The Introduction of a CO₂ Emissions Trading System for Realizing an East Asian Low-Carbon Community

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Abstract

Based on a scenario study of the introduction of CO₂ emissions trading system using Glocal Century Energy Environment Planning (G-CEEP) model, this study proposes a policy framework of East Asian Low-Carbon Community among Japan, Korea and China, which is similar to EU Emissions Trading System (EU ETS). Achieving the CO₂ emission reduction targets in 2020, Japan, Korea and China would reduce 40.9%, 41.1% and 11.5% of their total abatement costs, if an East Asian Low-Carbon Community could be built by introducing carbon trading. For carbon credit selling countries such as China, they also gain extra carbon reductions and "cleaner" environments. The carbon leakage in this carbon trading scenario shows a negative result of -1.79%, indicating that there is no carbon leakage and even more carbon emissions are reduced than no trading scenario. In this sense, an East Asian Low-Carbon Community is worth considering to deal with the problem of global warming.

1. Introduction

There is a great deal of uncertainty about climate change issues, and a low-carbon society is vital to achieve the sustainability of human society. At COP 15, the Japanese government announced that it would reduce its GHG emissions by 25% by 2020 from the 1990 level; South Korea would cut 30% of its GHG emissions of business as usual (BAU) case in 2020; China pledged to make a 40% to 45% cut in its carbon intensity, namely the GHG emissions per unit of Gross Domestic Product (GDP) by 2020, compared with the 2005 level. In the mid-term target, Japan planned to build 9 nuclear power plants with 80% of capacity utilization (METI, 2010). However, the Japanese government reviewed its energy policy...
because of the Great East Japan Earthquake in March 2011, and decided to reset the GHG emissions reduction target in 2020 to 5% - 9% cut from 1990 level (domestic reduction only, not considering the carbon credit from abroad) in the Innovative Strategy for Energy and the Environment (NPU, 2012), which was much lower than the previous 25% reduction target. As to South Korea, the CO₂ emission intensity is 0.57 t per thousand USD\(^1\), compared with Germany (0.27 t per thousand USD), Japan (0.25 t per thousand USD), UK (0.23 t per thousand USD) and USA (0.43 t per thousand USD), the energy efficiency is lower than that of these developed countries. For China, the CO₂ emissions in 2020 will be 1.7 - 1.9 times of the 2005 level (annual rate 3.8% - 4.4%), if the above reduction target is achieved, which means that about 23% - 30% of the CO₂ emissions are reduced while a 6% economic growth\(^2\) is maintained. It is noted that China has a large cost-effective reduction potential. However, there are technical and economic limits with respect to the China’s efforts to achieve the emission reduction target. Not only China, but also other developing countries such as Brazil, India and Mexico, are confronted with these common challenges. Details can be seen in Figure 1.

In terms of the economic growth, almost no country can have a high GDP per capita level while it maintains a very low level of per capita energy consumption. Along with the economic development of developing countries, including China, there will be continued growth in the energy consumptions and CO₂ emissions in the future and developing countries will face severe challenges in reducing their GHG emission.

Currently, the realization of a low-carbon society is recognized as a common goal throughout the whole world, including both developed and developing countries, and there are several issues that need to be considered such as the urgency of the climate change, the same effect of CO₂ reductions no matter where to reduce, co-benefits of CO₂ emission reduction measures, etc. According to the development of innovative technologies, the transfer of appropriate technologies, the reform of the economic and social system, and strategic innovation, the building of a multinational low-carbon society would help to realize the sustainable development of developing countries and to achieve global sustainability.

This study will focus on the cooperation among Japan, South Korea and China, which account for about 30% of the world’s primary energy consumption and CO₂ emissions, and raise a policy framework for the East Asian Low-Carbon Community, based on a scenario study of the introduction of a CO₂ emissions trading system using G-CEEP model, to pro-
pose a reciprocal international policy for implementing this concept.

2. Policy Framework of a Wide-area Low-Carbon Society and Its Significance

To realize a wide-area low-carbon society, besides climate change mitigation measures, it is critical to develop a sustainable international community with harmonious integration of economy, environment and society. The significance of this issue lies in the development of innovative low-carbon technologies, transfer of existing technologies, and transformation to a low-carbon society. In detail, a study should be conducted for the creation of a low-carbon economy industry system and related life cycle, the eco-design of energy and material cycles by international cooperation, demonstrating the feasibility of realizing a low-carbon society by pilot projects, presenting the roadmap to realize the process of transition to a sustainable low-carbon society, policy recommendations to induce the construction of a low-carbon society in Asia, empirical research for embodying international reciprocity based on common strategic interests among Japan, Korea and China, etc.

The East Asian Low-Carbon Community has a multi-layered structure and this study raises a policy framework of 4 axes.
The first axis stands for the time period. As shown in Figure 2, based on the Principle of Common but Differentiated Responsibilities, according to the agenda of the United Nations Framework Convention on Climate Change (UNFCCC), three stages actions are considered in this study, i.e., spontaneous, voluntary and binding commitments. As the case of China, three stages are assumed that the first stage has expired in 2012; from 2013 to 2020 is the voluntary period and the binding commitment period starts from 2020. In fact, China has proposed the 40-45% of carbon intensity reduction target by 2020 and it starts the voluntary stage from the previous spontaneous stage.

The second axis stands for the regional linkages, shown in Figure 3. In dealing with the global climate change problem, it is necessary to realize a low-carbon community at the local level (urban-rural linkages), at the middle level (intercity linkages), to the global level (international linkages), and it also means to “think globally, act locally”.

The third axis stands for the policy integration. From specific issues to complex issues, from local problems to global problems, policy integration is required – ‘kill two birds with one stone’. In particular, in the case of developing countries, they are confronted with poverty, pollution and the global climate change problem which need to be addressed simultaneously. Japan, South Korea and China account for about 25% of the world’s aggregate economic output, 25% of the total electricity consumption, and 30% of CO2 emissions, and the economies of these countries are also likely to ex-
The Introduction of a CO₂ Emissions Trading System for Realizing an East Asian Low-Carbon Community

Moreover, the CO₂ emissions of Japan in 1990 were $11.43 \times 10^8$ tons and were $13.7 \times 10^8$ tons in 2007. That is, the CO₂ emission reduced by improving the efficiency of China’s coal-fired power generation is almost equivalent to half of the total CO₂ emissions of Japan in 2007, let alone the large effects of pollutant reduction opportunities associated with it. In other words, this is the “result” of “international reciprocity”.

In this way, building a Low-Carbon Community would contribute to the development of global sustainability through partnerships between developed and developing countries. Specifically, the following achievements can be expected:

The fourth axis stands for sharing results. The CO₂ emission reduction framework aims at a win-win solution for all the participants, and designing a mechanism which also has co-beneficial effects on other emissions. For example, the thermal power generation of China in 2007 was $27229.3 \times 10^8$ kWh, the average efficiencies of coal-fired power generation of Japan and China are 43% and 32%, respectively. Therefore, if the efficiency of China’s coal-fired power generation could be improved to the Japanese level through technology transfer, CO₂ emissions will be reduced by $7.1 \times 10^8$ tons.

Besides CO₂ emissions, trans-boundary air pollutants such as NOₓ, SOₓ and particulates also present serious problems in some regions.

The regional linkages of “East Asian Low-Carbon Community”

![Figure 3: Regional linkages of “East Asian Low-Carbon Community”](image)
1) The Proposal for an East Asian Low-Carbon Community

The East Asian version of the EU Emissions Trading System (EU ETS) is proposed in this study, which consists of a number of countries including Japan, Korea and China. However, East Asia is a region which is diverse and rapidly transforming in terms of politics, economics and military capability, with implication for energy and the environment. Consequently, it will be not as simple as the realization of the EU ETS. On the other hand, as described above, with respect to the uncertainty of the climate change problem, CO₂ characteristics and co-benefits of CO₂ emission reduction measures, the global low-carbon community with “international reciprocity”, such as the so called East Asian Low-Carbon Community, is a more feasible proposal with higher priority, when compared with the proposal of an East Asian Community. Thus, establishing a Low-Carbon Community including Japan, Korea and China is certainly worth considering as a priority measure.

2) Pathways for Achieving CO₂ Emission Reduction Targets

As mentioned in the introduction, Japan, Korea and China have announced their CO₂ emission reduction targets by 2020 in COP 15. Japan has achieved the world's highest level in energy saving and efficiency and it is costly to further reduce CO₂ emissions. As mentioned above, if the efficiency of China's coal-fired power generation is improved to the Japanese level in 2005, the CO₂ emission reduced is almost equivalent to half of the total CO₂ emission of Japan in 2007. The technology transfer from Japan will help other East Asian countries to achieve their CO₂ emissions targets.

3) Green Growth

According to the above technology transfer, it not only reduces CO₂ emissions, but also contributes to the environmental and energy technologies of Japan, especially for the large companies and SMEs (Small and Medium Enterprises) – ‘kill many birds with one stone’. Also, there is a “shelf life” for most technologies, as evidenced by the rapidly shrinking “gap” between two countries. If circumstances prevent a developed country A from entering a developing country, such as China, another developed country B could enter the said developing country to replace developed country A. As for industrial-academic-government cooperation, it is an urgent issue to facilitate the overseas expansion of industrial technologies.

4) Sustainable Development and Climate Change Mitigation for Developing Countries

The realization of a low-carbon community is a demonstration project for international reciprocity. China has a higher
The Introduction of a CO2 Emissions Trading System for Realizing an East Asian Low-Carbon Community

CO2 emission intensity than Japan, and it is easier to achieve a low-carbon community there than in developed countries. This is indicative of what is known as the latecomer’s advantages. In other words, there is a strong incentive for developing and emerging countries to adopt the low-carbon policy, in partnership with developed countries, if the relationship between economic growth and reducing pollution or co-benefits from low-carbon emissions is clarified.

3. Development of G-CEEP Model

This study follows the GLOBAL 2100 model (Manne and Richels, 1992), to develop a large scale non-linear integrated planning model, the G-CEEP model, and it is used for low-carbon economy analysis among Japan, Korea and China, with 5-years per period from 2010 to 2050. The model mainly consists of three sub-models: macro-economic sub-model, energy balance sub-model and environmental sub-model. The production output in macro-economic sub-model is indicated as the sum of consumption, investment and energy system cost. The investment is determined by the initial investment and the annual growth rate. The relationship of the production output, capital stock, population, electricity and non-electricity are expressed by a two-level CES production function (Su et al., 2010, 2012a, 2012b). The key constraints in the energy balance sub-model

![G-CEEP model diagram](image-url)

**Figure 4: G-CEEP model**
are the energy system cost constraint and energy supply and demand balance. Also, the depletion of fossil fuels, such as coal, oil and natural gas, and the annual available renewable energy are considered as strict constraints. The environmental sub-model is to calculate the energy related emissions according to the emission factors under specific scenarios. Details are shown in Figure 4.

4. Assessment of CO₂ Emissions Trading System

4.1 Concept of the Low-carbon Community

For developed or newly industrializing countries, such as Japan and Korea, existing carbon intensities are relatively low and it is costly to reduce carbon emissions. Developing countries have no compulsory emission reduction obligations according to the UNFCCC’s “common but differentiated responsibilities”, and the carbon emissions originating in developing countries will grow to meet social and development needs. A market-based approach is used to abate carbon emissions by providing economic incentives for achieving reductions, allowing countries that have permitted emissions to sell this excess capacity to countries that are over their targets. Thus, the countries with strict climate policy are able to meet the reduction targets at costs significantly lower than projected. Japan, Korea and China lead the economic development of Asia, covering developed, mid-developed and developing countries, which is a representative community in East Asia. This section introduces a comparative scenario with emissions trading only occurring among Japan, Korea and China as a “Low-carbon Community”, and focuses on the following questions:

- What occurs when the emissions trading is allowed?
- How does emissions trading affect the cost of carbon emission reduction and what is the price of the traded carbon credit?

4.2 Abatement with carbon trading

In this section, carbon trading is assumed to occur among Japan, Korea and China, in order to achieve the reduction targets with lower costs.

4.2.1 Carbon trading

Carbon trading lowers domestic carbon emission reductions by countries as carbon credit buying, by Japan and Korea in this study, increases the demand for carbon trading, and then lowers total reduction costs. The carbon credit seller, namely China in this study, gains revenue from carbon trading, and improves its domestic carbon emission reduction level. Carbon emissions abatement and trading for Japan, Korea and China in 2020 are given in Figure 5. The results
show that China sells 143.0 Mt carbon while Japan reduces 90.4 Mt carbon by carbon trading and Korea reduces 52.6 Mt carbon by carbon trading. By means of carbon trading, the abatement costs are cut significantly (see Figure 6). Japan needs to cost 48.4 billion USD (in 2000 USD) if there is no carbon trading, to reduce its carbon emission 25% under 1990 level while the domestic reduction cost is cut down to 11.1 billion USD, even if the trading cost of 17.5 billion USD is counted in, the total abatement cost still reduces by 40.9%, by achieving its 27.3% of total carbon emissions with carbon trading. For Korea, the total abatement cost reduces from 20.7 to 12.2 billion USD by achieving its 24.8% of total carbon emissions with carbon trading. At the same time, China gains 27.7 billion
USD from selling carbon credit. The total abatement cost of China still reduces by 11.5%, although it results in more reduction than in the no trading scenario. Generally speaking, reducing carbon emissions domestically is sometimes costly and inefficient for developed countries because of existing low-carbon intensity economic and industrial systems. Carbon emissions trading is a market-based approach used to control climate change at relative lower abatement costs. For developing countries, they can profit from carbon trading and still lower total abatement costs by selling their carbon credits. It is a win-win solution for emissions abatement.

4.2.2 Carbon price

This study considers an international carbon price (carbon trading price) and a domestic carbon price. The international carbon price is determined by using marginal abatement cost (MAC) curves, which derives from carbon credit demand and supply curves while the domestic carbon price is determined by domestic reductions and abatement costs. The prices in 2020 are given in Figure 7. The international carbon price under trading among the specified countries is 193.8 USD/tC. For domestic carbon prices, Japan decreases from 343.8 to 219.8 USD/tC and Korea from 333.9 to 204.1 USD/tC. At the same time, China increases the domestic carbon price from 19.4 to 61.4 USD/tC in that year. The increasing domestic abatement cost in China is partly compensated by the financial revenue from selling carbon credit, and of course, the improved “cleaner” environment produced by extra carbon abatement is also a valuable profit. Similar analysis can be seen in (Den Elzen et al., 2011), where the international carbon price under full emission trading is 36
USD/tCO\(_2\) (132 USD/tC) (USD in 2005). All the countries in the trading community benefit from selling or buying carbon credits, because the seller can gain revenue from a higher international carbon price (relative to domestic carbon price) and the buyer can lower their abatement cost by a lower international carbon price (relative to domestic carbon price).

### 4.2.3 Carbon leakage

Carbon leakage is defined as “the increase in CO\(_2\) emissions outside the countries taking domestic mitigation action divided by the reduction in the emissions of these countries” (IPCC 2007). It occurs when the emissions policy of a country raises its costs, then the carbon intensive industries would be shifted to another country with less stringent mitigation rules, leading to higher emissions in this country and therefore to carbon leakage. On most occasions, developed countries have strict climate policy while developing countries have less or no constraints on carbon emissions. Thus, the carbon intensive industries may then move from developed countries to developing countries. Among developed countries, carbon leakage also occurs when there are different levels of strictness, although the leakage is relatively small.

According to the definition, the carbon leakage in this study is calculated by the following equation:

\[
C_{lkg} = 1 - \frac{\sum_{r=1}^{R} (E_{ref,r} - E_{trd,r})}{\sum_{r=1}^{R} (E_{ref,r} - E_{tar,r})}
\]

(1)

Where \(C_{lkg}\) is carbon leakage in percentage. \(E_{ref,r}\), \(E_{tar,r}\) and \(E_{trd,r}\) are carbon emissions in reference scenario, emission target scenario and carbon trading scenario, respectively, for each country \(r\).

According to Equation (1), the carbon leakage shows a negative result of -1.79%, indicating that there is no carbon leakage in the carbon trading scenario and it even reduces more carbon emissions than emission target scenario. That's because the emission target is set strictly as the proposal for China and there are no carbon emission “leaks” during the carbon trading. Instead, China lowers its carbon intensity by reducing extra carbon emissions and this reduces more carbon emissions, compared to emission target scenario.

### 4.3 Discussions

This section simulates a scenario where emission trading only takes place among Japan, Korea, and China and it demonstrates the possible impact of emission trading. Of course, emission trading may occur among Japan, Korea, China and other countries in the world. In this case, the carbon emission trading may occur in some other developing countries with more relaxed constraints on carbon emissions which even make the abatement cost lower than the current results.
The results in this study present a possible development path for Japan, Korea and China as a low-carbon community.

Other Asian countries and major developed countries in the world will be added to G-CEEP model in a future study so that traditional fossil fuels such as coal, oil and natural gas, and carbon credits can be traded as commodities. The study will focuses on fossil fuels and carbon credits trading among different countries, to analyze economic and environmental effects of climate change worldwide.

5. Conclusions

Dealing with global warming, a policy framework has been proposed where achieving a Low-Carbon Society is realized by the cooperation of several countries with different economic development levels and carbon emission levels. The framework has a multi-layered structure with 4 axes, including different stages to achieve the emission target, regional linkages which include urban-rural, intercity and international linkages, policy integration and the sharing of results. A tentative exploration has been conducted in East Asia, including Japan, Korea and China. Carbon emissions trading is a market-based approach used to lower abatement costs for both carbon selling and buying countries. This research analyzes the possible impact of emission trading by simulating a scenario where emission trading takes place among Japan, Korea, and China as a low-carbon community. The results show that developed countries such as Japan and Korea will lower total reduction costs, even when the costs of buying carbon credits are counted in. Japan reduces 40.9% of its total abatement cost and Korea reduces it by 41.1% of total abatement cost, compared to the no trading scenario. For developing countries, such as China in this study, they also benefit from the selling of carbon credits. China raises the domestic abatement costs to produce extra carbon emissions for selling, but it gains financial revenue from selling carbon credit and the total abatement cost of China is still reduced by 11.5%. In addition, a “cleaner” environment provided by the relative stringent constraints on carbon emissions is also a valuable “profit” for China. The international carbon price in this carbon trading scenario is 193.8 USD/tC, lying in between the domestic carbon prices of carbon selling and buying countries. The carbon leakage in this carbon trading scenario shows a negative result of -1.79%, indicating that there is no carbon leakage and it even reduces more carbon emissions than the no trading scenario. From the analyses of MAC curves, carbon trading raises the domestic carbon price of China and China needs to improve the reduction efficiency of different abatement measures to meet the extra carbon re-
duction. For carbon credit buying countries, such as Japan and Korea, the abatement measures with low MAC are apt to be the substitute of abatement measures with high MAC, under carbon trading scenario, in order to lower the domestic abatement costs. In this sense, it is worth considering the establishment of an East Asian Low-Carbon Community to deal with the problem of global warming.

Notes
1) Calculated according to IEA (2012) and GDP uses purchasing power parities (2005 USD).
2) Calculated according to the IEA (2011)

References