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# Evaluation and Implications of Greenhouse Gas and Energy Targert Management System in Korea

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**Abstract**
The Korean government has been implementing the Greenhouse Gas and Energy Target Management System towards big emitters and energy glutton entities, based on the Framework Act on Low Carbon, Green Growth since 2010. The Target Management System is a tool for smoother transition to the Emissions Trading Scheme which is set to start in 2015, and offers the opportunity for covered entities to reduce greenhouse gases. The GHG emission and energy consumption levels of controlled entities was reported to the government for the first time in late March of 2013, for the first year that the policy was implemented in 2012. This study focuses on the controlled entities of the power and industry sector, which account for 97% of all covered entities, by analyzing their submitted GHG emissions and energy consumption records and evaluating implementation performance as well as suggesting institutional improvements and complementary measures. Based on analysis of performance results, GHG emissions were effectively reduced by an excess of 7.6%, and energy consumption by an excess of 4.3%, showing the effectiveness of the Target Management System in reducing GHG emissions and energy consumption. Among sub-sectors, the machinery industry is shown to have the highest target accomplishment rate, whereas the elecrticity sub-sector could not meet reduction goals as a result of frequent shutdown of nuclear power plants in 2012. Analysis of performance result according to the big company group and the small and medium company group shows that the big company group shows an average reduction ratio of GHG and energy usage, respectively, of 0.1168 and 0.0344. These numbers were satisfactory compared to the reduction ratios of small and medium companies of -0.0910 and -0.1627, showing that in order to successfully implement the Target Management System, the government must offer its financial and technical support to the small and medium companies.
**Keywords:** Greenhoese Gas, Energy, Target Management System, Achievement Ratio, GEAR index

## 1. Introduction

The Korean government has implemented the Energy Target Management System since 2010, based on the Framework Act on Low Carbon, Green Growth to realize the National Greenhouse Gas Reduction Mid-term Goals (reducing national overall emissions to 30% below business-as-usual levels by 2020). The Energy Target Management System regulates big emitters and energy gluttons by designating them as controlled entities, by which they undergo third-party verification of their performance results compared to greenhouse gas emission/ fossil fuel usage targets. Enterprises whose three-year average of both greenhouse gases and energy consumption exceeds standards are designated as controlled entities, and the number of controlled entity will be expanded in the coming years.

Table 1 Criteria for inclusion of controlled entity based on $CO_2$ emissions and energy consumptions.

| | Until Dec. 31st, 2011 | | From January 1st, 2012.1.1 | | From January 1st, 2014 | |
|---|---|---|---|---|---|---|
| | Company - Based | Facility - Based | Company - Based | Facility - Based | Company - Based | Facility - Based |
| $CO_2$ Emissions ($tCO_2e$) | 125,000 | 25,000 | 87,500 | 20,000 | 50,000 | 15,000 |
| Fuel consumptions (Tera Joules) | 500 | 100 | 350 | 90 | 200 | 80 |

The overall program is managed by the Ministry of Environment, and the Ministry of Trade, Industry and Energy, the Ministry of Land, Infrastructure and Transport, the Ministry of Agriculture, Food and Rural Affairs which are the relevant departments, manage individual controlled entities. By 2012 standards, 76% of total GHG emissions are covered by the Energy Target Management System; thus, this system is a very central part of the Korean

government's GHG reduction policy. Table 2 shows the number of enterprises regulated by relevant departments, and the expected versus permitted GHG emissions. Also, Table 3 shows more specifically the predicted emissions, permitted emissions, and reduction coefficient in each industrial classification.

Table 2 Predicted emissions and permitted emissions by controlled entities in 2012.

| Sector | Controlled Entities | Base year average emissions('07~'09) | Expected emissions | Permitted emissions | Reduction(Ave. reduction rate) |
|---|---|---|---|---|---|
| Food & Agri. | 26 | 2,351 | 2,770 | 2,746 | 24(0.88%) |
| Power & Ind. | 366 | 466,006 | 585,158 | 576,833 | 8,325(1.42%) |
| Waste | 21 | 9,390 | 10,109 | 9,855 | 254(2.51%) |
| Building & Transportation | 45 | 7,290 | 8,306 | 8,182 | 124(1.49%) |
| Total | 458 | 485,037 | 606,343 | 597,616 | 8,727(1.44%) |

Unit : Number of Companies, 1,000t$CO_2$e

Table 3 Predicted, permitted emissions, and reduction coefficient of the power and industry sector in 2012.

| Industrial Classification | Number of company | Expected emissions in 2012 | Permitted emissions in 2012 | Reduction coefficient |
|---|---|---|---|---|
| Electricity Industry | 33 | 242,924 | 239,279 | 0.985 |
| Steel Industry | 38 | 119,669 | 118,350 | 0.989 |
| Cement Industry | 24 | 50,369 | 49,864 | 0.99 |
| Petrochemical Industry | 76 | 59,708 | 58,938 | 0.9872 |
| Oil Refining Industry | 4 | 34,803 | 34,354 | 0.9871 |
| Semiconductor, Display | 34 | 37,358 | 36,268 | 0.9812 |
| Paper Industry | 55 | 9,749 | 9,605 | 0.986 |
| Nonferrous Industry | 17 | 6,181 | 6,100 | 0.987 |
| Automobile Industry | 19 | 4,462 | 4,415 | 0.9898 |
| Ceramic Industry | 20 | 5,257 | 5,193 | 0.986 |
| Textile Industry | 13 | 5,534 | 5,465 | 0.9883 |
| Shipbuilding Industry | 8 | 3,349 | 3,307 | 0.9882 |
| Communication Industry | 5 | 3,586 | 3,516 | 0.9803 |
| Machinery Industry | 18 | 1,969 | 1,942 | 0.9801 |
| Mining Industry | 2 | 240 | 238 | 0.9952 |
| Total | 366 | 585,158 | 576,834 | |

The goal of this study is to analyze the GHG emissions and energy consumption performance of the controlled entities of the power and industry sector in 2012, which was the first year that the Target Management System was implemented. This study will analyze the outcomes of implementation, and suggest points of improvement in the policy.

## 2. Method

There are 366 controlled entities in the power and industry sector, which accounts for approximately 80% of the total controlled entities. In terms of emissions, the subjects in the power and industry sector account for approximately 97% of total emissions. The analyzed data in this study is derived from 355 certified statements and performance result reports of 15 types of business in the power and industry sector. To evaluate target achievement, the Greenhouse Gas and Energy Achievement Ratio (GEAR) index was utilized. The GEAR ratio is defined as the ratio of GHG emissions or energy consumption levels to permitted energy consumption levels of controlled entities. Moreover, to easily gauge whether goals were met, the GEAR ratio was ultimately defined

as (1-ratio) (Equation 1). That is, in the case that the target was met, the GEAR value is positive (+); if it was not and additional reduction is necessary, then the value is negative (-)

$$GEAR(GHG)=1-\frac{\sum_{i}^{n}(\text{Direct Emissions}+\text{Indirect Emissions})(tCO2e)}{\text{Permitted Emission}(tCO2e)} \text{ or } GEAR(Energy)=1-\frac{\text{Energy Usage}(TJ)}{\text{Permitted Energy Consumption}(TJ)} \quad (1)$$

where *n* refers to the type of business, which is the 15 industrial classifications(sub-sectors) within the power and energy sector.

## 3. Results

This study is based on analyzed data from 335 certified statements and performance result reports of controlled entities in the power and industry sector. Target achievement evaluation consists of three methods: 1) the achievement rate of all 335 controlled entities, 2) the achievement rate of all 15 individual industrial classifications, and 3) the achievement rate of both the big company group and the small and medium company group.

### *3.1 Evaluation of all controlled entities of the power and industry sector*

As stated previously, the power and industry sector accounts for 97% of the total GHG emissions of all controlled entities; thus, this sector is an important and crucial part of the Target Management System. According to analysis, the total permitted emissions of 335 controlled entities was 564,032,343 t $CO_2e$. The real GHG emissions was 524,338,681 t $CO_2e$, amounting to 92.96% of the target amount and therefore reaching a surplus achievement of 7.3%. Allotted energy consumption amount was 7,180,854TJ, whereas the actual amount was 6,873,517 TJ, equaling a surplus achievement of 4.28%. The average GHG reduction rate of each enterprise was 0.0858, and the energy reduction rate was 0.0042. In the case of GHG, the emitted amount as compared to target amounts (GEAR) ranged from 0.69 to -11.17. This was a larger deviation than that of energy consumption amounts as compared to target amounts, which ranged from 0.91 to -10.96. Table 4 and Figure 1 show the GEAR values of both GHG and energy consumption of 335 companies (Fig. 1).

Table 4 Statistical characteristics of the GHG and energy achievement ratio.

| | GHG | ENERGY |
|---|---|---|
| Mean | 0.085811 | 0.004201 |
| Median | 0.140775 | 0.079591 |
| Maximum | 0.696241 | 0.910266 |
| Minimum | -11.17002 | -10.96259 |
| Std. Dev. | 0.720270 | 0.747279 |
| Skewness | -12.16504 | -10.37013 |
| Kurtosis | 182.3040 | 143.3496 |
| Jarque-Bera | 457022.2 | 280955.8 |
| Probability | 0.000000 | 0.000000 |
| Sum | 28.74668 | 1.407179 |
| Sum Sq. Dev. | 173.2756 | 186.5143 |
| Observations | 335 | 335 |

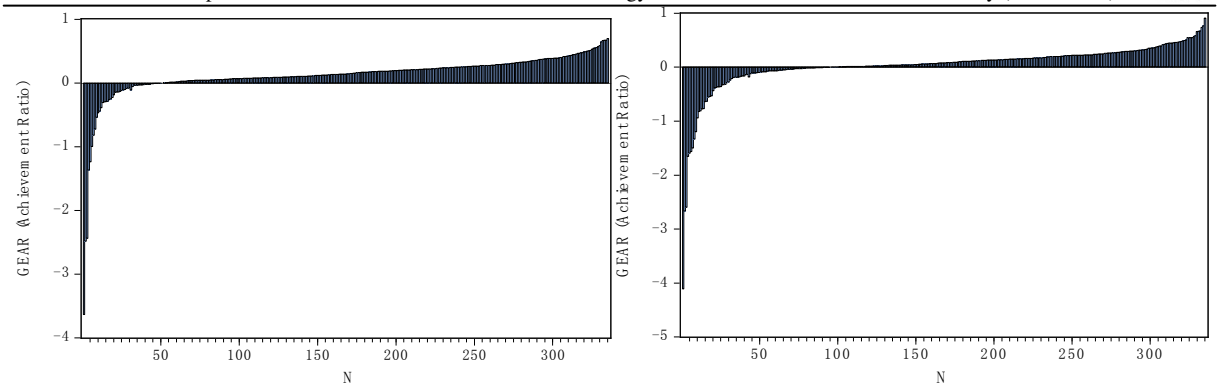


Fig. 1 Achievement ratios of 335 controlled entities (left : GHG, right : energy).

Upon closer examination of the achievement ratios, it can be seen that 285 companies out of total 335 achieved goals in GHG, and 241 companies achieved goals in energy consumption, making achievement rates 85% and 72%, respectively. Most companies were distributed between 0 and 0.2 (Fig. 3)

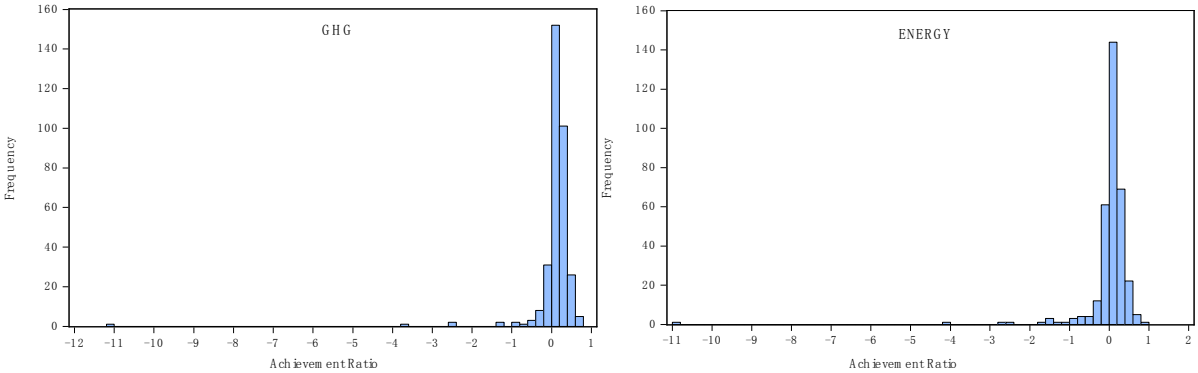


Fig. 2 Histograms of the achievement ratios of 335 controlled entities (left : GHG, right : energy).

*3.2 Evaluation of each industrial classification within the power and industry sector*

The subjects of the Target Management System in the power and industry sector are split again among 15 industrial classifications, according to the types of business. Subjects must submit GHG and energy consumption levels of the past 3 years to the government, which must in turn designate permitted GHG emission and energy consumption rates based on the GHG reduction goals and reduction coefficient of each industry. Table 5 shows the levels/amounts of standard emission, standard energy consumption, allowed GHG emissions, actual GHG emissions, allowed energy consumption, actual energy consumption, GHG goal achievement ratio, and energy goal achievement ratio.

The average GHG goal achievement ratio for overall industry is 0.136, whereas the energy goal achievement ratio for overall sub-sector is 0.098, indicating that the reduction ratio of GHG was higher than that of energy (Table 6). For GHG, the achievement ratio of the machinery industry was highest, whereas for energy, the semiconductor sub-sector showed best performance. The sub-sectors that failed for GHG was the generation and energy, and for energy consumption, the mining sub-sector and the generation and energy sub-sector, showing a general failure in the generation and energy sub-sector to meet goals(Fig. 3). This is estimated to be a result of the use of fossil fuels in generation to meet summer electricity demands, due to frequent failure of nuclear power plants.

According to correlation analysis of the achievement ratio of GHG and energy consumption goals of the 15 sub-sectors, there is a relatively high correlation of 0.85 (Table 7). This shows that the sub-sectors that were able to successfully reduce GHG emissions were also able to reduce energy usage.

Table 5 Achievement ratio based on industrial classification(sub-sectors) in 2012.

| Industrial Classification | Base emissions | Base energy consum. | GHG permitted | GHG emission | Aallowed Energy. consu. | Energy usage | GEAR GHG | GEAR Energy |
|---|---|---|---|---|---|---|---|---|
| Mining Indus. | 236,277 | 1,447 | 238,240 | 236,831 | 1,460 | 1,485 | 0.0059 | -0.0173 |
| Textile Indus. | 2,977,457 | 49,834 | 3,753,082 | 3,154,638 | 64,441 | 54,565 | 0.1595 | 0.1533 |
| Paper ndustry | 7,404,282 | 116,682 | 9,118,321 | 7,573,492 | 148,194 | 139,199 | 0.1694 | 0.0607 |
| Oil Refining | 24,814,090 | 287,111 | 34,607,124 | 28,639,846 | 397,665 | 381,513 | 0.1724 | 0.0406 |
| Petrochemical | 47,684,520 | 789,613 | 60,754,992 | 50,262,528 | 1,007,029 | 898,371 | 0.1727 | 0.1079 |
| Ceramic Indu. | 4,140,400 | 43,884 | 5,186,534 | 4,421,299 | 58,270 | 48,249 | 0.1475 | 0.1720 |
| Cement Indus. | 44,833,400 | 231,633 | 48,155,224 | 42,313,496 | 251,533 | 222,632 | 0.1213 | 0.1149 |
| Steel Industry | 82,683,488 | 960,085 | 118,167,584 | 105,313,072 | 1,430,393 | 1,276,413 | 0.1088 | 0.1076 |
| Nonferrous | 4,531,196 | 69,553 | 5,956,530 | 5,461,264 | 91,442 | 87,194 | 0.0831 | 0.0465 |
| Machinery | 1,488,358 | 27,175 | 2,114,970 | 1,610,348 | 38,784 | 30,861 | 0.2386 | 0.2043 |
| Semiconduct | 17,798,962 | 240,090 | 32,173,148 | 25,247,314 | 435,080 | 338,003 | 0.2153 | 0.2231 |
| Automobile | 3,406,751 | 65,460 | 4,402,568 | 3,883,793 | 82,617 | 78,405 | 0.1178 | 0.0510 |
| Shipbuilding | 2,370,265 | 38,666 | 3,307,258 | 2,590,439 | 54,570 | 45,027 | 0.2167 | 0.1749 |
| Electricity | 21,194,2496 | 2,716,011 | 232,610,416 | 240,986,080 | 3,052,125 | 3,215,926 | -0.0360 | -0.0537 |
| Communi | 2,458,620 | 47,336 | 3,515,586 | 3,000,208 | 67,742 | 61,541 | 0.1466 | 0.0915 |

Table 6 Statistical characteristics of GHG and energy achievement ratio based on industrial classification

| | GHG | ENERGY |
|---|---|---|
| Mean | 0.135982 | 0.098488 |
| Median | 0.147543 | 0.107649 |
| Maximum | 0.238595 | 0.223124 |
| Minimum | -0.036007 | -0.053668 |
| Std. Dev. | 0.074882 | 0.079167 |
| Skewness | -0.917044 | -0.214076 |
| Kurtosis | 3.329121 | 2.299188 |
| Jarque-Bera | 2.170125 | 0.421532 |
| Probability | 0.337881 | 0.809964 |
| Sum | 2.039732 | 1.477324 |
| Sum Sq. Dev. | 0.078503 | 0.087744 |
| Observations | 15 | 15 |

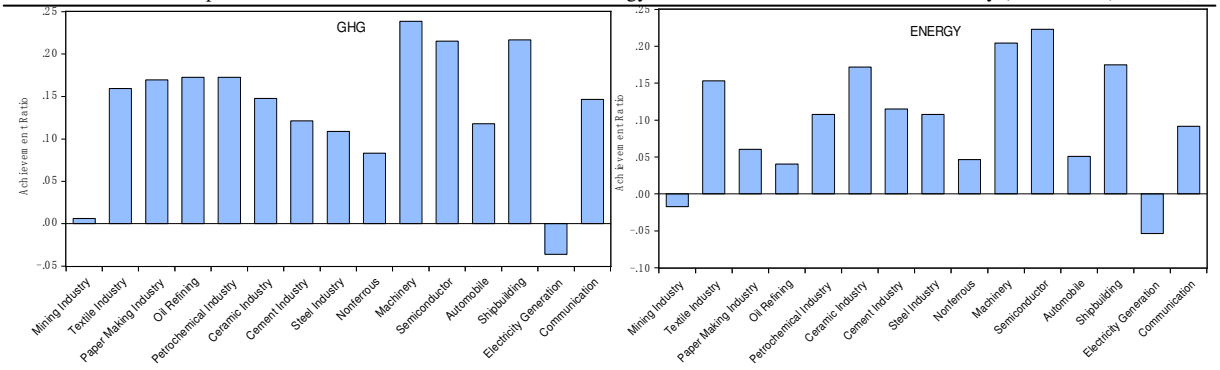


Fig. 3 Achievement ratios based on the industrial classification(sub-sector) (left : GHG, right : energy).

Table 4 Correlation coefficient between GHG and energy achievement ratio.

| | GHG | ENERGY |
|---|---|---|
| GHG | 1 | 0.84688 |
| ENERGY | 0.84688 | 1 |

*3.3 Evaluation of achievement ratios in the big company group and small and medium company group in the power and industry sector*

Among the 335 controlled entiries of the Target Management System, there are 50 small and medium companies, amounting to about 15% of the total. Analysis of basic statistics shows that the average reduction ratio of big companies is 0.1168 for GHG and 0.0334 for energy. This is a relatively high achievement rate compared to -0.0910 and -0.1627 respectively for small and medium companies (Table 8). Thus, larger companies in the big company group were able to successfully reduce carbon emissions, whereas small and medium companies mostly faced difficulty in doing so. This alludes to the limited human resources, financial support, and technical support that small and medium companies receive and the poor surroundings that they face as a result. Therefore, for efficient reduction of GHG emissions and energy consumption, the government should approach policies towards small and medium companies through financial and technical support rather than regulations. Moreover, the correlation between energy and GHG goal achievement rates are shown to be higher in small and medium companies at 0.977. This shows that small and medium sized companies generally face problems in both GHG reduction and energy consumption reduction, showing a correlation in a negative sense. Figure 4 shows the achievement ratios of the big company group and the small and medium business group.

Table 8 Statistical characteristics of the GHG and energy achievement ratio based on company size

| | Big Company Group | | Small-medium Company Group | |
|---|---|---|---|---|
| | GHG | ENERGY | GHG | ENERGY |
| Mean | 0.116833 | 0.033482 | -0.091012 | -0.162701 |
| Median | 0.144630 | 0.083138 | 0.093431 | 0.060276 |
| Maximum | 0.675218 | 0.910266 | 0.696241 | 0.767965 |
| Minimum | -3.634059 | -4.111113 | -11.17002 | -10.96259 |
| Std. Dev. | 0.384710 | 0.447245 | 1.607841 | 1.599182 |
| Skewness | -5.69345 | -4.86789 | -6.603505 | -6.223456 |
| Kurtosis | 47.48685 | 37.28390 | 45.99964 | 42.46382 |
| Jarque-Bera | 25129.17 | 15136.21 | 4299.713 | 3638.677 |
| Probability | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Sum | 33.41412 | 9.575732 | -4.641621 | -8.297772 |
| Sum Sq. Dev. | 42.18044 | 57.00796 | 129.2576 | 127.8692 |
| Observations | 285 | 285 | 50 | 50 |

 

Table 9 Correlation coefficient between GHG and energy achievement ratio.

| | Big Company Group | | Small-medium Company Group | |
|---|---|---|---|---|
| | GHG | ENERGY | GHG | ENERGY |
| GHG | 1 | 0.8857859 | 1.000000 | 0.977892 |
| ENERGY | 0.8857859 | 1 | 0.977892 | 1.000000 |

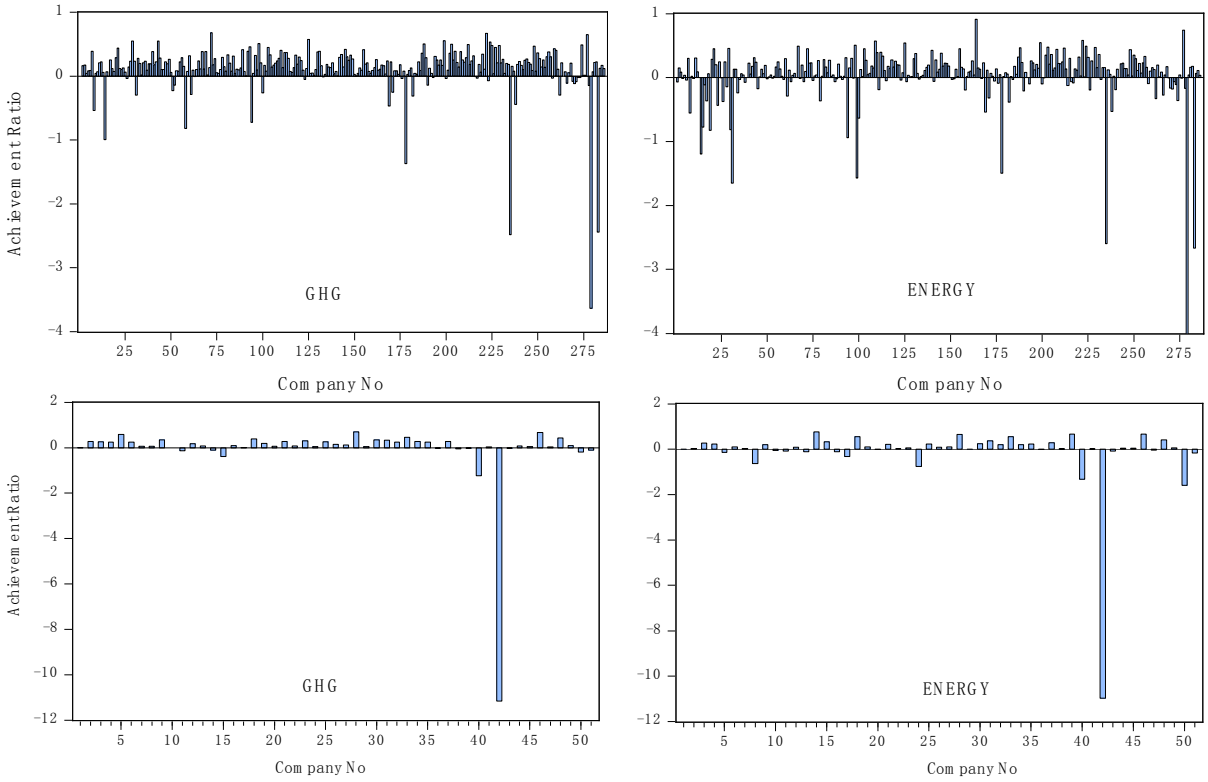


Fig. 4 Achievement ratios based on company size (top: big company, bottom: small-medium company).

## 4. Discussion

This study was conducted by analyzing the achievement ratio index of reducing GHG and energy consumption of 335 controlled entities in the power and industry sector. Three methods were utilized to evaluate target achievement. 1) the achievement ratio of all 355 controlled entities, 2) the achievement ratio of all 15 individual industrial classifications, and 3) the achievement ratio of both the big company group and the small and medium company group.

Results show that the power and industry sector accomplished a surplus achievement in GHG and energy use reduction of 7.3% and 4.28%, respectively. Analysis of GHG reduction and energy consumption reduction for each company showed that GHG reduction had a lesser disparity than energy consumption reduction. According to sector analysis, the average GHG achievement ratio was 0.136 and the energy achievement rate 0.098, making the reduction ratio of GHG higher than that of energy. For individual sectors, data showed that the machinery industry had a high achievement ratio, whereas the generation and energy industry could not accomplish goals. This could be because yearly differences in energy supply and demand were not initially factored in designating allowed emission/consumption levels. Therefore, there was an increase in fossil fuel usage following frequent shutdowns of nuclear power plants in 2012 when the energy demand was high in the summer. Finally, comparison of reduction ratios of the big company group and the small and medium company group shows that the achievement ratio of the big company group for GHG and energy consumption was 0.1168 and 0.0334, respectively, which was higher than the ratio for small and medium companies at -0.0910 and -0.1627. This shows that larger companies could reduce GHG emissions through the Target Management System, whereas small and medium companies could not, indirectly bringing to light the limited human, financial, technical resources of smaller companies. Therefore, this shows the need for government support both financially and

technically in order to facilitate GHG reduction and energy consumption reduction.

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