

Post-2020 Greenhouse Reduction Target of Korea: Evaluation and Its Implications

Sangjun Lee

1. Introduction

It is era of New Climate Regime (Paris Regime). The Paris Agreement was officially entered into force on November 4 this year, 2015. Following the Paris Agreement last year, ratification of Parties have been proceeded at a faster pace than anticipated¹. The official entry into force of the Paris Agreement shows that the era of the new climate regime is within reach.

Compared with the Kyoto Protocol, in which only some developed countries are obliged to reduce greenhouse gas (GHG), the new regime is a new system in which all countries participate in actions in response to climate change. As of the end of November, 190 countries that accounted for more than 96% of the world's total emissions have submitted "Intended Nationally Determined Contribution" (INDC) which is the basis for the new regime. Especially, during the ratification process of the Paris Agreement, the United States, China and India, which are world's largest emitters, actively participated in the process. Therefore, the new era should be read as a signal that climate

change is a global problem and that the world has come to have a consensus on urgent needs to react to climate change problem.

Climate change is an environmental problem, but reacting to climate change is fundamentally an economic problem. As proved by sluggish negotiation progress over the years until the Paris Agreement, any actions mitigating and adapting to climate change are closely linked to economic interests of Parties. It is widely accepted that GHG emissions from energy consumption have been inevitable in the process of economic growth. Therefore, the new regime means that the whole world supports the transition of the paradigm of existing economic growth toward a low carbon economy.

Prior to the Paris agreement, Korea announced its goal of reducing emissions by 37% below Business-as-Usual (BAU) scenario by 2030 last year (Joint Announcement by related Ministries, 2015). Since the agreement is fundamentally a bottom-up approach based on Nationally Determined Contribution (NDC), it is important to set GHG

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¹ Conditions for entry into force have been achieved on October 5, 2016. According to Article 21.1 of the Paris Agreement, If at least 55 Parties and Parties that accounts for more than 55% of global emissions ratify, the Agreement will officially enter into force after 30 days.

emission reduction targets and implement corresponding policies by individual country. It is also a challenge for Korea to set reasonable policy measures for greenhouse gas reduction and foster new growth engines. Accordingly, it is highly likely that the existing GHG reduction policies will be adjusted or strengthened or various policies and support measures will be introduced in the course of implementing the targets. In the end, Korea's GHG reduction target has a significant impact on Korea's overall economy. The impact on the manufacturing sector, which is the core of our economy, is expected to be significant. In this article, we will evaluate the post-2020 GHG reduction target and examine implications of the target.

2. The New Climate Regime (Paris Regime)

2.1. Overview of the New Climate Regime

A series of the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC), which was published in 2014, shows trends in observed climate change, climate change impacts and adaptation, climate change mitigation strategies. The report clearly demonstrates that climate change is attributable to human activities. It also lays down the impacts of climate change, which is evident throughout human life to ecosystem and so on (IPCC, 2014).

Global efforts to recognize the effects of climate change and curb climate change are not recent ones. The international community's efforts to mitigate climate change have been relatively long. The United Nations Framework Convention on Climate Change (UNFCCC) is the starting point for the international community's efforts to response climate change problem. Since then, the Kyoto Protocol, which was

usually referred to as the Kyoto Regime, was signed in 1997 and efforts by the international community to reduce greenhouse gas emissions have been started.

However, the Kyoto Regime had many limitations. First, the Kyoto regime was an imperfect system imposing a reduction obligation only on 38 countries classified as Annex I countries. At the time of the Kyoto Protocol, it was natural for countries with historical responsibilities to climate change, especially developed countries, to have a duty to cut down emissions. However, as the Kyoto Regime lasted for more than 10 years, imbalance of the system has been amplified since it failed to limit emission growth from developing countries. Specifically, emerging economies such as China and India have rapidly increased their GHG emissions due to rapid economic growth and the participation of developing countries in GHG system has become a necessity for global mitigation efforts.

Second, the limitation of top-down reduction approach was exposed. The top-down goal setting had to be questioned as to whether the appropriate targets were imposed and implemented reflecting the capabilities and circumstances of the Parties involved in the reduction. Developed countries that felt overly burdened had to withdraw from the Kyoto Regime or refuse to ratify the Protocol. As a result, the Kyoto Protocol became titular (Roh, 2014)².

The discussions to improve the incompleteness of the Kyoto Regime continued, but the progress of the agreement was sluggish due to the significantly different standpoints between developed and developing country Parties³. Here, we will introduce relatively recent negotiations for the sake of simplicity of discussion.

The basic framework for the new regime was agreed at the 2011 Durban Conference (COP 17)

2 The absence of major developed nations and China has resulted in the emission of greenhouse gases from countries participating in the Kyoto Protocol second commitment period, which is only 14% of the global emissions.

3 As a representative example, the failure to reach an agreement in the Copenhagen Conference of Parties (COP 15) is often mentioned. It is possible to refer to Roh (2014) for the process of discussion under the Convention on Climate Change for the establishment of a new climate regime as a follower after the Kyoto Regime.

and the 2013 Warsaw conference (COP 19). The Durban Conference agreed to form a new climate regime, in which all developed and developing countries will participate following the Kyoto Protocol. In other words, it becomes clear that the new regime is the system in which all the Parties participate. At the Warsaw conference, countries agreed to set a GHG reduction target through a bottom-up approach called INDC. Through the negotiation process, the Lima conference in 2014 (COP 20) agreed on the guidelines for the preparation of the INDC and the components of the new regime.

Compared with the Kyoto Regime, the characteristics of the new regime can be easily deduced from the limitations of the Kyoto Regime discussed above. First, it is a system in which all parties participate⁴. GHG mitigation actions are similar to the provision of public goods with properties of non-rivalry and non-excludability. If a country is to faithfully reduce GHG emissions, as is the general nature of public goods, all countries benefit from it as well as the country. Therefore, all countries are tempted to take free riding on greenhouse gas reduction and global mitigation actions will fall short of optimal level. In this respect, the nature of the system in which all nations participate is of importance. If there are a number of countries outside the new system, these countries can easily enjoy the fruits of other countries' efforts within the regime. Hence, the system itself will be vulnerable inevitably.

Second, the bottom-up reduction approach is important for robustness of the new regime. The INDC-based bottom-up reduction target setting has been able to avoid the possibility of debate over

individual countries' reduction capabilities or national circumstances, which has been pointed out as a limitation in the top-down approach. As each country voluntarily submitted its reduction targets in accordance with the national conditions of the country, the proof of the ambition of the reduction targets and the conditions of the countries were passed to each Party. Because it is a self-determined goal, the individual countries have responsibility for the implementation of the goal. Therefore, the possibility of avoiding the responsibilities of implementing the reduction obligations due to the climate regime itself, as in the case of the Kyoto system, has been reduced. Therefore, the bottom-up approach is the basis for enhancing the robustness of the new climate regime⁵.

2.2. Implications of the New Climate Regime

The Paris Regime will be an inflection point that confirms the global willingness to respond to climate change. The complexity of the interests of developed and developing country Parties is evident in the process of negotiations, but the new Regime will be an opportunity to demonstrate global commitment to the need to respond to climate change.

Therefore, the new system will be an important turning point to suggest a new paradigm of economic development. The new economic development paradigm is aimed at a 'low carbon economy.' Transition to the low-carbon economy is already occurring worldwide. Recent developments such as low-carbon technology development and the deployment of renewable energy are becoming more prominent. For example, EU and China are planning and

4 The COP 17 decision clarifies that the new regime is a system in which all Parties participate. Decision 1/CP.17 para 2. states "develop a protocol, another legal instrument or an agreed upon outcome with legal force under the Convention applicable to all Parties..." <<http://unfccc.int/resource/docs/2011/cop17/eng/09a01.pdf#page=2>>

5 The bottom-up approach, in which countries voluntarily set and submit reduction targets, is similar to the voluntary decision to supply public goods. In other words, the bottom-up system is likely to show a level of GHG reduction at a level that is lower than the global target of 2 °C, such as the problem of supply of public goods at a level lower than the socially optimal level. A comprehensive report on the INDC already published by the UNFCCC points out that the INDCs submitted by each country are not sufficient for the goal of the second degree. In light of the limitations of this bottom-up approach, future climate negotiations is likely to focus on 'review' process. Therefore, this system is sometimes called 'pledge and review' process.

implementing bold investment in the clean energy sector. The emergence of the new system will surely accelerate this transition.

Considering that most of the greenhouse gases are emitted from the energy sector (fuel combustion), the new system will have the greatest impact on the energy sector. In other words, the foundation of the low-carbon economy supported by the Paris Regime will rely on innovation and transformation in the energy sector. Changes in the energy industry and the market are already underway and new markets and industries are emerging. The trend of this change can not be easily accommodated in the export-oriented economy based on the manufacturing sector such as Korea. In particular, the intensive energy-consuming industries such as steel and petrochemicals account for a considerable portion of the Korean manufacturing industry, which will challenge the Korean economy and require fundamental innovation and transformation.

3. GHG Reduction Target of Korea

In order to set the goal of reducing GHG emissions in Korea, related ministries such as the Ministry of Trade, Industry and Energy, the Ministry of Foreign Affairs, the Ministry of Environment and the Ministry of Land set up a Joint Climate Change Task Force (April 2014). In addition, the Post-2020 Joint Working Group was established, in which research institutes such as the Korea Energy Economics Institute, the Korea Transportation Research Institute, and the Korea Rural Economic Institute participate (May 2014). The task force is responsible for monitoring of the process and the coordination of issues. The working group is responsible for carrying out practical empirical analysis for establishing reduction targets such as GHG emission predictions and reduction potential analysis.

Based on the analysis results of the working group, the government prepared four reduction target scenarios

through consultation with related ministries. Also the four scenarios were discussed through public hearing process. Korean government completed the submission of the INDC to the UNFCCC on June 30, 2015.

3.1. Greenhouse Gas Emission Predictions

3.1.1. National GHG Emission Predictions

GHG emission forecasts serve as an important basis for setting GHG emissions targets. Even if a country do not set a greenhouse gas reduction target against the emission estimates (BAU), it is difficult to set a reduction target arbitrarily without information on the future emissions. Setting estimates of GHG emissions is an essential process for estimating whether a reduction target is achievable or not.

Korea has also been involved in long discussions through the joint working group to derive reasonable greenhouse gas emission estimates prior to setting greenhouse gas reduction targets. The GHG emission forecast for the post-2020 reduction target in Korea was based on the 2nd Energy Basic Plan announced and published in January 2014 by the government. Since the energy sector accounts for more than 85% of the GHG emissions (87.2% in 2012), and the energy basic plan includes the predictions of up to 2035, the government decided to utilize the plan. Industrial processes, agriculture and livestock sectors that are not included in the basic plan are newly estimated and supplemented the plan.

The forecasts for the energy sector was based on the KEEI-EGM (Energy and Greenhouse Gas Modeling) System, which has been developed and operated by the Korea Energy Economics Institute. Briefly the energy sector projections calculate the energy demand by multiplying the activity data forecasts (e.g. crude steel production) by energy efficiency variables representing energy demand per activity and applying the emission factor to calculate the greenhouse gas emissions. For the non-energy sector, GHG emission estimates are generated by directly applying emission factors for each sector based on activity forecasts.

Table 1. GHG emission prediction by 2030(Unit: mil. tCO₂eq)

| | 2013 | 2020 | 2025 | 2030 | Annual Average Growth (%) | |
|------------|-------|-------|-------|-------|---------------------------|---------|
| | | | | | '13~'20 | '13~'30 |
| Energy | 592.2 | 677.5 | 700.5 | 738.9 | 1.94 | 1.32 |
| Non-Energy | 87.7 | 104.9 | 109.1 | 111.7 | 2.59 | 1.43 |
| Total | 679.8 | 782.5 | 809.7 | 850.6 | 2.03 | 1.33 |

Source: Post-2020 Joint Working Group

Table 2. GHG emission predictions by sector(Unit: mil. tCO₂eq)

| Sector | 2013 | 2020 | 2025 | 2030 | Annual Average Growth (%) | |
|----------------------------|-------|-------|-------|-------|---------------------------|---------|
| | | | | | '13~'20 | '13~'30 |
| Energy | | | | | | |
| Transformation | 233.4 | 295.5 | 303.9 | 333.1 | 3.43 | 2.11 |
| Industry | 211.7 | 225.8 | 234.6 | 239.1 | 0.93 | 0.72 |
| Transportation | 86.0 | 95.4 | 100.5 | 104.1 | 1.49 | 1.13 |
| Household, Commercial etc. | 54.3 | 53.1 | 53.6 | 54.1 | -0.32 | -0.02 |
| Fugitives | 6.8 | 7.7 | 8.0 | 8.4 | 1.79 | 1.25 |
| Energy Subtotal (A) | 592.2 | 677.5 | 700.5 | 738.9 | 1.94 | 1.32 |
| Non-Energy | | | | | | |
| Industrial Processes | 50.9 | 68.7 | 72.8 | 75.6 | 4.38 | 2.35 |
| Wastes | 14.9 | 15.4 | 15.5 | 15.5 | 0.47 | 0.23 |
| Agriculture | 21.9 | 20.9 | 20.9 | 20.7 | -0.67 | -0.33 |
| Non-Energy Subtotal (B) | 87.7 | 104.9 | 109.1 | 111.7 | 2.59 | 1.43 |
| Total (A+B) | 679.8 | 782.5 | 809.7 | 850.6 | 2.03 | 1.33 |

Source: Post-2020 Joint Working Group

As a result of GHG emission estimates, the emission estimate for 2030 is 850.6 million tons (CO₂eq.), which is an annual average increase of 1.33% during the forecast period. The energy sector accounted for 86.9% of total emissions and predicted

to reach 738.9 million tons in 2030, with an average annual increase of 1.32% over the forecast period. Meanwhile, emissions from the non-energy sector are expected to reach 111.7 million tons in 2030 with an annual average increase of 1.43%.

3.1.2. Emission Predictions by Sector

The results of GHG emission forecasts by major sectors are summarized in the Table 2. First, in the transformation sector, GHG emissions before 2020 are expected to increase slightly faster than the next decade with annual average of 3.4%. But after 2020, the growth would slow down. So the growth rate is calculated by annual average of 2.1% for the whole period. This trend is due to the rapid growth of the fabricated metal product industry (e.g. semiconductors, electronics) which has high demand for electricity in the production process.

Energy intensive industries such as petrochemicals, primary metals, and non-metallic minerals are expected to exhibit stable growth during the projection period. Hence, GHG emissions from industrial sector is expected to grow at an annual average rate of 0.7%, which is less than the emissions in transformation sector. Meanwhile, the transportation sector is expected to increase gradually, but the growth rate is expected to decline gradually.

The building sector (e.g. household and commercial sectors) is expected to have a slight decline in emissions due to stabilization of economic growth and the impact of population stagnation. On the other hand, the industrial process emissions are

expected to increase at a faster rate due to the growth of major emitting industries such as semiconductors, displays, and electronics. Looking at other non-energy sectors, emissions from the waste sector are to increase moderately while emissions from the agricultural sector are expected to decrease moderately.

3.1.3. GHG Reduction Target of Korea

Before public hearing process, Korean government proposed four reduction scenarios compared to the emission estimates for setting the post-2020 national greenhouse gas reduction targets. The scenarios are based on GHG reduction technologies, which are expected to be applied at a future point in time, and mitigation policies and costs. Also, the government conducted economic impact assessments on the reduction scenarios. Details of four proposed scenarios are provided in the table below (Table 3).

The first scenario is equivalent to 5.5% above 2012 emission level (14.7% below BAU). It has been derived by assuming to strengthening the current and planned GHG reduction policies for each sector such as industry, power generation, transportation, and buildings. Also available cost-effective mitigation

Table 3. Post-2020 GHG reduction scenarios of Korea

| Reduction Scenarios | | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 |
|--|---------------------------|------------|------------|------------|------------|
| Target Emissions (mil. tCO ₂ eq) | | 726 | 688 | 632 | 585 |
| Reduction Rate (%) | Compared to BAU | △14.7% | △19.2% | △25.7% | △31.3% |
| | Compared to 2012 level | 5.5% | 0% | △8.1% | △15.0% |
| Intensity Improvement Compared to 2012 (%) | per GDP (ton/mil. won) | △38.6% | △41.8% | △46.6% | △50.5% |
| | per Capita (ton/pop.) | 0.9% | △4.4% | △12.3% | △18.8% |
| GDP decline (2030 outlook) | | △0.22% | △0.33% | △0.54% | △0.78% |

Source: Post-2020 Joint Working Group

technologies were reflected in the scenario. The second scenario is reducing 2030 emissions below the predicted emission up to 2012 emission level (19.2% below BAU). In addition to the first scenario, additional reduction measures are included in the second scenario including some costly measures. For example, reduction measures such as shutdown of some coal-fired power plant, introduction of building and factory energy management system are included in the scenario. The third scenario is a level of 8.1% reduction compared to the 2012 emissions (25.7% below BAU). With all measures up to the second scenario, additional reduction measures were applied in this scenario. Especially, measures which require relatively large-scale financial investment and public expenditure were considered. These are increasing the share of nuclear power, introducing and commercializing carbon capture and storage (CCS) technology, speeding up green car supply. In addition to the reduction measures in the third scenario, the fourth scenario is to reduce 15% of the emissions below 2012 level (31.3% below BAU) including all additional mitigation measures. Additional measures considered include the addition of nuclear power (conditional on public acceptance), further applications of CCS, and replacing coal-fired power generation with gas.

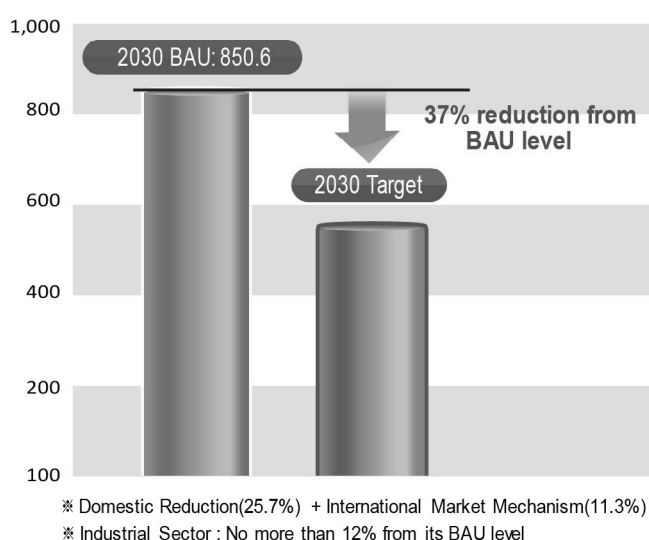
Based on the four reduction scenarios, the government announced its target of reducing GHG emissions by 37% compared to BAU (851 million tons) in 2030 after collecting diverse public opinions from all sectors (Figure 1).

In the process of public hearing on the four targets, industry and civil society expressed opposing views. The industry has argued that the reduction burden should be relaxed in consideration of the structure of Korean economy (e.g. high share of manufacturing) and the high energy efficiency of the industry. On the other hand, the international

community and the civil society suggested to set a progressive reduction target reflecting Korea's climate action leadership among developing countries and Lima decision of no-backsliding.

Finally, the government proposed a reduction of 37% below BAU as in scenario 3 (25.7% reduction) with 11.3% reduction utilizing international markets. The government has set its reduction target to a higher level than the four scenarios proposed, taking into consideration the opinions raised in the process of public hearing and the international status of Korea. The government also considered emergence of new energy industries and fostering these industries for new growth engine. In order to create new energy industries and innovate the manufacturing industry while maintaining the national stance to respond positively to the climate change, National Green Growth Committee recommended to strengthened previous 30% reduction target from BAU by 2020. The government finally adopted this recommendation and determined the goal of reducing 37% below BAU.

Figure 1. Post-2020 GHG reduction target of Korea



Source: Joint Announcement by related Ministries (2015)

Table 4. Evaluation of Korea's GHG reduction target

| Emission Estimate 2030 (mil. tCO ₂ eq) | Emission Target | Target Emissions (mil. tCO ₂ eq) | Compared to 2012 (688.3 mil. tCO ₂ eq) | | |
|--|-------------------|--|---|---|---|
| | | | Reduction Rate | Per GDP Intensity (2012: 0.623 ton/mil. won) | Per Capita Intensity (2012: 13.8 ton/pop.) |
| 850.6 | △37% below BAU | 536 | △22% | △54.7% (2030: 0.282 ton/mil. won) | △25% (2030: 10.3 ton/pop.) |

Note: Author's calculation

Source: Post-2020 Joint Working Group

The government also announced various complementary measures to alleviate the burden on the industry during the process of implementing the GHG reduction target, reflecting industry sector's concerns raised during the public hearings. As a representative example, the government proposed a plan to secure additional reduction potential for by utilizing the international carbon market mechanism.

It also expressed intention that the industrial sector reduction rate would not exceed the level of 12% from its sectoral BAU according to scenario 2. The government expressed intention to improve related laws and policies such as the GHG Emission Trading Act and others. These changes aim to improve the institutional basis so as to reduce GHG emissions reasonably. The government proposed to consider additional nuclear power plant, to develop GHG reduction technologies in transportation and building sectors, and to promote the transition to a low-carbon economy.

4. Evaluation of Korea's GHG Reduction Target and Its Implications

4.1. Evaluation of Korea's GHG Reduction Target

As discussed above, Korea's post-2020 reduction target was set above scenarios originally proposed by the government. This is the result taking into consideration of the international responsibility of

Korea and its leadership of climate actions among developing countries.

Table 4 summarizes some evaluations of the target. Reducing emissions by 37% compared to BAU emissions by 2030 translates to a 54.7% reduction in emissions per GDP and a 25% reduction in emissions per capita. As of 2012, Korea is ranked 7th in the global carbon dioxide emission, 16th in the cumulative GHG emission, and 6th in the OECD in the emissions per capita. Considering the Korea's status in global GHG emission, the government decided to raise ambition to the international community.

The reduction target can be assessed through examining the national circumstances, of which the industrial composition of economy of Korea is considered to be the most important part⁶. Korea's industrial structure can be characterized by its high share of manufacturing sector. Korea maintains a high proportion of manufacturing and energy intensive industries of country's total value-added. The share of manufacturing in Korea is 31% as of 2013, indicating that the manufacturing sector maintains a high proportion of the sector compared to major developed countries. Looking at the share of manufacturing in major countries, the US, Japan, and EU account for 12.9%, 15.3%, and 18.2% in 2013. In China, where manufacturing has grown rapidly in recent years, manufacturing accounts for 31.8% in 2013, which is similar to Korea.

6 In 2013, Korea's industrial sector emitted 350 million tons of CO₂eq, accounting for 50% of the country's total emissions (including indirect and industrial process emissions).

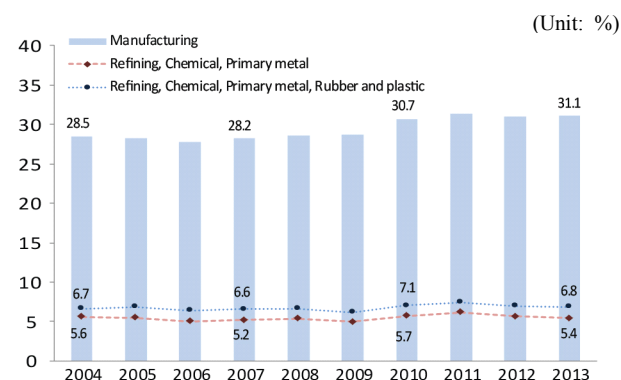
In addition, the proportion of energy intensive industries in the manufacturing sector is also high. Of the total value added in Korea in 2013, energy intensive sectors (oil refining, chemicals, primary metals, rubber and plastics) account for as much as 6.8%. Therefore, it is difficult to expect a short-term reduction effects due to the high proportion of manufacturing and energy intensive industries. Reducing GHG emissions in the short-term progressively, it seems inevitable to pay high abatement costs which may weaken industrial competitiveness.

Although a country maintains a high proportion of manufacturing, if the energy efficiency level of the sector is low, it can reduce greenhouse gas emissions with relatively low costs. However, Korea's manufacturing sector, especially the energy intensive sector, has already achieved world-class energy efficiency level and has been continuously improving its efficiency.

The energy efficiency level of Korea's energy intensive industries has already achieved the highest level in the world. Let us look at the steelmaking industry and the petrochemical industry, which have the highest greenhouse gas emissions in the manufacturing sector as a representative example. Comparing the energy efficiency of the steelmaking and petrochemical industries with other countries, the energy efficiency of the industry is confirmed to be among the highest in the world. In addition, energy efficiency levels of Korea's major industries such as display, pulp and paper are also beyond other countries (FKI, 2012).

Korea's manufacturing sector has been the main driver of rapid GHG growth, but it should also be taken into account that the manufacturing sector was the driving force of economic growth. The contribution rate to economic growth of Korean manufacturing industry is more than 30% each year, and manufacturing has played a leading role in breaking economic recession by recent global

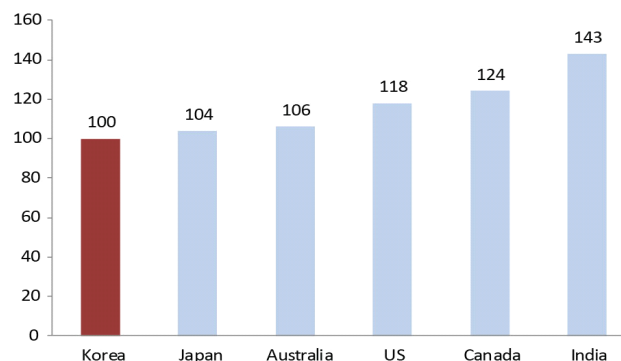
Figure 2. Share of manufacturing and energy intensive industries in Korea



Note: Author's own calculation based on national account data from Bank of Korea

Source: Economic Statistics System, Bank of Korea (ecos.bok.or.kr)

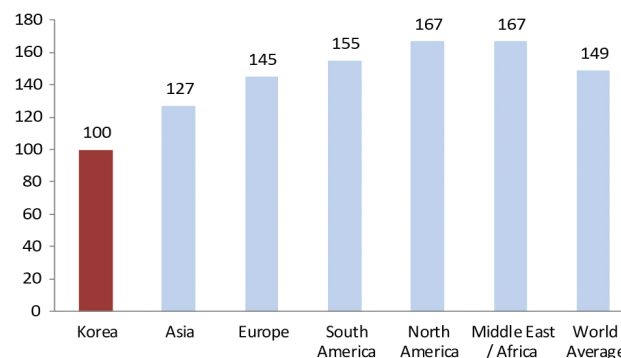
Figure 3. Energy efficiency comparison of steel-making industry



Note: Energy usage index producing one unit of product

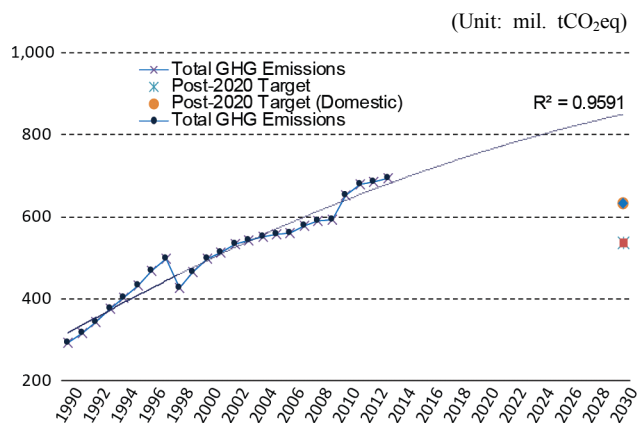
Source: APP Steel T/F (2010), recited from FKI (2012)

Figure 4. Energy efficiency comparison of petrochemical industry: NCC (Naphtha Cracking Center) process



Note: Energy usage index producing one unit of product

Source: Solomon Associates (2009), recited from FKI (2012)

Figure 5. Total GHG emissions in Korea and 2030 reduction target

Note: Author's own work

Source: GIR (2015)

economic crisis in Korea⁷. However, China's manufacturing competitiveness index has been rapidly catching up every year at the world's fourth-highest level (UNIDO, 2013).

In order to evaluate the post-2020 reduction target of Korea, we can also compare Korea's target with other countries. GHG reduction targets included in the INDC are diversified because they are determined voluntarily in consideration of the national circumstances of each country. More specifically, advanced countries that have reached the peak of GHG emissions often set absolute targets against the base year, while developing countries that do not have stabilized GHG emission targets have set targets for relative reduction (reduction compared to BAU, intensity target)⁸. Looking at the details of each country's INDC, the differences between countries are more prominent. It is not easy to compare the reduction targets between countries. However, it is necessary to compare and evaluate

GHG reduction targets among countries, and it is necessary to try from various perspectives. In this paper, in order to compare the ambitions embodied in each country's reduction target, the type of the national reduction target was evaluated on the basis of GHG emission trends and per GDP intensity trends. Although the trends do not fully show ambitiousness of each country's reduction target, we can deduce efforts needed to reach the targets by investigating where the target is located from the current trend⁹.

Korea's Post-2020 reduction target is slightly strengthened compared to the 2020 reduction target set in 2009. However, comparing the post-2020 reduction target with the total GHG emissions trend in Korea shows that it requires a significant reduction than the GHG emission trend in Korea (Figure 5). Given current emissions trends, it can be inferred that to achieve the post-2020 GHG emission reduction target, the GHG emissions peaked before 2030 and must shift to a declining trend. Looking at the trend, it seems that the decline in the short term can not be achieved. Also if it reaches its peak in the vicinity of 2030, it may be difficult to achieve the reduction target. Hence, it will be necessary to aggressively reduce greenhouse gas emissions, and this will explain Korea's ambition as well as difficulty to meet the target.

When the reduction target of Korea is converted to per GDP intensity, it seems that there is a burden to accelerate the improvement of the emission intensity in order to achieve the target in 2030 (Figure 6). It is natural for any country to pursue energy efficiency improvements, and in this process, the emission intensity generally tends to decline year

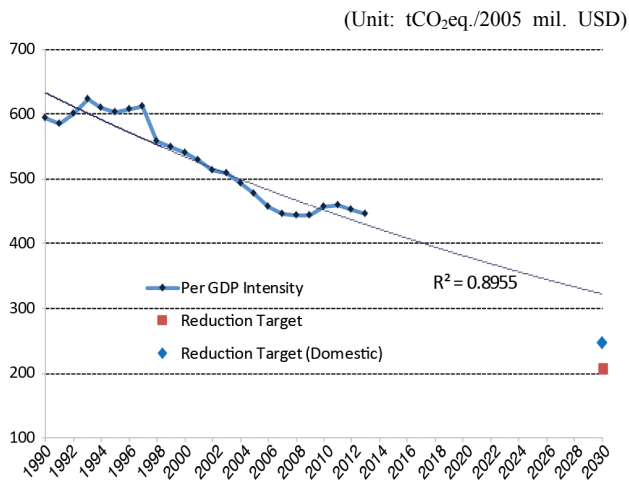
⁷ In the midst of the global financial crisis, the share of manufacturing in growth rate in 2010 was 55.4%. It has played a key role in breaking the manufacturing crisis in Korea.

⁸ Up-to-date information of each country's INDC can be found in the UNFCCC INDC portal.

<http://unfccc.int/focus/indc_portal/items/8766.php>

⁹ A comparison of countries based on the absolute amount of reduction compared to baseline is also a way to easily compare the reduction targets of various countries. In this paper, no comparison was made on the basis of absolute quantity. This is because it is easier to compare reduction targets on an absolute basis, but it does not indicate the size of the reduction effort required by a particular country.

Figure 6. Per GDP emission intensity and 2030 reduction target of Korea



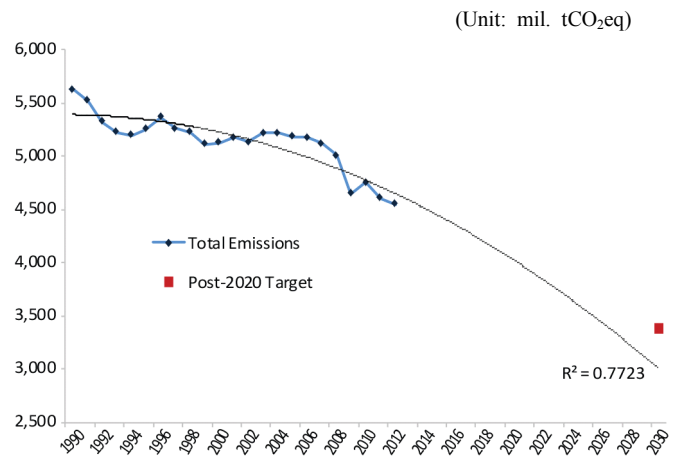
Note: Author's own work
Source: GIR (2014), OECD

by year¹⁰. In other words, when the per GDP emission intensity is plotted for each country, it shows a downward trend. However, it should be noted that this trend is not a spontaneous improvement, but it should be continuously manifested through various efforts such as efficient energy use, energy saving, and a transition to a low carbon economy. Given this point, we can deduce from the fact that Korea needs to further strengthen its efforts to improve the intensity from the current trend (Figure 6).

However, as mentioned above, considering the high energy efficiency level of Korea's major industries, it seems that the marginal abatement cost to further improve the intensity will not be low. Here, there are difficulties facing Korean economy in relation to GHG reduction.

If we evaluate the GHG reduction targets of other countries in the same way, it can be compared with Korea more systematically. As a representative example, EU 2030 GHG reduction targets was reviewed. Comparing the EU's target with current GHG emissions trends, it seems that it can be

Figure 7. Total GHG emissions and 2030 reduction target of EU

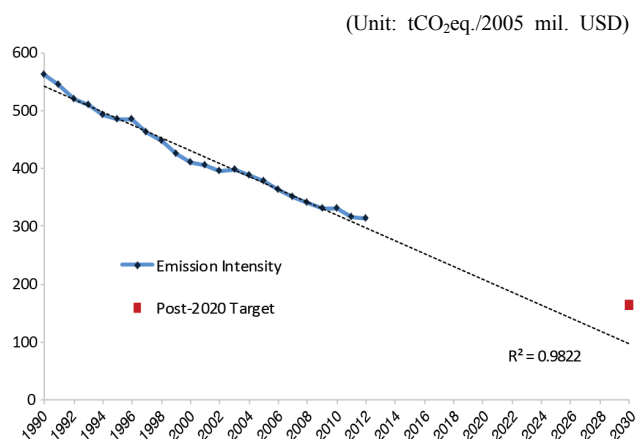


Note: Author's own work
Source: UNFCCC

achieved if the current trend is maintained. As shown in Figure 7, if the trend line is derived from the existing total GHG emission trend and the EU's 2030 target is depicted. We can easily find that the EU's reduction target is located above GHG emission trend line. Therefore, we may conclude that if the current trend is maintained, the reduction target can be achieved. Of course, future trends of GHG have many uncertainties, but if EU maintains current reductions, it seems highly likely that it will achieve the reduction targets.

Converting the EU's reduction target to per GDP intensity leads to the same conclusion. Figure 8 compares the EU GHG reduction target with the intensity improvement trend. Contrary to the case of Korea, it is confirmed that the EU's 2030 greenhouse gas reduction target is located higher than the unit improvement trend line. If they maintain current intensity declining trend, the EU's reduction targets will be easily achievable, and therefore the EU's reduction targets do not seem to be highly ambitious.

¹⁰ Emission intensity can be assessed in a number of ways. Typically, there is per GDP intensity, which means greenhouse gas emissions per unit of GDP, and a per capita intensity, which means greenhouse gas emissions per person. In this paper, we use the unit of GDP which represents GHG emissions per unit of value added of a national economy as a representative index.

Figure 8. Per GDP emission intensity and 2030 reduction target of EU

Note: Author's own work

Source: UNFCCC, OECD

Of course, the EU has been faithfully implementing its greenhouse gas reduction efforts so far, and it is reasonable to assume that such efforts have already been reflected in the EU's trend of total emissions and the improvement of per GDP intensity. However, existing reduction efforts can not serve as a basis for judging the ambition of 2030 targets. It is reasonable to interpret the ambitiousness of the target as a reduction efforts which are additional to the previous GHG reduction efforts. Because the efforts so far have been faithful, it can not be justified not to make additional reduction efforts in the future.

In general, the more GHG reduction efforts are undertaken in a country, the lower the means of reduction and the more expensive means of reduction. A relatively high economic cost is required to achieve additional greenhouse gas reductions. Taking this into account, the EU seems to have set its reduction targets in view of the future achievability of GHG reduction, which is expected to be relatively costly, considering the existing greenhouse gas reduction efforts.

In addition to the EU, greenhouse gas reduction targets of major developed countries have a similar pattern. For example, the GHG reduction targets in the United States and Japan are either higher or near the trend line of the current GHG emission and per GDP intensity¹¹. In short, the target of reducing GHG emissions by major countries seems to be set by taking into account the possibility of achieving their targets. In a similar way to this paper, BNEF (2015) assessed whether the reduction targets of major countries are ambitious based on the submitted INDC. It should be noted that the BNEF indicated that Korea has a higher rate of reduction compared to the US or EU when converted to the reduction rate compared to BAU. The reduction rate compared to BAU is the best indicator of how much reduction effort is needed compared to the current situation. The fact that Korea has been rated as the most ambitious reduction target means that Korea needs to make the most significant reduction effort. In addition to that, BNEF (2015) pointed out that the efficiency of Korea's industrial sector is at the highest level in OECD, and therefore there is no cheap GHG reduction options. As pointed out earlier in this article, it is reaffirmed that the reduction of the industrial sector in Korea is not easy.

4.2. Implications of Korea's Post-2020 GHG Reduction Target

The advent of Paris Regime are considered to be an opportunity as well as a threat to Korean economy. In order to preemptively respond to recent changes induced by the regime, appropriate policy coordination and implementation will be necessary in accordance with changes. In other words, it is important to boldly adjust direction toward a low carbon economy to meet the Korea's GHG reduction target.

It is worth noting that to solve these recent

¹¹ For the sake of brevity of the discussion, we will not show the figure showing the GHG emission trends and intensity trends in comparison with GHG reduction targets for the US and Japan.

challenges requires a convergent approach between the industry and the energy sector. For example, it is true that the impact of the regime is deeply linked not only with climate change and energy sector but also with industrial restructuring and strengthening competitiveness. Since GHG emissions are directly related to economic activities such as manufacturing, the GHG reduction cannot be away from the industrial transformation. Thus, recent changes suggest that energy policy should not be considered independently of industry, but should be pursued in consideration of linkages with industry and energy.

GHG reduction targets are the result of various policies such as energy policy, industrial development policy and GHG emission regulations. Looking through the GHG reduction targets of major countries, it seems that the targets have been established from two points of view: definite reduction strategy and emission peak. However, Korea has many blank spaces in the two points.

As discussed above, there are two broadly contradictory views on the setting of GHG reduction target in Korea. The first is the aspect of ambition. It has been asserted that it is necessary to show sufficient ambition to the international society in consideration of Korea's climate action leadership among developing countries, Korea's economic status, and historical GHG emissions. On the other hand, it has been suggested that we must consider aspects of achievability. The achievability indicates a level that can be reached through appropriate policies or investments while moderately managing the economic impact. As a result, Korea's GHG reduction target seems to be mixed between ambition and achievability. The government set the target beyond the proposed four scenarios. On the other hand, the government show intention to utilize international mechanism and limit reduction rate in the industrial sector. Also the government suggested to foster new energy industry as a new growth engine

(Joint Announcement by related Ministries, 2015).

On December 6, Korean government finalized the "Basic Climate Change Action Plan" and "2030 National Greenhouse Gas Reduction Basic Roadmap." The Basic Plan established is the first comprehensive plan to address Korea's mid- to long-term climate change strategy and specific action plans including GHG reduction, adaptation and international cooperation. The Roadmap contains systematic measures to effectively achieve the national GHG reduction target of 37% compared to BAU in 2030 (Joint Announcement by related Ministries, 2016).

It is worth noting that both reports stressed the role of market and technology. Korea has expressed its intention to induce voluntary reduction actions through market and technology rather than direct regulations.

In line with the changes induced by New Climate Regime, where the linkages of industry, trade, and energy are increasing, energy policy should be in consideration of linkages between the various sectors.

First, GHG reduction policy should be implemented through harmonization of GHG reduction and industrial competitiveness. Policy development that attracts voluntary reduction of companies is necessary through market and technology development that can reflect 'climate change mitigation' and 'industrial reform (strengthening competitiveness of manufacturing sector)' in a integrated manner.

Second, energy demand management policy is a key alternative to meet energy supply-demand stability and response to climate change. Changes in the global market environment due to the development of ICT-energy convergence technologies are demanding rapid changes of the energy system from the supplier-oriented to the consumer-oriented and from the centralized to the decentralized energy system. In order to accelerate the transition of the

policy paradigm, it is necessary to expand the market basis of demand management policies. To this end, demand management industry should be activated.

Third, new energy industry need to emerge and grow quickly in Korea. Basically, it is necessary to build an energy system in which the price is determined by the demand and supply of energy and the appropriate resource allocation by price is needed. To do this, it is important to reform the regulated energy tariff system so that it is more flexible to follow the supply and demand of the market. In order to activate the new energy industry, it is necessary to increase the role of consumers, focusing on deregulation of the entire energy system and market opening.

Finally, the importance of market-oriented R&D should be stressed. In order to cope with the New Climate Regime, it is necessary to expand the energy R&D. There is a need to approach energy technology R&D as a integrated view of responding to climate change and increasing industrial competitiveness. This is because through energy technology R&D we can pursue not only GHG reduction but also creating new growth engines by enhancing factor productivity and taking advantage of the global market.

Rational and fair game rules are needed to make GHG reduction an opportunity rather than a burden. In order to make all players voluntarily participate in the GHG reduction, it should be noted that it is a priority to provide an proper environment where the players can demonstrate their maximum capabilities.

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