Chapter 10

Circular Economy Policy in Korea

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September 2016

This chapter should be cited as

Jin, I. (2016), 'Circular Economy Policy in Korea ', in Anbumozhi, V. and J. Kim (eds.), *Towards a Circular Economy: Corporate Management and Policy Pathways*. ERIA Research Project Report 2014-44, Jakarta: ERIA, pp.163-184.

Chapter 10

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1. Background Information

1.1. Background of Korea's Circular Economy

The linear approach to industrialisation has been successful in the Republic of Korea (henceforth, Korea) for decades. Korea's gross domestic product (GDP) currently ranks relatively high in the world. It also has a very high Human Development Index (HDI), used as the common measure of the quality of life in the world. However, because Korea faces environmental resource constraints, it needs to replace its linear approach to industrialisation with circular economy, a new economic model. The binding environmental resources of Korea have become a stringent constraint as a consequence of its accelerated economic growth.

Greenhouse gas (GHG) emissions have rapidly increased in the course of Korea's manufacturing-focused industrial development. Between 1990 and 2012, the country's GHG emissions more than doubled, from 295.5 million tonnes to 688.3 million tonnes of CO_2 equivalent. One of the largest energy consumers in the world, it has also become one of the largest emitters of CO_2. As of 2012, Korea's CO_2 emissions accounted for 4.9 percent of the OECD (Organisation for Economic Co-operation and Development) total,[1] making it the fourth largest of OECD's CO_2 emitters.

GHG emissions cause climate change,[2] which in turn can cause super typhoons, floods, severe heat waves, intense cold spells, super hurricanes, droughts, desertification, collapse of ecosystems, food shortages, water resource depletion, contagious disease outbreaks, climate refugees, etc. Without appropriate mitigation actions, climate change will damage up to 20 percent of the global GDP (Stern, 2006).

[1] For more details, see IEA (2014).

[2] As much as 97–98 percent of climate scientists believe that GHG emissions cause climate change. For more details, see Anderegg et al. (2010).

Recognising that climate change is taking its toll on the globe, Korea has taken substantial actions to transit into a circular economy. Selected examples of historical, legislative, and country-specific actions may be categorised into target management system (TMS), resource efficiency programme (REP), energy recovery[3] programme (ERP), recycling technology programme (RTP), and emission trading system (ETS).

1.2. Motivation Underlying Policy Intervention

Korea has adopted various policy instruments to transform a linear economy into a circular one. Although each of the instruments appears independent from one another, all instruments are underlined by a common motivation. The Kaya identity[4] can be used to better understand the common underlying motivation. It decomposes per capita GHG emissions into three components,[5] generally presented in the form:

$$\frac{\mathrm{C}}{\mathrm{P}} = \frac{\mathrm{G}}{\mathrm{P}} \times \frac{\mathrm{E}}{\mathrm{G}} \times \frac{\mathrm{C}}{\mathrm{E}} \qquad \text{(Eq. 1)}$$

where C, P, G, and E represent GHG emissions, population, GDP, and primary energy consumption, respectively. The identity expresses, for a given time, per capita GHG emissions as the product of per capita economic output (G/P), energy intensity of the economy (E/G),[6] and carbon intensity of the energy mix (C/E). In this analysis, we use CO_2 emissions for C, GDP in 2005 thousand US$ using purchasing power parities (PPP) for G, and total primary energy supply (TPES) for E.

The rate of change (ROC) of each component could be useful to see how the current quantity changes in relation to the prior quantity. Because of possible non-linear interactions between terms, the sum of the percentage changes of the three components would not generally add up to the percentage change of per capita CO_2 emissions. However, ROC of per capita CO_2 emissions in time can be obtained from ROCs of three components as follows:

$$\frac{(C/P)_t}{(C/P)_s} = \frac{(G/P)_t}{(G/P)_s} \times \frac{(E/G)_t}{(E/G)_s} \times \frac{(C/E)_t}{(C/E)_s} \qquad \text{(Eq. 2)}$$

where t and s represent, for example, 2 different years.

[3] Energy recovery includes any technique or method of minimising the input of energy to an overall system by the exchange of energy from one sub-system of the overall system with another. The energy can be in any form in either subsystem, but most energy recovery systems exchange thermal energy in either sensible or latent form (https://en.wikipedia.org/wiki/Energy_recovery).

[4] For more details, see Yamaji et al. (1991).

[5] The three components should be considered neither as fundamental driving forces in themselves nor as generally independent from each other. For more details, see IEA (2014).

[6] Energy intensity of the economy (E/G) is a measure of the energy efficiency of a national economy, and is calculated as units of energy consumption per unit of GDP. High/low energy intensities indicate a high/low price or cost of converting energy into GDP.

Table 10.1 shows the ROC of per capita CO_2 emissions in Korea, compared with the OECD total. As of 2012, Korea's ROC of per capita CO_2 emissions was greater than 2. It means that Korea's per capita CO_2 emissions more than doubled in 2 decades. In contrast, OECD total's ROC was less than 1; that is, per capita CO_2 emissions in OECD total decreased over the period.

Table 10.1. Rate of Change in CO_2 Emissions per Capita

	Korea			OECD total		
	1990 (A)	2012 (B)	ROC (C=B/A)	1990 (A)	2012 (B)	ROC (C=B/A)
C/P[1]	5.34	11.86	2.22	10.41	9.68	0.93

CO_2 = carbon dioxide, OECD = Organisation for Economic Co-operation and Development, ROC = rate of change.
[1] In tonnes of CO_2 per head.
Source: IEA and authors' calculations.

The Kaya identity in Eq. 1 would help understand what caused the drastic increase of per capita CO_2 emissions (C/P) in Korea. Table 10.2 shows that the growth of per capita economic output (G/P) was a driving force behind it. Korea's ROC of the component outstripped OECD total's by a large margin. The force was more than offsetting the reduction of the other two components. Even more, Korea's energy intensity of the economy (E/G) decreased less than OECD total's.

Table 10.2. Rate of Change in Emission Drivers

	Korea			OECD total		
	1990 (A)	2012 (B)	ROC (C=B/A)	1990 (A)	2012 (B)	ROC (C=B/A)
G/P[1]	10.90	27.99	2.57	22.80	31.25	1.37
E/G[2]	0.83	0.79	0.95	0.78	0.56	0.72
C/E[3]	0.59	0.54	0.91	0.59	0.55	0.94

OECD = Organisation for Economic Co-operation and Development, ROC = rate of change.
[1] In thousand 2005 US$ using purchasing power parities per head.
[2] In petajoules per billion 2005 US$ using purchasing power parities.
[3] In thousand tonnes of CO_2 per petajoules.
Source: IEA and authors' calculations.

The result points out that Korea has relied on a linear approach to industrialisation. Kaya's identity suggests a strong correlation between C/P and G/P with all other factors held constant. An implicit trade-off exists between emission reduction and economic growth. Any effective regulation to reduce C/P is likely to hamper G/P in a linear approach. Thus, Korea should find novel ways of decoupling economic growth from environmental constraints. It is the underlying motivation why Korea tries pre-emptively to transform a linear economy into a circular one.

1.3. Framework of Analysis

The Kaya identity may serve well as a framework for this analysis. The decomposition points to the possibility that a well-designed mix of policy instruments would facilitate the shift to a circular economy. The goal is to search an optimal policy mix that would promote the transformation into a circular economy at a low cost. It explains why Korea has designed a national strategy which tries to implement various policy instruments in a cost-effective way.

Corresponding to Kaya's components, five critical policy instruments can be highlighted: TMS, REP, ERP, RTP, and ETS. Table 10.3 proposes the correspondence between Kaya's components and selected policy categories. TMS may be the most effective measure from the perspective of global warming. Penalty (or tax) issues in TMS may be an important matter of national policy. To mitigate the implementation cost of TMS, most countries make an effort to utilise policy categories addressed in this chapter.

Table 10.3. Correspondence between Kaya's Components and Policy Instruments

Component	Policy Category	
C/P	Target management system	Emission trading system
G/P	Recycling technology programme	
E/G	Resource efficiency programme	
C/E	Energy recovery programme	

Source: Author

2. Description of Policies Adopted

2.1. Target Management System (TMS)

TMS is closely relevant in reducing per capita GHG emissions (C/P) and, thus, is the groundwork for the overall mitigation efforts. It could also serve to support REP, ERP, RTP, and ETS instruments.

2.1.1. Goals

A direct goal of TMS is to reduce GHG emissions. TMS first sets the national midterm target, then sets sectoral reduction targets for emissions-intensive sectors: power generation, manufacturing, construction, waste management, and transport. It then imposes facility-specific mitigation targets on preselected large-scale facilities belonging to emissions-intensive sectors. Companies that fail to meet the targets are subject to penalties.

An ultimate goal of TMS is to engage all parts of society in GHG mitigation efforts. To do so, TMS tries to advance regulations in collaborating with various stakeholders: agencies, industries, and civic communities. Conditions of domestic industries would be taken into account through negotiation with participations.

2.1.2. Implementation

The workflow of TMS is subject to the Framework Act on Low Carbon Green Growth and the Guidelines for the Operation of Target Management Scheme. As a starting point, sectors accounting for the majority of emissions are identified. Next, controlled entities are designated for such sectors.[7] They submit reports on previous emissions to the controlling departments. Controlling departments and the Greenhouse Gas Inventory & Research Center of Korea (GIR) review the reports for double counting or omission. They establish facility-specific GHG emissions targets. Then controlled entities submit implementation reports to meet mitigation targets. They also submit emissions reports to show the year's emissions. Both emissions and implementation reports are first confirmed by third-party verifying institutes and then reviewed by controlling departments. Finally, those reports are submitted to GIR. If their implementation reports do not comply with the monitor-report-verification standards, controlled entities may be subject to remedial measures. The whole process is rolled out through the national GHG management system. This system collects data related to facility-specific GHG statistics. Through the system, controlling departments can access to GHG emissions data reported by controlled entities.

Table 10.4 shows sectoral GHG reduction targets rate by 2020 for seven sectors.

Table 10.4. Sectoral Reduction Targets by 2020

Sector	Reduction rate (%)	Sector	Reduction rate (%)
Industry	18.2	Agriculture, Forestry & Fishery	5.2
Power Generation	26.7	Waste	12.3
Transport	34.3	Public	25.0
Buildings	26.9	Total	30.0

Source: Greenhouse Gas Inventory & Research Center of Korea.

2.1.3. Challenges

As a mandatory regulation, TMS brings in a number of challenges to be carefully dealt with. If implemented inadequately, it might cause a big burden to controlled entities. Consequently, economic growth could be hampered because of deadweight loss by poor regulation. For cost-effectiveness, adequacy of regulation should be ensured. Guidelines related to setting targets need to be clearly articulated in advance. Double-counting or omission of entities should also be minutely checked. Implementation plans should be set up as accurately as possible. Since the role of verifying institutes is critical, they should be quite well disciplined. Controlling departments should reasonably resolve objections against designations. Altogether, prudent

[7] As of 2014, controlled entities included companies with 50,000 tCO2eq of GHG emissions and 200 TJ of energy consumption. Facilities with 15,000 t2eq of GHG emissions and 80 TJ of energy consumption were designated as controlled entities. For more details, see GIR (2014).

responses to challenges would induce the efficient achievement of targets. As spotlighted in Kaya's identity, energy efficiency improvement and renewable energy deployment are significant to reduce emissions. The design of TMS compatible with promoting REP and/or ERP is another concern.

2.2. Resource Efficiency Programme (REP)

REP tries to manage the quantity of raw materials used to convert energy into GDP. Reducing resource use can reduce GHG emissions.[8] In that sense, REP corresponds to lowering the energy intensity of the economy (E/G).[9] Practically, the energy intensity could be controlled by saving units of energy consumption per unit of GDP. The fall of E/G would result in the drop of C/P, with all other factors held constant.

2.2.1. Goals

A direct goal of REP is to reduce the amount of resource required to provide products and services.[10] For that purpose, REP tries to adopt a more efficient production process and/or to recycle resources. REP tends to facilitate products embodying less resource input. For instance, energy savings are likely to reduce energy costs, but be accompanied by additional costs of introducing an energy-efficient process. A financial cost saving to energy users can be obtained when the former more than offsets the latter. To meet such a condition, REP provides manufacturers with some incentives to improve their products' efficiency. REP also induces consumers to purchase more energy-efficient products in the market place.

A more strategic goal of REP is to enhance national security. As resource efficiency is improved, resource imports from foreign countries would decrease. Moreover, depletion of domestic resources would be slowed down.

2.2.2. Implementation

The Ministry of Commerce, Industry and Energy, through the Korea Energy Management Corporation (KEMCO), has operated EEPs. First, the Energy Efficiency Standards & Labelling Program has been in use since 1992. The label on seven target items shows the energy-efficiency grade of the model from one to five.[11] The programme is authorised by the Rational Energy Utilization Act. Next, the Certification of High Efficiency Energy-using Appliance Program has been implemented where energy-using products with relatively high level of

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[8] According to the International Energy Agency, improved energy efficiency in buildings, industrial processes, and transportation could reduce by one third the world's energy needs in 2050, and help control global emissions of greenhouse gases. For more details, see Hebden (2006).

[9] In Korea, various policy instruments have been utilised to improve energy efficiency. For example, tax breaks, loan and subsidy programmes, energy conservation technologies, various pilot projects, energy exhibition and energy service companies, etc. Here, among those programmes, energy efficiency programmes are discussed in detail.

[10] For example, the European Union (EU) currently measures resource productivity by European country and for the EU as a whole through the Eurostat system, and these statistics have shown a satisfying increase in resource productivity for the EU since 2000. For more details, see Resource (2015).

[11] The seven target items are electric refrigerator, electric air-conditioner, incandescent bulb, fluorescent lamp, self-ballasted lamp, ballast for fluorescent lamp, and passenger car. It is to encourage efficiency in the production and use of energy.

energy efficiency are certified. Government organisations should use certified products. The programme is based on the Rational Energy Utilization Act. The Energy-Saving Office Equipment & Home Electronics Program, a voluntary partnership between the government and manufacturers, has also been in use since 1999. Energy-saving products are certified if they meet the energy-efficiency guideline proposed by KEMCO.[12] One of the standards is an automatic switch to power-saving mode when not in use. Warning labels apply to products that fail to meet the standard. The programme is based on announcement No. 1998-136 of the Ministry of Commerce, Industry and Energy. Furthermore, the Average Fuel Economy regulation on cars has been introduced since 2006 where the average fuel economy of all cars sold by a manufacturer over 1 year must meet the standards. The required level varies with engine capacity. It is patterned after the US Corporate Average Fuel Economy system.

2.2.3. Challenges

From a simple engineering perspective, the improvement of energy efficiency (E/G) would reduce energy consumption all the time. However, energy consumption may not be reduced by the amount predicted by the model. It is because of the direct rebound effect. As improved energy efficiency tends to make energy services cheaper, consumption of those services may increase. Increased consumption offsets some potential energy savings. Actually, an extensive historical analysis of technological efficiency improvements has conclusively shown that energy efficiency improvements are almost always outpaced by a net increase in resource use.[13] Considering the limit of REP, ERP catches our attention.

2.3. Energy Recovery Programme (ERP)

ERP has a strong connection with the carbon intensity of the energy mix (C/E). The carbon intensity could be lowered when energy recovers from wastes. The fall of C/E is likely to cause the drop of C/P, with all other factors held constant.

2.3.1. Goals

A goal of ERP is to increase the demand and supply of energy from waste. In Korea, 84 percent of the energy supply comes from fossil-based energy sources. Thus, the deployment of energy recovery is one of the key priorities to achieve a circular economy. Increasing the use of energy from waste is the most effective strategy to move beyond oil.[14] The National Strategy for Green Growth has a target of increasing the share of renewable sources in TPES. In addition, the government plans to increase the use of nuclear power, the least expensive means to generate electricity and produces almost zero GHG.

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[12] Manufacturers of selected items can attach energy-saving labels on their products. Examples of selected items are televisions, microwave ovens, computers, and printers.

[13] For more details, see Huesemann and Huesemann (2011).

[14] Reflecting such a perspective, worldwide investment in renewable energy reached US$155 billion in 2008. It was a sevenfold increase from 2002. The United Nations Environment Programme (UNEP) has pointed out that the investment must more than triple until 2020 as global carbon emissions would have peaked by that time. For more details, see UNEP (2009a).

An affiliate goal of ERP is to reduce the generation cost of energy from waste. It would require substantial and continuous investment to foster renewable industries. The public sector should execute a significant amount of research and development (R&D) investment.

2.3.2. Implementation

The most exemplary ERP is the Renewable Portfolio Standard (RPS). RPS, applied to major power generators since 2012, obliges electricity companies to produce a certain portion of electricity from renewable sources. RPS applies to power generators with a capacity of 500 MW or more. Target generators are the Korea Water Resources Corporation and the Korea District Heating Corporation that cover a total of 13 publicly owned and privately owned power generators. Retail suppliers are not directly regulated under the RPS scheme.[15] The renewable portfolio of target generators started from 2 percent of all power generated in 2012. It should amount to 10 percent until 2022. Target generators are permitted to borrow up to 20 percent of the total amount of renewable energy they require for a given year. The borrowing comes from their renewable portfolios for the following years. They should submit the reason for borrowing and quantity to be borrowed.

Renewable energy certificates (REC) are awarded to certified eligible facilities. A renewable energy generator intending to qualify as an eligible facility must apply for the certification. The generator's renewable energy facilities should conform to designated standards for any given renewable resource. Once certified, an eligible facility is automatically registered with the new and renewable energy RPS management system. REC documents 1 MWh of electricity generation from an eligible facility. It is used to demonstrate compliance with RPS requirements.

The Ministry of Trade, Industry and Energy is responsible for announcing the amount of energy subject to RPS and may adjust the amount every 3 years based on a review of technology, performance, and other circumstances. RECs are issued by the Korean New and Renewable Energy Center of the Korean Energy Management Corporation. The issuance, trading, and tracking of RECs are done through the RPS management system.

2.3.3. Challenges

'Not-in-my-back-yard' (NIMBY) concerns may be a significant challenge to overall levels of renewable energy deployment. NIMBY is mainly stirred by visual and other impacts of renewable energy facilities and their constructions are likely to be blocked by local residents.[16] Some projects might be delayed for years just because of aesthetic concerns. So, NIMBY may cause variable or intermittent energy production.

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[15] It is because only one power retail distributor exists in the Korean market. Most big power generators are still owned by the public sector.

[16] For more details, see Schirber (2008).

The lack of government support may be another critical challenge. The private market for renewable energy technologies usually does not stand on its own feet. Government support has pulled the growth of the renewable energy industry at least in the initial phase. An exemplary programme is feed-in-tariffs. Under this programme, renewable energy generators are able to earn a premium in accordance with the price table promulgated by the government. Such government supports for ERP are likely to go along with the Recycling Technology Programme (RTP).

2.4. Recycling Technology Programme (RTP)

RTP focuses on developing cutting-edge, converged recycling technology. It goes beyond a linear relation between Kaya's C/P and G/P components. RTP could accelerate the transit into a circular economy by reconciling the rise of G/P with the fall of E/G or C/E.

2.4.1. Goals

A goal of RTP is to lower the share of resource-intensive industry in GDP. Korea's economy heavily relies on resource-intensive industries: steel, petrochemicals, and cement. They accounted for 12 percent of total value-added as of 2008.[17] A way to get away from dependence on resource-intensive industries is to raise the share of the service sector. For example, the service sector's energy intensity is less than one third of the manufacturing sector's energy intensity.

A more ultimate goal of RTP is to build the basis for circular growth. The proper management of electronic waste (or waste electrical and electronic equipment) has become a major concern due to the large volumes of the waste being generated. Also, rare metals found in discarded electronic devices can cause potential environmental impacts associated with toxic chemicals. The potential resource recovery from electronic devices is based on the development of recycling technology.

2.4.2. Implementation

In Korea, recycling technologies are treated as typical green technologies. The Key Green Technology Development and Commercialization Strategies, announced in 2009, was designed as a road map to develop green (including recycling) technologies. In the strategy, core green technologies are categorised into five groups: (i) climate change, (ii) energy source technology, (iii) technologies to improve efficiency, (iv) end-of-pipe technology, and (v) R&D in virtual reality.

More recent recycling efforts in Korea include the recycling target rates, the extended producer responsibility list, the shared responsibility of distributors with producers, and the

[17] The weight is well above the OECD average of 8 percent. Actually, it is the highest in the OECD area.

better collection system by local governments. Along with the development of advanced waste recycling technology, the regulations to encourage its producers to adopt environmentally sustainable technologies are strengthened.

In addition, the certificates programme has been introduced since 2010 where 'green certificates' are awarded to qualified firms, projects, and technologies. A firm for which certified green technology accounts for more than 30 percent of sales is certified as a 'green firm'. Green firms, projects, and technologies have been funded through green financial products. Such products invest at least 60 percent of their capital in green firms and projects. Examples are green bonds, deposits, and investment funds. Also, a green private equity fund has been launched.[18] There are tax incentives for financial instruments. Dividends and interest from green financial products are tax-exempt up to certain ceilings.

2.4.3. Challenges

A challenge is to suppress government failures which may be brought in by RTP. Initially, RTP has been introduced to cope with market failures. As the basic recycling technologies are still too far from commercial viability to attract private investment, policy intervention for recycling technology is needed. But it often brings in government failure. Unless green certificates are well designed along with exit strategies, it would result in another disruptive bubble. Such a risk needs to be managed pre-emptively. To avoid a bubble, RTP should be as neutral as possible. When RTP concentrates on basic recycling technologies, side effects of policy intervention would be minimised.

Another challenge is the reallocation of labour and capital resources across sectors during the shift towards a circular economy. For workers, labour market flexibility to promote the redeployment of workers is essential.[19] Effective training is also critical for the shift to be successful. In particular, it is important to facilitate the entry of new firms in green industries. The new entry would account for a large share of radical innovations. At the same time, the exit of firms in resource-intensive industries needs to be facilitated. Strong global competitiveness of domestic industries is prerequisite for the adoption of new recycling technology.

2.5. Emission Trading System (ETS)

ETS could encompass all components of Kaya's identity. It corresponds to C/P in that it could serve as the market pricing mechanism to meet the midterm reduction target. It could be extended to serve as a trading platform for certificates related to other components: E/G and C/E.

[18] For more details, see UNEP (2009b).
[19] For more details, see OECD (2010c).

2.5.1. Goals

A main goal of ETS is to achieve GHG emissions target in a cost-effective way. ETS is a distinguishable policy instrument based on the market mechanism. If a company needs higher cost for voluntary mitigation, it may buy emissions permits in the market. On the other hand, if a company needs relatively lower cost for mitigation, it may sell extra emissions permits to gain profits. In this way, ETS helps the national GHG mitigation target to be more efficiently achieved.

A derived goal of ETS is to relieve the industry from GHG mitigation burdens.[20] Companies are given strategic options to choose through ETS: direct mitigation, permits trading, external mitigation, and/or permits borrowing. The company may strategically choose the most advantageous way with the lowest cost. In that way, companies under ETS could flexibly respond to the changes in the global carbon market.

A more ultimate goal of ETS is to establish a market-based, cost-effective stepping stone to mutually facilitate GHG reduction and economic growth. ETS could pull a shift to a circular economy by creating a new growth momentum suitable for a circular economy. Under a successfully implemented ETS, emissions reduction is likely to be compatible with sustainable economic growth.

2.5.2. Implementation

Even before the introduction of mandatory ETS, Korea had actively utilised trading mechanisms and since 2005 has participated in Clean Development Mechanism (CDM). CDM allows emissions-reduction projects in developing countries to earn certified emission reduction (CER) credits. Each CER is equivalent to 1 tonne of CO_2. CERs can be credited to projects funded by non-Annex I countries' own money. Korean investment companies have owned CERs and sold them to any Annex-1 country in the market. In addition, the Korea Certified Emissions Reduction (KCER) was introduced in 2005. KCER market is open to firms that have reduced CO_2 emissions by more than 500 tonnes a year. KCERs can also be traded in the market.

In 2012, the Act on the Allocation and Trading of GHG Emission Permits paved the way for the introduction of ETS. The mandatory ETS has been implemented since 2015. The Ministry of Environment supervises the operation of ETS by designating participants, planning emissions permits allocation, conducting monitoring–reporting–verification of emissions estimates, and introducing penalties. The Permit Allocation Committee deliberates and adjusts ETS-related major policies such as allocation plans and market stabilisation measures. GIR supports facility-specific allocations and registries for emissions permits and offsets. Companies whose annual emission volumes exceed a quota have to purchase extra emission rights from other companies. The sum of emission quotas amounts to 1.59 billion tonnes. It is about 21 percent less than the 2.02 billion tonnes suggested by companies. A quota of 15.98 billion Korean

[20] GIR estimates that the mitigation cost under ETS accounts for only 32–57 percent of that under TMS.

allowance units (KAUs) is allocated to each company. One KAU is equivalent to a tonne of CO_2 gas. KAUs are traded at the Korea Exchange. As of 2015, 502 companies were allowed to trade KAUs at the Korea Exchange.[21]

2.5.3. Challenges

A challenge is to operate ETS in a cost-effective way. Too stringent emissions quota would end up compromising the desperate efforts to boost the sagging economy. Governments usually encourage big companies to invest because it is one of the most time-efficient ways to revitalise the economy. Putting a cap on emissions would compromise much of the effect, unless ETS is operated as intended. Industrial sectors are concerned about the possible negative impact on their international competitiveness. Manufacturing firms subject to ETS would be reluctant to make a large-scale investment on their home soil. On the other hand, excessive quota would cause the price of KAU to converge to zero and make ETS malfunction. The supply–demand discrepancy may set off conflicts between controlled entities and controlling departments.

3. Outcomes and Impacts

Up to this point, major policy instruments are identified within Kaya's identity. The goal, implementation, and challenges of each instrument have been discussed briefly. We now analyse the performance of policy instruments. For that, the logic model is utilised.

The logic model is useful in evaluating the performance of government programmes whose intended result is not to achieve a financial benefit. In such situations, a programme logic model provides indicators in terms of output, outcome, and impact measures of performance. The output of government programmes can be measured in terms of the amount of money spent on a programme (e.g. their budgets), and/or the amount of work done (e.g. number of workers or number of years spent). Often, such as in TMS, REP, ERP, RTP, and ETS, the impact is long-term mission success far into the future. In those cases, the intermediate or shorter-term outcome may indicate progress towards the ultimate long-term impact.

Although it is relatively easy to measure the output, it is a poor indicator of goal achievement.[22] On the other hand, the outcome is a better indicator to show that the programme really meets the intended goals.[23] Government programmes are likely to begin by

[21] Examples of such companies are Samsung Electronics, Hyundai Motor, POSCO, Hyundai Heavy Industries, and Lotte Department Store.

[22] The workers may have just been 'spinning their wheels' without getting very far in terms of ultimate results or outcomes.

[23] Although outcomes are used as the primary indicators of programme success or failure, they are still insufficient. Outcomes may easily be achieved through processes independent of the programme and an evaluation of those outcomes would suggest programme success when in fact external outputs were responsible for the outcomes. For more details, see Rossi et al. (2004).

declaring grand new programmes and causes. But good beginnings do not guarantee the success of such programmes. What matters in the end is outcome and impact. Therefore, this analysis focuses on outcomes to evaluate the performance of government programmes.

It seems still early to verify the short-term outcome or long-term impact of policy interventions (TMS, REP, ERP, RTP, and ETS). It would take a few more years before outcomes of such programmes could be clearly recognisable. The logic model used in this analysis can be regarded as a formative evaluation during implementation to offer the chance to improve the programme. The short-term outcomes and long-term impacts of each policy instrument are investigated here within Kaya's identity.

3.1. Outcomes and Impacts of TMS

Since TMS was established only in 2012, reliable data about the short-term outcome are not available yet. It may take a few years to confirm that TMS is effective in achieving the midterm (2020) mitigation target. Although limited, some insights about the short-term outcome can be identified in terms of per capita CO_2 emissions. Table 10.5 shows that Korea's per capita CO_2 emissions continuously increased between 2008 and 2012. The upward trend is more clearly displayed through its ROC. On the other hand, OECD's per capita CO_2 emissions slightly decreased during the period. The difference can be zoomed in through the comparative indicator, which is calculated as the ratio of Korea's per capita CO_2 emissions over that of OECD. In sum, Korea's TMS has not achieved the expected outcome until now.

Table 10.5. Per Capita CO_2 Emissions

Year	Korea* (A)	OECD* (B)	ROC ($C = A_t / A_{2008}$)	Comparative (D = A / B)
2008	10.3	10.5	1.000	0.982
2009	10.6	9.8	1.025	1.076
2010	11.4	10.1	1.107	1.134
2011	11.8	9.9	1.147	1.198
2012	11.9	9.7	1.149	1.225

OECD = Organisation for Economic Co-operation and Development, ROC = rate of change.
* In tonnes of CO_2 per head.
Source: IEA and authors' calculations.

However, Korea's TMS has earned positive reviews for long-term impact. Its GHG reduction efforts have been internationally recognised. For instance, Korea's climate change policy ranked second best in the 2010 CCPI evaluation. The pre-emptive policy intervention also enables Korea to get well prepared for carbon-related international trade barriers. If mitigation goals are successfully met, Korea could reinforce its international status as one of the leading countries in GHG mitigation.

TMS has laid the groundwork for sustained reduction of GHG emissions. Cost-effective mitigation strategies for buildings, transportation means, and industrial sectors have been set up. It is mandatory for controlled entities to report their GHG emissions. Carbon information is more easily available through the national GHG inventory reporting system. In the end, a long-term national GHG reduction target from 2020 onwards is about to be established.

3.2. Outcomes and Impacts of REP

The short-term outcome of TMS seems to fall short of the mark. The shortfall may be accounted by the economic growth. It manifests the importance of controlling resource use during the economic growth. Most of all, the output of sector-specific energy saving programme to cut the energy intensity has been more or less effective. For example, AFE programme boosted average fuel economy from 10.8 km/litre to 11.5 km/litre between 2006 and 2008, and contributed 7.3 percent CO_2-emissions reduction.

The short-term outcome of REP can be evaluated in terms of energy intensity of the economy. Table 10.6 shows how Korea's energy intensity has dropped since 2008, shown more definitely through its ROC. However, Korea falls behind OECD with respect to the pace of enhancement in energy intensity as the comparative indicator distinctly reveals. Even worse, the gap has been expanded. In sum, the short-term outcome of Korea's REP can be regarded as outstanding even though the pace needs to be accelerated.

Table 10.6. Energy Intensity

Year	Korea* (A)	OECD* (B)	ROC ($C = A_t / A_{2008}$)	Comparative (D = A / B)
2008	8.34	6.90	1.000	1.209
2009	8.41	6.83	1.008	1.231
2010	7.91	5.97	0.948	1.326
2011	7.95	5.75	0.953	1.384
2012	7.88	5.61	0.944	1.406

OECD = Organisation for Economic Co-operation and Development, ROC = rate of change.
* In petajoules per billion 2005 US$ using purchasing power parities.
Source: IEA and authors' calculations.

The long-term impact of REP would be more evident in the future. The Systematic Implementation of the National GHG Emissions Reduction Roadmap was announced in 2014. GHG from the transportation sector will be reduced through expansion of ITS, pay-per-mile car insurance, car-sharing systems, and low-carbon vehicles such as the bus rapid transit. In addition, the efficiency of various facilities and equipment will be improved. For instance, the Building Energy Management System and the Home Energy Management System will be introduced and disseminated. Furthermore, policies will be adopted to reduce GHG in the areas of public sector, agriculture, forestry, fishery industries, and waste.

3.3. Outcomes and Impacts of ERP

The short-term output of ERP can be shown through the contribution of energy recovery to TPES. As of 2007, Korea's share of non-renewable waste in TPES was one of the lowest in the OECD area. Table 10.7 shows the weights of renewable energies and energy from waste in TPES since 2008. The contribution from renewable energies has continuously increased, but falls short of initial expectation. The weight of non-renewable waste remained flat until 2010, but has jumped up since 2011.

Table 10.7. Contribution from Renewable Energies and Energy from Waste

	2008	2009	2010	2011	2012
Renewables*	0.594	0.654	0.712	0.733	0.749
Non-renewable waste*	0.890	0.850	0.874	0.987	1.051

* % contribution to TPES (total primary energy supply).
Source: IEA and authors' calculations.

ERP to increase the demand and supply of non-renewable waste has not shown a tangible outcome. The short-term outcome of ERP can be shown in terms of carbon intensity of energy mix. Table 10.8 shows that Korea's carbon intensity of energy mix presented neither an upward nor downward trend within a 5-year span. The pattern of its ROC was practically the same. However, the comparative indicator between Korea and OECD has fallen into a gentle gradient since 2009, maybe due to the relatively fast uptake of low-carbon technologies in Korea. For instance, Korea's use of nuclear energy has been enlarged to reduce CO_2 emissions from power plants.

Table 10.8. Carbon Intensity of Energy Mix

Year	Korea* (A)	OECD* (B)	ROC ($C = A_t / A_{2008}$)	Comparative (D = A / B)
2008	52.8	55.8	1.000	0.947
2009	53.7	54.9	1.018	0.978
2010	53.9	55.2	1.021	0.976
2011	54.1	55.5	1.025	0.974
2012	53.8	55.3	1.018	0.973

OECD = Organisation for Economic Co-operation and Development, ROC = rate of change.
* In thousand tonnes of CO_2 per petajoules.
Source: IEA and authors' calculations.

3.4. Outcomes and Impacts of RTP

An output of RTP can be assessed by indicators to show the status of green R&D. Table 10.9 shows Korea's total R&D, green technology (GT) R&D, and core GT R&D during the first-year (2009–2013) plan. The GT R&D has increased at the compound annual growth rate (CAGR) of 11.7 percent. It is higher than the total R&D's CAGR of 8.6 percent. It is noteworthy that the CAGR of core GT R&D is even higher. The relatively higher CAGR suggests that more R&D investments have been allocated to green technologies.

Table 10.9. Green R&D (trillion ₩)

Year	Total R&D	Green Technology (GT) R&D	Core GT R&D
2009	12.41	1.95	1.43
2010	13.68	2.24	1.71
2011	14.85	2.55	1.98
2012	15.91	2.71	2.06
CAGR (%)	8.61	11.73	13.00

CAGR = compound annual growth rate, R&D = research and development, ₩ = Korean won.
Source: Green Technology Center Korea.

The short-term outcome can be assessed to determine whether RTP has contributed to the economic growth with GHG emissions controlled. Table 10.10 shows the ROC of each component of Kaya's identity. The declining trend in ROC of E/G shows that the short-term outcome of REP is positive. In contrast, the flat ROC of C/E demonstrates that the short-term outcome of ERP falls short of its goal. Much less, those outcomes are overwhelmed by outstanding pace of economic growth (G/P). Altogether, the short-term outcome of RTP is disputable.

Table 10.10. Rate of Change in Emission Drivers

Year	C/P	G/P	E/G	C/E
2008	1.000	1.000	1.000	1.000
2009	1.025	1.000	1.008	1.018
2010	1.107	1.143	0.948	1.021
2011	1.147	1.175	0.953	1.025
2012	1.149	1.195	0.944	1.018

Source: IEA and authors' calculations.

3.5. Outcomes and Impacts of ETS

The short-term output of CDM was satisfactory. As of 2010, Korea has 35 CDM projects registered with renewable energy projects accounting for a third of them. Another 47 projects are in the process of registration. The United Nations Framework Convention on Climate Change (UNFCCC) predicts that Korea's registered projects would reduce CO_2 equivalent by an average of 15 million tonnes per year, a 4.4-percent reduction of the total. Korea ranks fourth behind China (59 percent), India (12 percent), and Brazil (6 percent).

The short-term output of voluntary carbon market was not satisfactory. In practice, there were few buyers, given the lack of a domestic reduction obligation. Thus, the government bought most KCERs to compensate efforts to reduce GHG emissions. As of 2009, 5.6 million KCERs have been generated from 287 projects. The government purchased 4.7 million of total KCER for ₩23 billion (US$20 million).

The short-term output of ETS since its launch is disappointing. Trading has been minimal so far because corporations are uncertain about the volume of GHG that they would emit in the future. On the first trade, KAU trading volume reached 1,190 tonnes. Additional 190 tonnes were traded in the next 4 days. Since then, there is no trade of KAU because of shortage of sellers in the market.

To ensure a soft landing of ETS, the offset credit trading was commenced on 6 April 2015. The GHG emissions reduced by entities other than corporations subject to TMS are certified for emission allowances. Corporations allotted the emission allowances can request the conversion of the certified offset credit into Korea Credit Unit (KCU). KCUs can be traded in the emissions trading market of Korea Exchange Corporations subject to TMS are able to trade KAUs and KCUs. In the first week, 79,658 tonnes of KCUs were traded. The listing of KCUs is expected to stimulate more brisk trading in the emissions trading market.

The short-term outcome of ETS is not yet certain. It can be assessed to see whether the emissions trading market is vitalised. The successful implementation of ETS would construct the foundation for a market-friendly, cost-effective GHG reduction. The institutional basis for a linkage with an offset mechanism is already formed. Roles of the market and the private sector would be broadened by successfully implementing the linkage. Eventually, enhancing the market function of emissions reductions would spread a circular lifestyle applicable to everyday life.

4. Implications for ASEAN Countries

Hereafter, a set of policy actions for decision makers in ASEAN are recommended. It aims to work collectively and beyond them. Future research directions for scholars are also provided.

4.1. Setting Pre-emptive Target

Korea ratified the Kyoto Protocol to the UN Framework Convention on Climate Change (UNFCCC) as a non-Annex I country. Thus, it has no obligation to set a specific GHG-reduction target. However, it has been pre-emptively involved in the CDM since unilateral projects were allowed. Unilateral CDMs are funded by developing countries' money and not by Annex-1 countries.

Finalising the national midterm target shows that Korea has pursued a pre-emptive strategy to transit towards a circular economy. The business-as-usual scenario (BAU) was a rise of 36.9 percent in GHG emissions between 2005 and 2020. Three initially considered options were to cut emissions by 21 percent, 27 percent, or 30 percent relative to the BAU. Those options implied an 8-percent increase in emissions, no change, or a cut of 4 percent relative to 2005, respectively. Each option was analysed based on Korea's capacity to make reductions and the subsequent macroeconomic impact. Finally, the most ambitious option of a 30-percent reduction was selected as the national midterm target.

The midterm target of Korea is thus positioned between the advanced countries and developing countries. The 2020 targets for Japan, the US, and the EU are approximately 30-percent, 17-percent, and 13-percent reductions relative to 2005, respectively. Those targets still require larger emissions reductions. Mexico has also pledged to reduce emissions by up to 30 percent relative to its BAU baseline by 2020 on the condition of adequate financial and technology transfer mechanisms from developed countries. In contrast, Korea's target is not conditional on international agreements and support. Although not legally binding, the target is guiding Korea's climate change policy framework.

The target under TMS is highly significant as it provides a foothold prior to post-2012 climate change negotiations. In 2015, the Korean government announced it will reduce GHG emissions by 37 percent from the previous projected emission levels for 2030.

4.2. Comprehensive Framework

The shift to a circular economy may require a national strategy that encompasses various policy instruments in a comprehensive framework. Individual policy instruments tend to focus on certain aspects of the transition. The effect of an instrument might be offset by the effect of another. Thus, it is important that policy instruments be orchestrated within a comprehensive framework. The national strategy based on Kaya identity could be used as a cornerstone.

Korea has made intensive efforts to develop a comprehensive strategy at the national level. In 2008, Low Carbon/Green Growth was proclaimed as the nation's vision to guide its development during the next 50 years. In 2009, the first Five-Year (2008–2013) Plan for Green Growth was announced along with the National Strategy for Green Growth to expedite policy implementation at the central government level. Also, the midterm target for national GHG reduction was announced. In 2010, the Framework Act on Low Carbon/ Green Growth was enacted, covering the economy, industry, national territory, environment, and public conduct. In 2011, the Act on the Creation and Facilitation of Use of Smart Grids was enacted as the legal basis for building smart grids. In 2012, the Act on the Allocation and Trading of Greenhouse-Gas Emission Permits was legislated to establish the institutional foundation of the ETS. In 2014, the second Five-Year (2014–2018) Plan for Green Growth was announced to actively use the institutional foundation built during the past 5 years.

Developing countries like those in ASEAN may be willing to begin the shift to a circular economy through various policy instruments. When strategically approached, it would be helpful to derive an optimal policy mix at the national level. For instance, they may use the national strategy and/or the 5-year plan encompassing all major policy interventions: TMS, REP, ERP, RTP, and ETS. The successful transit towards a circular economy may require a socio-economic system. Focused efforts through national initiatives would be essential for the settlement of a sound institutional foundation. An example of such an initiative may be the recycling of resources throughout the entire manufacturing process: factor input, production, use, disposal, and recycling. The governing principle is to firmly establish 3R (reduce–reuse–

recycle). ETS could easily be extended to a more comprehensive certificate trading about resources recycling, and the twin pillars of sustainable energy policy: REP and ERP.

4.3. Taking Practical Actions

The national strategy to pursue circular economy needs to be developed. The impact of the industry sector may be evident in a decomposition of final resource consumption by sector. Compared with developed countries, a developing country would rely more heavily on its industry sector. Nevertheless, the service sector's energy intensity is generally less than that of the manufacturing sector. Thus, a strategy to the share of service sector in total value-added would help a developing country follow the growth path towards a circular economy.

The practical approach to dealing with oppositions from the private sector would be critical. As mentioned, NIMBY (not-in-my-backyard) concerns are likely to be severe obstacles against deployment of renewable energy. A national strategy to particularly develop cooperative structures may be essential as it would help the overwhelming majority of locals believe that renewable energy resources can enhance the neighbourhood.[24] It is obvious that projects are generally more likely to succeed if they have broad public support and the consent of local communities. To do that, a say and a stake need to be given to communities. It is noteworthy that many renewable energy projects are owned by communities in countries such as Germany and Denmark.[25]

Policy instruments relevant to daily living activities are fundamental. Korea uses a system to effectively collect garbage waste and reuse natural resources.[26] Under the system, recycling is mandatory, and garbage must be separated accordingly as common garbage, food waste, recyclable, and large waste objects. Such policies exist throughout the country. Recycled items can be disposed of in any clear plastic bag or divided by items and bound. Containers should be rinsed or washed before disposal. Recyclable waste should be placed in designated areas outside the building. Because some items such as batteries, cell phones, unused medicine, etc. require careful disposal, a separate container for such items should be in place. It is recommended that unused medicines be taken to the nearest drug store for proper disposal. Most large apartment complexes have marked boxes for recyclables. Houses and small apartments/villas should place in position net bags for recyclables.

4.4. Global Cooperation

A key obstacle to the implementation of ETS is concern about its impact on the international competitiveness of domestic industries. A strict ETS may successfully reduce emissions domestically but cause an increase in emissions in neighbouring countries, a phenomenon called carbon leakage. If ETS of a country raises local costs, then another country without ETS

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[24] For more details, see Gourlay (2008).
[25] For more details, see http://www.korea4expats.com/article-waste-disposal-recycling-korea.html
[26] For more details, see http://www.korea4expats.com/article-waste-disposal-recycling-korea.html

may have a trading advantage. If demand for these goods remains the same, production may move offshore to the cheaper country without ETS, the reason companies seem to be overly anxious about the burden of ETS.

Although there is yet no consensus on the magnitude of long-term leakage effects, it manifests the importance of global cooperation. Carbon leakage is a type of spillover effect, which can be positive or negative. For example, ETS might lead to technological developments that aid global reductions. To amplify positive externalities, carbon leakage may be controlled through changes in trading patterns. An exemplary case is to measure the balance of emissions embodied in trade.

Moreover, as more countries take ETS, the positive externalities would get larger. Fortunately, ETS has been successfully introduced in many countries and the market-based environment policy is currently being executed in over 30 countries. In EU, ETS has been implemented since 2005. In New Zealand, a national-level ETS has been implemented since July 2010. In the US, a state-level ETS has been implemented in California. In addition, ETS implementation has been prepared in developing counties such as China, Taiwan, Chile, and Turkey.

Even before ASEAN member states establish ETS domestically, they could participate in CDM projects. CDM constitutes the official international carbon market together with ETS and the Joint Implementation under the Kyoto Protocol. CDM allows emission-reduction projects in developing countries to earn CER credits. Non-Annex I countries owning CERs can sell them to any Annex-1 country in the market. Annex I countries can use CERs to meet a part of their emissions-reduction targets under the Kyoto Protocol. It would be helpful to set up the National GHG Management System. Its role may be to operate ETS, allocating allowance unit across sectors, and verify ETS-related statistics. The role to cooperate with international organisations is also played by the National GHG Management System.

4.5. Maintaining Balance between Penalties and Incentives

The cost-effective implementation of policy instruments would serve as the groundwork for national GHG mitigation efforts. For that purpose, the balance between penalties and incentives needs to be strategically maintained.

As for the penalty, fines under TMS and taxes in energy prices can be managed. The ratio of environmental taxes over total tax revenue may be a key indicator. Tax reforms to raise the ratio may be considered and the share of taxes in energy prices may be another indicator. For example, the government can raise the tax on fossil fuel–based energy sources such as diesel, gasoline, LPG butane, light fuel, and heavy oil. The higher prices would help slow down the consumption growth of such energy sources. Closing the gap between domestic and international fossil fuel prices could cut GHG emissions in ASEAN countries (Burniaux et al., 2009). Generally, feed-in-tariffs could be assessed on each energy source. The renewable energy generators earn a premium in accordance with the price table promulgated by the government. It usually represents the difference between the market price of electricity and the power production cost using renewable resources. Feed-in-tariffs would promote the distribution of renewable energy technology.

As for the incentive, voluntary emissions-reduction targets may work well. The firms may be eligible for low-interest-rate loans on energy-saving facilities, tax benefits, and technical support. Although voluntary approaches are not cost-effective in addressing environmental externalities, they can reveal information about abatement costs and environmental damage at an early stage (de Serres et al., 2010).

Under the mandatory scheme, the government needs to flexibly respond to voices from controlled entities. During the initial stage, companies under TMS and/or ETS would receive carbon allowances for free. Revenues generated from ETS operation (fees, fines, etc.) should be spent to advance circular economy. A couple of options can be used for TMS to operate more smoothly. For instance, voluntary mitigation outside ETS may count towards mitigation targets under ETS. Borrowing from future permits and banking of permits may be allowed. Companies that overachieve mitigating targets can earn rewards by selling or banking extra permits. Overall, public–private partnerships can be invigorated.

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