Chapter 11

Low-Carbon Management of POSCO in Circular Economy: Current Status and Limitations

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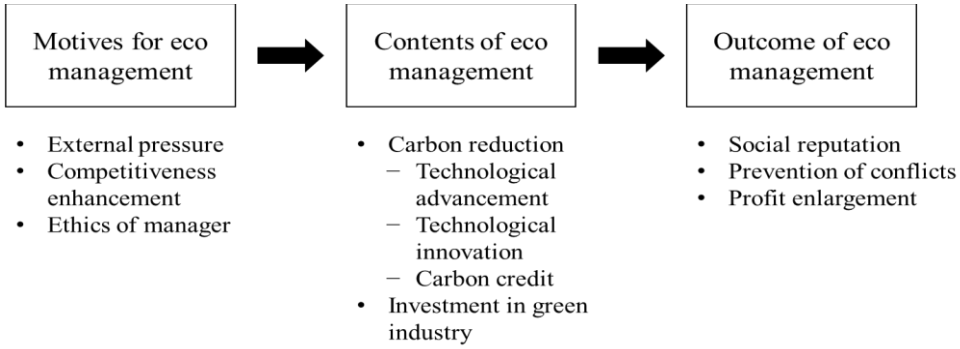
1. Introduction

In this chapter, we present a case analysis of POSCO, a steel-making company in the Republic of Korea (henceforth Korea). In analysing the case, we referred to POSCO's 2014 annual report on carbon management. Since 2009, POSCO has been annually publishing carbon-management reports in Korean and English. Since this 2014 report summarises POSCO's efforts in reducing carbon emissions in a year, it highly fits our case analysis. In addition, we interviewed some POSCO employees to obtain internal information about the company's green management.

Figure 11.1 shows the theoretical model used for our case analysis. This model was developed from the survey of past studies about green management. Thus, three issues framed this case analysis.

- What are POSCO's major motives for circular economy?
- What has POSCO done to reduce greenhouse gas (GHG) emissions? How much investment has POSCO made in green industries?
- What are the positive or negative impacts of POSCO's circular economy?

Figure 11.1. Theoretical Model of Circular and Green Management



Source: Author.

1.1. Overview

Established in 1968, POSCO operates two integrated steelworks in Pohang and Gwangyang in Korea. In 2012, it achieved US$35.7 billion of sales of crude steel and 3.8 million tonnes of steel production, resulting in US$2.8 billion of operating sales. This confirms POSCO's 1st ranking in the steel industry in Korea. Despite the deteriorating business environment caused by various factors in recent times, POSCO has endeavoured to raise its market share in the domestic market and has posted profitability by expanding sales of high-value-added products. POSCO has likewise reinforced its activities related to research and development for new products and steel-processing technology. In addition, the company's global expansion is progressing with the construction of galvanised steel plants in India and China, stainless-steel cold rolling mills in Viet Nam, and operational factories in India, Indonesia, Mexico, and Viet Nam.

POSCO's management performance on sustainability has been recognised early by domestic and international institutions. From 2005 to 2012, POSCO was listed in the Dow Jones Sustainability Index, a global evaluation index for sustainability. From 2010 to 2012, POSCO earned first place in the global steel makers' competitiveness as indexed by the World Steel Dynamics, the leading steel information service firm in the US. In 2012, it occupied the 30th place in the Global Sustainability 100 companies of the World Economic Forum, a meeting for political and business leaders to create the foremost global partnership of business, political, intellectual, and other leaders. It was also named the best company in the Carbon Disclosure Leadership Index by the Carbon Disclosure Project Group Committee.

The opportunities and threats to POSCO's carbon management are summarised in Figure 11.2. Extreme weather conditions cause operational deterioration as a result of difficulty in acquiring raw materials and unreliable water supply which leads to increased production cost. Also, the threat of a decrease in global competitiveness is expected as carbon regulations are introduced to the industry. With the strengthening of regulations on carbon emissions, a decrease in steel production is expected. On the side of opportunities, the dominance of green markets will lead to the development of energy-efficient steel that can provide the early

markets with new products. As of now, the demand in the transport sector for high-performance steel is increasing. Other opportunities for the industry are increase in demand for renewable steel, involvement in green industries and renewable energy projects, and reinforcement of stakeholder awareness through external evaluation and transparent disclosure of information.

Figure 11.2. Threats and Opportunities

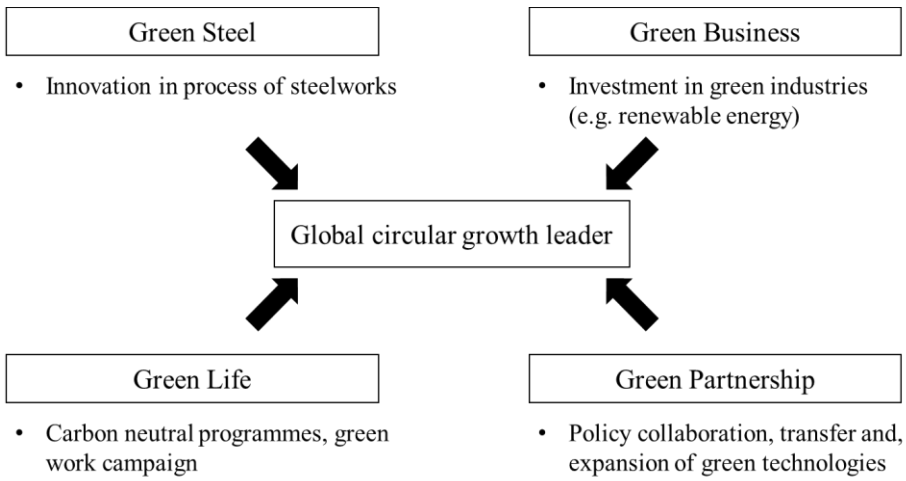
Threats	Opportunities
• Flood and drought – Deterioration of operational condition – insecurity of raw materials and water – Increase in distribution costs • Costs for compliance to carbon regulation – Decrease in global competitiveness • Restriction on total carbon emission – Decrease in production of steel • Increase in social responsibility for major emitting firms	• Domination of green markets – Development of energy efficient steel • Increase in demands for renewable steel • Participation in green industries • Innovative technological development – Differentiation of competitiveness • Transparent information on external evaluation – Raise in market recognition

Source: POSCO Carbon Report 2014.

As the steel industry pushes forward with new projects, POSCO aims to add 70 million tonnes of steel to the global production system by 2020, develop steel-based materials and eco-friendly materials for the materials sector, and foster renewable energy projects.

Green steel, green business, green life, and green partnership comprise POSCO's green management envisioned for 2020. Green steel targets carbon reduction in the production process through improvement of energy-saving and efficiency processes. Green business implements renewable energy projects such as wind power, fuel-cell generation, and waste resource recovery, while participating in green industries like smart grids and lithium material. Green life includes green walk campaigns to encourage employees and their families to practice green life and support carbon-reduction projects. Green partnership encourages carbon policies for domestic and foreign cooperation and strengthens corporate activities for a low-carbon society. Figure 11.3 shows the areas of POSCO's green management.

Figure 11.3. Four Areas of Circular and Green Management



Source: POSCO Carbon Report 2014.

In February 2010, POSCO announced its voluntary GHG target of reducing the amount of CO_2 emissions per tonne of crude steel from 2.1 tonnes to 1.98 tonnes or a 9-percent reduction by 2020. In conjunction with the plan to reduce the use of coal materials, the company plans to invest ₩1.5 trillion by 2018 to improve energy efficiency. Under the Basic Act on Low Carbon Green Growth, the Korean government implements the Energy Target Management and sets 12.5 thousand tonnes of CO_2 emissions as the target goal for firms. From 2012, 458 firms have been designated by the Energy Target Management to carry out this goal. In 2012, POSCO was given the target goal of reducing its carbon emissions to 96.3 thousand tonnes.

POSCO's emissions-reduction efforts have shortened its process of steel production and reduced its CO_2 emissions to 77 million tonnes in 2012 compared to 79.29 million tonnes in 2011. Compared to 2011, POSCO's crude steel production increased by 1.8 percent while CO_2 emissions diminished by 1.5 percent. CO_2 emissions per tonne of produced steel decreased by more than 3 percent, from 2.10 tonnes to 2.03 tonnes, an indication of energy efficiency. To improve its process for producing molten iron, POSCO has reduced its coal consumption and increased the amount of scrap metal used. POSCO has also reduced by 1.02 million tonnes the CO_2 emissions of its transported ingredients, by 5.6 thousand tonnes the transport of employees, and by 1.5 thousand tonnes its domestic and foreign business trips. For example, POSCO employees have passionately participated in commuting by bicycle and cutting down unnecessary foreign business trips. Innovation in steel production is also significant as shown by the 659 thousand tonnes CO_2 reduction as a result of the upgraded car fuel efficiency which came from high-strength automotive steel production, the 2.51 million tonnes of CO_2 emissions reduction through the use of low iron-loss electronic steel which increases a steel's energy efficiency, and the 6.29 million tonnes of CO_2 emissions reduction as a result of a blast furnace slag which generates a substitute ingredient for eco-friendly cement in construction of the steel production process.

Table 11.1 shows the 13 issues POSCO has identified and prioritised in carbon management:

Table 11.1. Issues in POSCO's Circular and Green Management

Rank 2012	Rank 2011	Issues
1	6	Climate-change response strategies
2	1	Corporate policy to reduce carbon emission
3	3	GHG-emissions reduction efforts of POSCO family
4	4	Performance of carbon management
5	7	Activities to reduce GHG emissions at sites
6	5	Carbon disclosure
7	2	New green business
8	12	Carbon management governance
9	8	GHG reduction target
10	11	GHG-emissions reduction through products and by-products
11	10	Management risks related to climate change
12	9	Carbon accounting
13	13	Participation in carbon market

GHG = greenhouse gas.
Source: POSCO Carbon Report 2014.

1.2. Motives

What are the drivers of POSCO's green management? What has made POSCO's management pay attention to green management? In management theory, economic rationality and social rationality form the backgrounds of managerial decision-making (Oliver, 1997). Economic rationality means that the aim of decision-making is to use internal resources optimally and to maximise corporate performance. In contrast, social rationality makes managers decide in the process of adapting to outside pressures; this decision provides the firm with social legitimacy. Which is more important in understanding the motives of POSCO's green management?

An interview with a POSCO executive shows both factors are found. First, the efforts to reduce GHG emissions can reduce costs in the manufacturing process. Success in energy efficiency leads to cost reduction in energy consumption. Second, the attitude of the management toward carbon reduction is not very aggressive. As with most Korean companies, the biggest reason behind managerial concern for green management is government regulations. For example, the Korean Energy Control Enterprise has set GHG emissions targets for large Korean companies and has been pushing them to reach this target.

Academic literature on circular economy stresses the importance of proactive attitude of corporate management to adapt to outside pressure about carbon emissions reduction. Managers should be able to use the pressure for low-carbon economy as a new growth opportunity. In POSCO, the proactive attitude of the management seems to be very weak. Although managers have recently begun to consider the necessity of carbon-emissions reduction, they have yet to imagine the strategic adaptation to low-carbon pressures.

1.3. Greening the Steel Production

This part addresses how POSCO attempts to reduce CO_2 emissions in the steel production process.

1.3.1. Energy efficiency

POSCO's struggles for energy efficiency are divided into three periods. In the first period (1999–2008), POSCO invested ₩1.43 trillion in energy facilities and saved 2.91 tonnes of oil equivalent of energy due to agreement with the government on voluntary energy reduction. In the second period (2009–2015), small and medium-sized investment projects for energy efficiency were conducted. Most large energy-recovery projects were completed. The government's Energy Target Management has been in operation since 2011; ISO 50001 was adopted in 2012. In the third period (2016–2020), POSCO will bring in innovative technologies beyond the limits of current technologies.

Activities to improve energy efficiency are the following:

- Most by-product gases from the steel process are used to recover the energy source.
- To raise self-efficiency in blast furnace by-product gas, combined cycle power plants were established in Gwangyang in 2010 and in Pohang in 2013.
- From 2011, task-force-teams have worked to increase the efficiency of combustion heat-generation in the entire steel factories.
- From 2012, NOx discharge from the combustion plant has been suppressed and steel mill pulse combustion technology has been developed to improve combustion efficiency.
- By utilising advanced information technology, including the smart grid, POSCO tries to accomplish energy efficiency and cost savings.
- By utilising skylights, lighting viscous and automatic control system, and LED lighting, POSCO has improved the working environment and reduced electricity costs.

1.3.2. Process improvement techniques

POSCO will develop and utilise innovative technologies in the future.

- In steelmaking process at Ilgwan steel works, scrap metal issued in the converter to lower CO_2 emissions, and a new type of heat converter has been developed to increase the limit from 15 percent to 50 percent of the conventional scrap usage.
- Using ammonia, technologies have been developed to absorb and separate CO_2 from the blast furnace by-product gas.
- By utilising PSA techniques, the optimal separation processes and adsorbent for the separation of CO and CO_2 have been developed since 2011.
- From 2009, techniques for improving the energy efficiency of steel process to recover the heat held by the high temperature slag have been developed.
- A power-generation system, which simultaneously absorbs the source of heat generated from heating the steel mill and converts it into electric power, is being developed.
- In preparation for the era where massive clean hydrogen manufacturing system is possible, POSCO is developing technologies to replace coals with hydrogens, thereby reducing iron ores.

1.3.3. Carbon management system

POSCO conducts the following for an effective green management at firm level.

- From 2006, POSCO has followed its guidelines for unique carbon estimation based on global standards such as those of the Intergovernmental Panel on Climate Change, the World Business Council for Sustainable Development, the World Resources Institute, the World Steel Association, and the ISO14404. From 2011, POSCO has set up an internal GHG management system in accordance with the action plans of the GHG Energy Target Management of the Korean government.
- The ISO 50001 (energy management system) was finalised in June 2011. POSCO set a task force in January 2012 and acquired the ISO 50001 certification in September 2012.
- An incentive programme has been devised for those in production units who achieve reductions in GHG emissions by their energy efficiency improvement activities.

1.3.4. Circular thinking in business

The necessity for climate change mitigation and carbon-emissions reduction may financially cost heavily for a firm, but new business opportunities can be made by strategic actions.

- By producing and distributing energy-efficient steel products, POSCO is ready for the low-carbon economies. With lightweight and high-strength automotive steel, the weight of a car is lightened by 10 percent and the amount of carbon emissions is reduced by 5 percent. By distributing high-energy efficient electric steels to generators, power-transmission and distribution transformers, and motors, energy efficiency is increased in the final products.

- By utilising the slags generated in the process of steel production, renewable slags are recycled as raw material of cement or as aggregate substitutes. In 2012, 6.29 million tonnes of CO_2-emission reduction was realised by using 8.01 million tonnes of slags as substitute for cement.

- From 2005 to 2011, POSCO participated in GHG-emissions reduction projects conducted by the Korea Energy Management Corporate and earned 3.55 million tonnes of carbon credits by increasing its electric power generation through energy efficiency in steelworks and by reducing GHG through renewable energy. In 2008, POSCO earned 27,000 tonnes of carbon credits per year for 10 years for the United Nations Framework Convention on Climate Change's approval of its Gwanyang Small Hydro Power as a Clean Development Mechanism (CDM) project. Moreover, POSCO gained 21,000 tonnes of carbon credits per year for 30 years by joining in the forest project in Uruguay and taking part in the Future Carbon Fund of the Asian Development Bank and the carbon credit funds of the Ministry of Knowledge Economy.

- In 2012, POSCO completed the construction of a 12-MW solar power plant in Sinan Country, South Jeolla Province. By extension, a 40-MW wind power plant was assembled in Taegi Mountain in Gangwon Province in 2008 and, for the first time in Korea, an offshore wind power plant with total 30-MW scale is being planned to be constructed in Jeju Island in partnership with Doosan Heavy Industries.

- For the waste-energy project, POSCO is pushing its power-generation projects using household wastes and district heating supply project using sewage heat. In 2012, the company installed 100 kW of fuel cells at Seoul Seobuk Hospital and Seoul Children's Grand Park. It has also started to build a fuel-cell power plant at an amusement park in Jakarta, Indonesia, and has contracted with the Fuel Cell Energy in the United States for transferring cell-manufacturing technology.

- In 2012, POSCO invented a direct-extraction technology of non-evaporative lithium, a core ingredient in mobile phones and electronic car batteries, and entered a joint

venture for a lithium battery business with Korea Resources Corporation and a Bolivian state-owned company.

1.4. Social Innovations for Circular Economy

1.4.1. Green community

As a GHG-emissions reduction project, POSCO's carbon-neutral programme was launched in 2009 with support from civic organisations, housewives, and students. Participants in this programme are encouraged to propose new ideas to offset carbon emissions. The most doable suggestions can get corporate sponsorship. In 2012, for instance, teams of university students were selected for sponsorship and their projects conducted to propagate carbon-neutral awareness among students.

1.4.2. POSCO family green walk campaign

Launched in 2011, the POSCO Family Green Walk Campaign targets POSCO's employees and their families to acquire green habits through four energy-saving actions: walk, turn-off, reduce, and recycle. They can post ideas and achievements on the Green Walk homepage and ear green coins that can be used to purchase green books or donate them to people vulnerable to climate change.

1.4.3. Green steelworks

Steelworks in Gwanyang and Pohang encourage their employees to commute by bicycles or inner-circle vans. Starting April 2012, Pohang steelworks has designated every Monday as bicycle commuting day and bought 4,000 bicycles for the project. With the help of the city of Pohang, POSCO employees can use three bicycle-only lanes that connect workers' residences to their workplace. A mileage system has also been adopted where workers can get 10 credits of mileage when commuting by bicycle, which can be used for buying company concert tickets and renting sports and recreational facilities.

1.4.4. Energy-saving and power-saving activity

Where electricity supply is unstable, POSCO has prepared various energy-saving plans to raise the awareness of their employees regarding energy saving and response to the government policy on climate change. Pohang steelworks has initiated power-saving taskforce teams to enhance energy efficiency and has succeeded in saving ₩5 billion using cheaper night-time power. At Gwangyang steelworks, shop floor units are taking measures to save energy by adjusting the time to change rolls. POSCO's other energy-saving projects include modifying the grey water facility, installing a boiler waste heat-recovery facility, and setting up an energy patrol team.

1.5. Partnership for Circular Economy

POSCO was the only steel maker in the world to be selected in the Carbon Disclosure Leadership Index for its transparent disclosure of carbon information in governance, risks and opportunities, strategies, GHG emissions, and communication (Han, Sung-Hee from Manager, POSCO Environment & Energy Department). The company continuously fulfils its obligations to build a green economy while cooperating closely with its stakeholders to achieve actual reduction of GHG emissions.

1.5.1. Carbon disclosure

Since 2003, POSCO has been participating in the Dow Jones Sustainability Indexes and Carbon Disclosure Project by disclosing activities related to climate change and CO_2 emissions. By doing so, POSCO earns positive evaluation from the external institutions.

The Dow Jones Sustainability Index annually releases its list of 300 corporations whose sustainability indices belong to the top 10 percent. For 8 consecutive years since 2005, POSCO's good performance has been noted; it topped the environment score in 2012. In 2010, among all steel makers in the world and the 500 corporations listed by the Financial Times Stock Exchange, POSCO was rated as good performer at Carbon Disclosure Leadership Index and Carbon Performance Leadership Index by the Carbon Disclosure Project and, in 2012, took the first place in the Carbon Disclosure Leadership Index. In the Environmental Tracking Carbon Ranking released by the Environmental Investment Organization, POSCO was selected as one of the top 10 among Asian and Pacific firms.

1.5.2. Climate action by the World Steel Association

POSCO has also been involved in the global steel makers' climate change programme by the World Steel Association. To upgrade the steel industry's reduction technology, POSCO has been participating in Worldsteel CO_2 Breakthrough Programme since 2003, the year the programme started. The CO_2 capture method developed by Worldsteel has been raised to global standard through the establishment of ISO methodology.

1.5.3. Global partnership for energy efficiency

In July 2010, the Global Superior Energy Performance Partnership initiated by the Clean Energy Ministerial raised attention to the need for energy security by reducing energy consumption in industrial and commercial buildings. POSCO joined in the steel working group of sectors that comprised the partnership. In Global Superior Energy Performance Partnership, where there are six working groups, POSCO is participating in one of them: steel working group. POSCO attended the workshop held in Tokyo in March 2012 to discuss the working group's activities and plans.

Table 11.2. Goals for the GSEP Steel Working Group

1	Develop and implement energy management system for steelworks.
2	Develop and implement methodology to use, improve, and verify performance index.
3	Identify and disseminate technologies, including technologies that can be commercialised for reducing CO_2 emissions from iron-and steel-making through energy saving and other breakthroughs.
4	Disseminate information on the steelmaking industry's burden on the environment and facilitation of resource recycling.
5	Exchange information on financial support for carbon policy and technology dissemination of the steelmaking industry.

Source: POSCO Carbon Report 2014.

2. Discussion

In this chapter, we investigate and discuss the comparative review of existing research and case studies as summarised above.

Circular economy at the corporate level in extant studies have been organised into (i) carbon reduction in offices and factories by technological change, (ii) introduction of innovative technologies on carbon reduction, (iii) participation in the carbon market, and (iv) investment and participation in the green industry as a new growth industry. Although POSCO's circular economy and management approaches appear in all areas, the efforts on the first and second parts are relatively more strongly represented than the third or fourth. To illustrate, POSCO's crude steel production in 2012 increased by 1.8 percent than that in 2011 whereas its CO_2 emissions were reduced by 1.5 percent. This implies that POSCO has succeeded in reducing CO_2 emissions by improving its energy efficiency and processing technology. In addition, because reducing GHG has been part of the government's management system since 2011, POSCO was motivated to aggressively participate in carbon reduction.

The fourth part of circular thinking and management is awareness for new business opportunities in green industries and creation of new revenue streams. POSCO's carbon report suggests two activities on this: utilisation of slags generated in the steel-making process and supplying energy-efficient steel for generators or motors. Such activities, however, are still at the initial stage. Besides, POSCO fosters the establishment of solar and wind power plants and participates in other energy projects such as those concerning fuel cells and lithium batteries.

The third area is participation in the carbon market. Introduced in 2015, the carbon market in Korea was still at the beginning stage in 2016. In overseas markets, however, a firm can earn carbon credits by joining in CDM projects as POSCO has done by participating in Gwangyang small hydro and Uruguay forest projects.

The POSCO carbon report mostly deals with the content of green management and barely touches on results and motives of green management. Green business motives are usually

organised into institutional pressure from the outside, preceding efforts of companies to improve competitiveness, and ethics of managers. Of these, institutional pressure is considered as the first motive for green management. As explained in the case of the government's GHG target management, institutional pressure is the most powerful initiative and is regarded as coercive pressure (DiMaggio and Powel, 1983). Nevertheless, it may not be to the interest of POSCO, one of the major conglomerates in Korea, to cite external regulatory pressures as reason for its green management. Rather, disclosing the second or the third motive may be more advantageous, especially the second motive of improving competitiveness as it suits more POSCO's status as a leading firm in the market.

Previous studies suggest that firms proactively respond to calls for social responsibility and environmental management (Aguinis and Glavas, 2012). Unfortunately, however, the important issues discussed above are not fully explained in POSCO's carbon report. Because of the importance of corporate social responsibility and sustainability, it is necessary for POSCO to show how it plans to contribute to the society while catching business opportunities and reacting to changes with proactive attitude.

In short, POSCO can describe in detail the institutional pressures that push its green management. As a competitive firm, it should recognise the changing environment and counter it with proper strategies and by being responsive to environmental changes. Lastly, it should address its managers' ethical and strategic intentions by presenting in detail the managerial policies of its CEO on green management.

Omitted in this discussion are POSCO's resource and experiences which can be the basis in propelling green management. In theories on corporate strategy, resource-based views are considerable in researching green management (Wenerfelt, 1984; Barney, 1990).

Performance, the last part of circular management, is rarely dealt in POSCO's carbon report. It is important for POSCO's green management to specify the internal and social impacts of its green management as its value may fade away if it does not produce positive impacts on society and on its competitiveness and performance as a firm. Although not easy, it is important to calculate its investment in green management and how it has contributed to the firm's revenues. Thus, estimating the causal relationship between green management and corporate financial performance or social performance is required.

2.1. Implications for Policymakers

Governments should be able to make the private sector participate in creating circular economies. An effective mechanism for public–private partnership should be developed. To realise such mechanism, governments are required to understand why firms want to invest in circular economy. In our research model, outside pressure, competitive improvement, and corporate ethics are pointed out to be reasons why firms participate in green movement.

Exact understanding of the motives of corporate green management can lead to the development of sound government policies.

As green growth is being paid attention to climate change, energy crisis, and economic downturn, circular economy can be an opportunity for a firm's sustainable growth. Although some firms have been interested in circular principles, there are some hindrances for firms to actively invest in such fields.

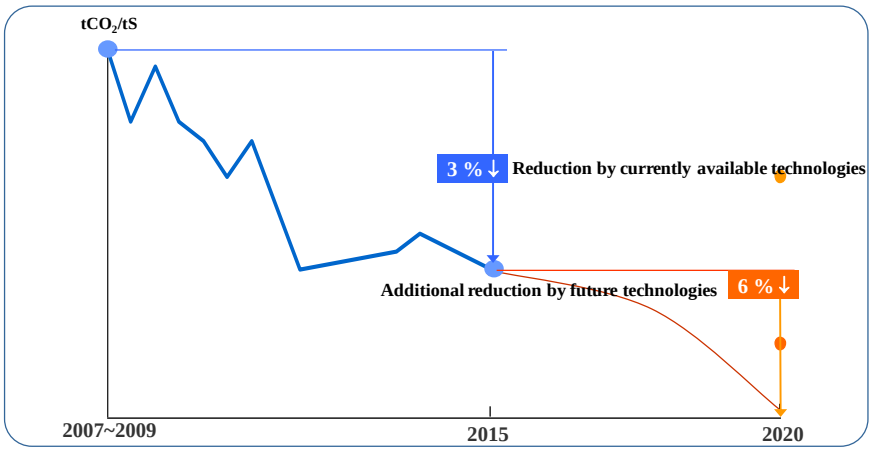
Following are the reasons firms cannot easily invest in the circular economy. Policymakers should consider the following issues to help green management of corporations. First, as the demand for green products or services is not sufficient, firms cannot proactively invest in green industries. Second, products and services in the market are very limited and consumers hardly have enough information about resource-efficient products or services. Third, the global standard for circular economy is immature. If circular economy is certified by internationally recognised institutions, many small and medium-sized firms will participate in the circular economy movement.

2.2. Implications for Corporate Managers

Among the 100 firms listed by the Davos Forum in 2012, POSCO was ranked the 30th most eco-friendly firm. For several years, the motivation for POSCO to reduce GHG is mostly attributed to the need for energy efficiency. The following implications are developed from the experience of POSCO.

First, technological improvement is critical in reducing carbon emissions. By using all available technologies on raw-material reduction and energy efficiency, POSCO, from 2007 to 2009, reduced GHG emissions to 2.09 tonnes of CO_2/tS. POSCO plans to invest about ₩150 billion in CO_2-reduction innovation technology to lower CO_2 emissions by 6 percent by 2020. New technologies on energy efficiency and clean energies are to be developed to create a circular economy.

Figure 11.4. CO_2 Reduction Plan of POSCO (2015–2020)



Source: POSCO Carbon Report 2014.

Second, various programmes to attract voluntary participation from the society may offset the pressure for carbon-emissions reduction from outside stakeholders. A social programme of POSCO is to let all types of members in the society voluntarily take part in carbon neutralisation.

Third, corporate responses to climate change need to be systematically consistent across the firm. The POSCO headquarters in Seoul launches some strategies on climate change, plans CDM projects, and invests in renewable energy businesses. Two major plants in Pohang and Gwangyang perform energy-efficiency projects and measure carbon emissions. The POSCO research institute conducts studies on climate-change policies in the world and suggests effective responses in the new environment. POSTECH, a university famous for science research in Korea, develops energy-efficiency technologies. As affiliated companies of POSCO, they remain consistent in creating synergy in all sorts of circular economic activities.

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