effects, and additional explanatory variables.

The results of quantitative analysis of the impacts of GHG emissions and energy target management system on the materials industry showed: for the group of large companies, target management companies released more GHGs into the air after implementation of the system than their non-target counterparts; meanwhile, after implementation, the difference in sales between target companies and non-target companies showed a slight decrease. It can be assumed that the reason the target management system did not have a significant impact on emissions reduction lies in an excessively large gap present in the amount of emissions within the subject groups before implementation of the system. According to the basic analysis of small and medium-sized enterprises (SMEs) showing a negligible difference in emissions between target and non-target companies, the gap in fact between the two groups shrank after implementation of the policy.

In order to examine more precisely the possible effects of the policy through basic analysis, this study conducted an analysis of the panel fixed effect. As a result, even after controlling changes in management activities such as fixed effects of group characteristics, fixed effects by year, and sales, the effect of GHG mitigation on SMEs was statistically significant. In other words, the use of SME data, an appropriate data for analysis of the application of the double difference method, showed that the target management system had a positive effect on GHG reduction in target companies.

Quantitative impact analysis of the GHG and Energy Target Management System on the materials industry reveals the following implications: the target management system, which cannot be considered a coercive regulatory means, was found to have a positive impact on the materials industry, an industry which does not have much room to cut GHG emissions. This makes it possible to expect that the South Korean ETS will have a positive impact on GHG reduction. However, the estimated impact of the environmental regulation on reductions was about 3 percent below the current amount of emissions. Although the direction for the policy effect was assessed as positive, the degree of effect can be viewed as insignificant. Therefore, regarding industrial groups without sufficient room to cut emissions, aggressive means of reduction should go hand in hand. As expected, it was found that the amount of GHG emissions was directly proportional to company sales. In this sense, policy makers should note the possibility that GHG reduction measures will hinder competitiveness of the materials industry, and thus should approach the task of finding appropriate levels of environmental regulations with great caution.

5. Policy Directions for Effective Implementation of the South Korean Emissions Trading System

□ Logic & consistency in calculation criteria for emissions allocation

Above all, logic in the basis for calculating total emission permits to each industry is essential. Currently, the production activities of a particular sector as a share of the entire industry has been used as a factor in determining the total amount of industrial emission permits, with the share of added value generated and production activity data used as supplementary materials. However, the amount of value added is used instead of sales figures to represent a measurement of production activities. This suggests a possibility that the value added amount fails to reflect real production activities in a certain sector.

Under the South Korean Emissions Trading System, a total national allowance is first determined and then emission permits allocated to individual sectors. For this reason, the original advantage of the ETS has been weakened, which therefore requires reconsideration. Allocation by sector and by business type has been adopted to resolve difficulties pertinent to the unpredictability of total emissions in accordance with allocation methods as well as the absence of categorization of business types at the beginning phase of the ETS. This has resulted in the downside of having regulators maintain a command-and-control regulation system. Therefore, instead of holding fast to the sectoral allocation method, current standards should shift from place-of-business to facility; in addition, allocation based on a benchmark should be refined through micro-analysis of products and processes. By perfecting such a system, market players should be allowed to directly respond to its advantages and disadvantages by sector or by type of business.

When determining a total allowance for the South Korean ETS, sectoral target emissions, or reduction targets, are necessary when considering the use of a full or partial carbon intensity limit. This approach is expected to lower the uncertainty associated with setting of emission permits. At the same time, it would be conducive to achieving the goals of detailed policy tasks including ensuring fairness and providing incentives for the shift to low carbon industry.

Fairness and consistency should be ensured when selecting target companies in individual sectors. Currently, the ETS is applied to all oil refining facilities, some cement manufacturing facilities, and all aviation facilities. Application of a benchmark coefficient, of which the scope of application is expected to expand, will possibly cause some unfairness due to the difference in the criteria for target facilities to receive emission permits. For instance, a place of business that produces a variety of products will face business categorization issues. In addition, as a place of business was categorized according to initial application by the company, there is a disparity between the South Korean industrial classification table and initial classification. Therefore, consistency may suffer when making sectoral allocations or applying emission or adjustment coefficients. In this sense, it is desirable to consider designating places of business with higher GHG emissions as intensive-management target companies.

On the other hand, it is necessary to ensure consistency despite duplicate calculation of indirect emissions. Currently, the amount of emissions generated from the power generation stage is separately dealt with and reflected in the calculation of total emissions under the ETS. As a result, when the emission coefficient for the power generation sector becomes lower, the amount of emissions will increase without additional reductions in the industrial sector. In addition, power loss during delivery has been found to be around 35 percent. However, no allocation principle has yet been established. Issues with duplicate calculation are expected to be resolved when power generators and consumers shoulder their share of the efforts to reduce GHGs.

□ Industrial considerations in introduction of benchmark-based allocation

This study also suggests the following considerations when introducing benchmark-based allocation: first, basic principles and objectives need to be established before such an introduction. There are generally two expected changes to allocation methods during the upcoming Phase 2 of the K-ETS: introduction of paid allocation and introduction of benchmark-based allocation. Currently, South Korea is applying benchmark-based allocation to businesses in only three industries: cement, refining, and aviation. Application of the method is under consideration for the steel industry, and to integrated steel mills and electric furnaces in particular. However, as such an application may be disadvantageous for some businesses, a thorough review is necessary before introduction. In addition, careful review is also necessary regarding development of the benchmark, to avoid the main issue of cutting uncontrolled process emissions.

In creation of benchmark coefficients used to determine the amount of free allocation, the most important consideration is the way related data is collected. This study suggests that outputs of major products manufactured by benchmark-applied facilities should be used as activity data required for the development of benchmark coefficients. If unavailable, outputs of intermediate products and the amount of raw materials or fuel consumed by, and other materials directly-related to the said facilities can also be used. In addition, activity data on these facilities needs to be collected and assessed according to common and consistent standards to ensure data reliability.

Second, when free and paid allocation methods are in operation, international competitiveness should be taken into account. According to the investigation conducted by this study, dependence on imports and exports, exchange rates, and international competitiveness vary by sector within the materials industry. Consequently, business outlook and countermeasures for such factors are also different. As some examples, for the steel industry, the greatest threat is Chinese steel makers; the nonferrous metal industry is vulnerable to commodity prices and foreign exchange fluctuations; the petrochemical industry is heavily dependent on exports. Therefore, it is necessary to clarify a measurement method gauging carbon leakage, into which sectoral characteristics of the materials industry are commonly reflected. Through this clarification process consistency of the measurement applicable to the materials industry should be ensured, as well as for measurements applicable to all other industries.

Third, in-depth research should be carried out on the impact allocation methods have on sectors or businesses. Laws stipulate that the K-ETS shall be designed and operated so as to produce objective, neutral results in terms of market competition structures and product characteristics by business, as well as the characteristics of the variety of institutions related to the ETS. However, the results of operations in 2015 reveal the potential for such results not being neutral.

Therefore, comprehensive efforts are needed to investigate and understand pressing ETS-issues associated with allocations. Therefore, the ETS should be operated in a way that sufficient time and effort is guaranteed. To that end, the results of operation of benchmark-based allocation, which has so far been applied on a limited basis, need to be reviewed, the method's shortcomings identified, and then issues figured out before such allocation is used for other industrial sectors. Second, after the choice is made as to whether grandfathering or benchmark-based allocation is appropriate, additional issues regarding offsets, operation of allowance reserves, newly registered companies, carbon leakage levels, and price support need to be clarified as countermeasures against the negative impacts that may accompany the allocation method being used on various sectors and industries.

□ Establishment of foundations for implementation of the ETS

First, it is of importance to ensure procedural transparency and openness suitable to basic policies related to environment and energy in order to establish the foundations for implementing the Emissions Trading System. In 2014, GHG emissions surged in most of the materials industry. There might have been several reasons behind the surge, but one seems to be a possibility of excessive GHG emissions by companies attempting to obtain more emission allocations just before introduction of the ETS in 2015. Accordingly, the way the ETS is operated will potentially impact corporate business strategies, which will subsequently incur greater corporate expenses. From the perspective of business, it is also desirable to have long-term, predictable and consistent policies in place.

Successful establishment and operation of the ETS require its integration with the government's existing fundamental policies related to environment and energy, making it is essential to present a transparent, well-aligned roadmap for the ETS, which is devised within the national basic policy framework for environment and energy. Therefore, the Ministry of Commerce, Industry and Energy, the Ministry of Strategy and Finance, and the Ministry of Environment should independently establish and propose policies on climate change and reduction of GHGs and do what they can; the Office for Government Policy Coordination should present a policy structure associated and integrated with a variety of environment and energy policies, which will be helpful to lead the entire industry to fully understand the ETS. The government should then continuously provide a broader picture for possible changes, thereby minimizing uncertainty regarding its stance on climate change.

Today, there is a dire need for impact analysis of changes in the ETS. Such analysis regarding climate change, particularly on the introduction and implementation of the ETS, and on institutional changes and their consequences has been in absolute scarcity. In this sense, South Korea urgently needs to prepare for planned or expected policy changes and possible scenarios in Phase 2 and 3 of the K-ETS through a comprehensive analysis of economic, social, and environmental impacts encompassing energy, transportation, land use, industry, health, and ecosystems. In addition, when a general and comprehensive impact analysis is carried out, clear guidelines for the collection and management of data needed for such an analysis can be presented; an extensive study on diverse analytic methodologies will be conducted and empirical models required for their development constructed. This will improve the data independently collected by the Bank of South Korea, the National Statistical Office, the South Korea Energy Corporation, and the South Korea Environment Corporation, and help make collection and management of data mutually complementary. In addition, such data is expected to encourage research activity at the Institute of Industrial Science and Technology, the South Korea Development Institute, the Environmental Policy and Assessment Institute, the Energy Economy Research Institute, the Legal Research Institute, and the Ecological Environmental Science Institute, thereby contributing to establishment and implementation of policies regarding climate change and GHG ETS.

On the other hand, the results of quantitative analysis in this study where the effects of the ETS were indirectly examined, suggest the need to differentiate targets for the GHG reduction policy. In the analysis using SME data, it was found that the difference in turnover between the environmentally regulated group and its comparison group was narrowed. This indicates that weakening of corporate competitiveness due to environmental regulations is more likely to occur in small and mid-sized companies than larger ones. Considering the share of emissions from SMEs is smaller than that from larger companies, a major focus of GHG reduction policy needs to be placed on those larger companies. In addition, although this study empirically confirmed impacts of the target management system on GHG reduction and sales decreased, the impacts were negligible and, if larger companies are included, estimated results would be unclear. Leading companies in the materials industry, which have little technical room to cut emissions, are very likely to have already been burdened by higher marginal abasement costs. Therefore, the K-ETS needs to be improved in a way that larger companies will be encouraged to voluntarily cut emissions.