Master's Thesis

Low Carbon Green Growth Policy and Energy Security in Korea

: A Research and Assessment of the Impact of Low Carbon Green Growth on Korea's Energy Security

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Graduate School of Seoul National University

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저탄소 녹색성장 정책과 한국의 에너지 안보

: 저탄소 녹색성장의 한국 에너지안보에 대한 영향 연구 및 평가

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Abstract

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The goal of the study is to examine the impact of low carbon green growth on Korea's energy security. In parts, by empirically assessing Korea's energy security, the study also aims to indicate which energy security dimensions should be improved in order to increase Korea's energy security (or alleviate energy insecurity).

As an empirical analysis to study how Lee Myung Bak government's "Low Carbon Green Growth" has been affecting energy security in Korea, the time scope of this study will be based on each three years of 'pre-green growth

period (2006-2008)' and 'green growth period (2009- 2011)'. Admittedly, it might be premature to evaluate a nation's strategy based on three year period. Therefore, the paper attempts to identify the change between the two periods and puts its value to becoming the first try to do so.

Before going into the assessment of the impact of Korea's national green policy on Korea's energy security, the study first lays out the conceptual framework of energy security. The study looks at the traditional definition and concept of energy security, and in attempt to expand the concept in hopes to have it adapted to current global issues the paper introduces new concepts of energy security as well. Many scholars have studied Korea's low carbon green growth policy and energy security. However, it is somewhat hard to find from these studies the direct link of Korea's low carbon green growth policy to Korea's energy security. Therefore this paper attempts to discover how the low carbon green growth policy has affected and changed Korea's energy security.

By reviewing studies in the new and traditional concepts of energy security, the analytical framework of the study is deductively arranged. And to make the analytical framework, relevant materials in the assessment and evaluation of energy security was referred, such as articles and publications from relevant journals and institutes. For the analysis, the study first examines the 8 dimension of energy security and attempts to introduce a more integrated

approach with an expanded concept of energy security.

The study then discusses the emergence of Korea's low carbon green growth policy and its relation to energy security. The study identify and assess the impact of low carbon green growth policy on the dimensions of Korea's energy security including energy supply, efficiency, economy, environment, technology, international corporation and policy. The intended contribution of the study is the policy recommendation to enhance and develop Korea's energy security policy from the findings of this empirical analysis.

The study shows that Korea is going in accordance with the green growth policy and therefore is securing its energy security in energy supply by renewable source, energy efficiency, energy economy, and technology. Through the assessment of the eight dimensions, thirteen factors out of eighteen showed expected outcomes, in accordance with green growth policy. However, five factors from *Efficiency*, *Environment*, *Nuclear Energy*, and *Policy* were retrogressive to the expected results. The findings and reviews in Chapter 5 answer the reasons to this discrepancy.

Admittedly, three year range might not be sufficient and even premature to assess a nation's policy. However, looking into the stream whether it is going in order or retrogressing, and if so what is causing such consequence—what is going well and what is not, and to discuss the future

direction of Korea's Green Growth policy, is the goal of this study.

Although this study accepts criticism of imprecise elaboration and analytical limitations as an impact assessment in terms of time scope and methodology, this endeavor expects to contribute to stimulate and diffuse analytical concerns on the impact of Korea's globally known green growth policy stream on energy security in academic communities of international corporation and security as well as in relevant fields in social sciences.

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Keywords: Energy Security, Korea, Low Carbon Green Growth
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Chapter 1

Introduction

1. Goal of the Study

Energy security is a concept signifying that a stable and reasonable supply of energy is important, for it is the foundation of all economic activities and is deeply related to national security. The world now is facing an environmental crisis represented by climate change, with its overwhelming scientific evidence, and at the same time a resource crisis with high oil prices.

The climate change issue, in particular, is threatening the lives of human being, destroying the ecological order and inducing climatic damage. And according to the Stern Review (2006)[1], energy efficiency and diversification of energy sources and supplies support energy security, as do clear long-term policy frameworks for investors in power generation. Carbon capture and storage is essential to maintaining the role of coal in providing secure and reliable energy for many economies.

[1] As the internationally recognized report on the effect of climate change on the world economy, the Stern Review on the Economics of Climate Change in 2006 states that climate change is the greatest market failure with the cost of 5 to 20 percent loss of global gross product.

While developing countries' economic development and world population growth are accelerating the energy price increase due to energy and resource depletion, developed countries have already been focusing on the efficient and environmentally friendly use of resources. However, oil importing countries will remain dependent, to a large extent, on the oil coming from politically unstable parts of the world and from suppliers that may actively use oil as a 'political weapon' (May, 2010).

Developed countries and European Union are promoting green industry growth by green technology development and environmental regulation. For example, Brazil has supported the development of a biofuel industrial sector for decades. China is subsidizing research and development (R&D) and industrial production of photovoltaic (PV) panels, most of which it exports. Morocco is investing public resources in producing electricity from concentrated solar power and plans to sell renewable energy to Europe[2]. The United States, on the other hand, is working for energy independency by developing renewable energy, and putting effort to become a leading role in international society for the climate change issue. And as with oil dependency, according to World Watch Institute, the broader energy security threats cannot be eliminated in a short term. But immediate steps to invest in

[2] The World Bank, Inclusive Green Growth: The Pathway to Sustainable Development, *Chapter 3: Green Innovation and Industrial Policies:1,*May 2012

a diverse, decentralized energy system that relies more heavily on domestic renewable resources will allow the United States to steadily enhance its security enhance its security in the years ahead (World Watch Institute, 2006).

Green growth secures increasing attentions in international community of sustainable development. On June 25, 2009, ministers from 34 countries, at the OECD Meeting of the Council, adopted the Declaration on Green Growth declaring that they will: "Strengthen their efforts to pursue green growth strategies as part of their responses to the crisis and beyond, acknowledging that green and growth can go hand-in-hand." They endorsed a mandate for the OECD to develop a Green Growth Strategy, bringing together economic, environmental, social, technological, and development aspects into a comprehensive framework (OECD, 2011b)[3].

With the energy prices becoming steeper, the existing type of growth became unsustainable as it harms the environment. And the existing ones facing the economical limit, new growth engines such as 'Green Industry', 'Green Technology' are now being established. Moreover, with the energy security becoming one of the leading issues with increasing attention being paid, in Korea, to deal with the difficulties that the international society now

[3] The Strategy responds to that mandate. It forms part of the OECD contributions to the Rio+20 Conference in June 2012.

faces in energy security and climate change, the national vision of low-carbon green growth was presented by former president Lee Myung-bak in an address on August 15, 2008.

Korea is the tenth largest energy consuming country in the world[4]. However, 97 percent of energy depends on oversea import. And as the climate change issue becomes more serious, the international society will impose stronger regulation to carbon emitting countries, and therefore Korea as well. Accordingly, global society has continuously discussed the international conferences and agreements on climate change. In Korea, with the announcement of "Low Carbon Green Growth" in 2008, the 'First Master National Energy Plan" was establish in August 27, 2008. In September 11, 2008 the "Strategy for the Development of Energy Industry" and in May 26, 2009 the "Strategy for the Development of New Growth Engine Vision", "Green Growth National Strategy and Five Year Plan" was established one after another, and the Presidential Committee on Green Growth (PCGG) was organized in November 8, 2008 in order to push ahead with theses plans and strategies. Moreover, "Framework Act on Low Carbon, Green growth" was enforced in April 14, 2010 to provide an institutional support. And as Korea regained its status as a non-permanent member of the United Nations

[4] U.S. Energy Information Administration, http://www.eia.gov/countries/cab.cfm?fips=KS (Last Visited May 6, 2013)

Security Council in October 2012 and also become the headquarter of the Green Climate Fund[5], the leading role and contribution of Korea in adapting to the global climate change and energy security will become more influential in global society.

Korea is among the global leaders of this rising trend. Green growth has been a keyword. And to implement the national vision the Presidential Committee on Green Growth was established under the direct supervision of former President Lee Myung-bak in November 2008. However, no serious attention is given to the impact of Korea's green growth policy on conceptualization and analytical framework of Korea's energy security yet. The recognition of this problem is the motivation of this thesis.

The research questions of the study are as the followings: How do we conceptualize the energy security in the age of global climate change in comprehensive terms? For the analysis, what dimensions of the energy security concept are analyzed? And what are the impact and the background

[5] In late 2010, the world's governments recognized a goal to keep the global temperature increase below 2 degrees Celsius (°C) in comparison with pre-industrial levels. Further, the Cancún Agreements have begun to anchor the emission reduction pledges made at the 2009 Copenhagen session in the formal United Nations Framework Convention on Climate Change (UNFCCC) process. There was also agreement to create a Transitional Committee to design a Green Climate Fund that could become an important vehicle for delivering climate change finance to developing countries and contribute to the goal of mobilizing USD 100 billion per year by 2020 from various sources, including public and private financing, from developed to developing countries(OECD, 2011a: 14).

of the outcomes of the newly emerged Korea's low carbon green growth policy on Korea's energy security?

Before going into the assessment of the impact of Korea's national green policy on Korea's energy security, the study first lays out the conceptual framework of energy security. The study looks at the traditional definition and concept of energy security, and in attempt to expand the concept in hopes to have it adapted to current global issues the paper introduces new concepts of energy security as well. For the analysis, the study first examines the dimension of energy security and attempts to introduce a more integrated approach with an expanded concept of energy security.

The goal of the study is to examine the impact of low carbon green growth on Korea's energy security. In parts, by empirically assessing Korea's energy security, the study also aims to indicate which energy security dimensions should be improved in order to increase Korea's energy security (or alleviate energy insecurity).

Admittedly, three year range might not be sufficient and even premature to assess a nation's policy. However, looking into the stream whether it is going in order or retrogressing, and if so what is causing such consequence—what is going well and what is not, and to discuss the future direction of Korea's green growth policy, is the goal of this study.

In the field of international cooperation and security, the academic concern for Korea's national green growth policy has not attracted much attention. Therefore, the contribution to the diffusion of the analytic concern for energy security, in relation to green growth, in the field of international cooperation as well as in the academic community of global green growth is the expected value of this study.

2. Scope and Method of the Study

As an empirical analysis to study how Lee Myung-bak government's "Low Carbon Green Growth" has been affecting energy security in Korea, the time scope of this study will be based on each three years of 'pre-green growth period (2006-2008)' and 'green growth period (2009-2011)'. As mentioned earlier, it might be premature to evaluate a nation's strategy based on three year period. Therefore, the paper attempts to identify the change between the two periods and puts its value to becoming the first try to do so.

By reviewing studies in the new and traditional concepts of energy security, the analytical framework of the study is deductively arranged. And to make the analytical framework, relevant materials in the assessment and evaluation of energy security will be referred. For the study, articles and

publications from relevant journals[6] and institutes[7] are also referred.

3. Value of the Study

Scholars have studied Korea's low carbon green growth policy for many years. As Zelenovskaya points out, while many countries have not yet started applying the Green Growth Strategy in their national policies, South Korea is the first country in the world to make it a national one (Zelenovskaya 2012). To improve Korea's energy independence, the first goal of the National Strategy for Green Growth aims at developing an extensive application of alternative energy technologies. This could also help to achieve its national goal of reducing GHGs to 244 million tons in 2020 (a 30% decrease compared to a business as usual projection). The South Korean government, thus, prioritized the following ten strategic-energy technologies in order to support and invest in their Research and Development (R&D). These technologies are: high-efficiency photovoltaic (PV) cells, fuel cells,

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[6] *Journal of Energy Security Energy Policy*
International Journal of Green Energy
Journal of World Energy Law & Business

[7] Global Green Growth Institute http://www.gggi.org/
UN ESCAP http://www.greengrowth.org/
Institute for the Analysis of Global Security (IAGS) http://www.iags.org/
US Energy Security Council http://www.usesc.org/energy_security/index.php

advanced nuclear power, green cars, smart grid, advanced carbon capture and storage (CCS), water treatment, rechargeable batteries, Light Emitting Diodes (LED), Green IT. [And] consequently, Korea plans to become a world leader in the emerging "green" global market for goods and services (Zelenovskaya 2012).

According to some scholars energy security is simply the availability of sufficient supplies at affordable prices; different countries interpret what the concept means for them differently. For Korea, energy security could mean balance of its scarcity of resources through diversification, trade and investment. Lee‘s administration had made energy security a national goal and had embarked on new action plans. These plans are well known as energy diplomacy. The main objectives of South Korea‘s energy security strategy can be summarized as follows: diversification of sources of energy and suppliers, consolidation of strategic oil reserves, conservation, rationalization and the quest for efficiency, and development of resources abroad. Therefore, in an attempt to secure primary energy sources and to escape from the extreme reliance on the Middle East, Korea has been trying to diversify its import sources. However, the dependence on that region still is very intense, for example: Korean deal on development of oil fields with UAE in March 2011 (Barbieri 2011).

Many scholars have studied Korea's low carbon green growth policy and energy security. However, it is somewhat hard to find from these studies the direct link of Korea's low carbon green growth policy to Korea's energy security. Therefore this paper attempts to discover how the low carbon green growth policy has affected and changed Korea's energy security.

Chapter 2

Conceptual and Analytical Frameworks

1. The Concept of Energy Security

1-1. Traditional Definition of Energy Security

Energy security usually is defined as "[r]eliable supplies at [a] reasonable price".[8] The concept of energy security is based on the concept of security in general. So it is appropriate to begin a discussion of energy security by clarifying what is meant by the word "security" as it relates to military and non-military policy (D. von Hippel et al., 2011).

[8] See e.g. Proninska, Kamila: Energy and security: regional and global dimensions, in: SIPRI Yearbook 2007- Armaments, Disarmament and International Security, Oxford University Press, 2007, p.216 and Yergin, Daniel: Ensuring Energy Security, Foreign Affairs, March / April, Vol. 86, No. 2, p.70

Hippel mentions Tanaka[9]'s definition that raises three key questions or components of security policy that are as follow: what to protect, what risks to be protected from, and how to protect. On the other hand, according to previous research, energy security is defined as the availability of a regular energy supply at an affordable price (IEA, 2001). It is also construed as mostly securing access to oil and other fossil fuels (D. von Hippel et al., 2011). The concept of energy security, as Hippel points out, is based on the concept of security in general. Therefore, it is appropriate to begin a discussion of energy security by clarifying what is meant by the word "security" as it relates to military and non-military policy.

Moreover, as Pant argues, the integration of economies has helped disperse growth beyond the location of developed countries, which has, in turn, corrected energy inequalities as well. The wealthiest 20 percent of the world consumes 80 percent of the resources, while about 1.6 billion people lack access to modern energy services (Pant, 2010). And energy security reflects the constant and multifaceted interaction between the domestic and the international (Ciuta, 2010).

In the United States, for example, though securitization of energy needs could be traced back to the early 1970s when the Organization of the

[9] Tanaka, Akihiko, 1997. Anzen Hosho: Sengo 50 Nen no Mosaju ("Security: 50 Years of Trial and Error"), Yomiuri Shimbun.

Petroleum Exporting Countries (OPEC) decided to fix oil prices and the Arab oil exporters put an embargo, it was in the 1940s that the United States (US) President, Franklin D. Roosevelt, defined energy as a vital component of national security; hence justifying the protection of the Saudi Arab royal family in return for privileging US access to Saudi oil (Pant, 2010).

Energy Security can also be described as "the uninterrupted physical availability at a price which is affordable, while respecting environment concerns"[10]. As Center for Strategic and International Studies (CSIS) and the World Resources Institute (WRI) note, it is "difficult to define energy security and even more challenging to articulate meaningful security goals"(Ladislaw, Sarah D. et al. 2008). However, it is not so difficult to notice that energy security has become one of the dominant international issues for quite some time now.

A report on National Security Consequences of US Oil Dependency by the Council on Foreign Relations (CFR) in October 2006 further underlined the need to deploy military forces to ensure energy supplies if so required (Pant, 2010). A 2005 study by the U.S. Department of Defense found that renewable energy can enhance the military's mission, providing flexible, reliable, and secure electricity supplies for many installations and

[10] International Energy Agency website, www.iea.org (Last visited November 29, 2012)

generating power for perimeter security devices at remote installations (World Watch Institute, 2006).

> *In a security environment that presents increasingly strong incentives to shift force structure and doctrine toward irregular warfare, counter-terrorism, constabulary operations, and so on, the possibility of war to seize or defend energy resources provides a much-needed rationale for preserving the heavy conventional forces that still consume the lion's share of defense spending around the world. This is especially true of naval building programs, whose ostensible purpose is always presumed to include securing the sea lines of communication that connect the producers and consumers of oil (Moran and Russell, 2008).*

Energy security, however, is also a global issue that requires global cooperation and assistance. Therefore, a more integrated approach with an expanded concept of the term is necessary. Energy is essential to improving the quality of life and opportunities in developed and developing nations. Therefore, ensuring sufficient, reliable and environmentally responsible supplies of energy at prices reflecting market fundamentals is a challenge for our countries and for mankind as a whole (G8 Summit 2006). Therefore, in today's world, all countries have to worry about this fundamental question: "How can sustainable growth be maintained with sufficient energy supplies, yet without damaging the whole planet?" (May, 2010).

Moreover, as Sovacool puts it, energy security is commonly

understood as the ‘availability of energy at all times in various forms, in sufficient quantities, and at affordable prices’ (United Nations Development Programme, 2000). It is also defined as how to equitably provide available, affordable, reliable, efficient, environmentally benign proactively governed and socially acceptable energy services to end-uses (Sovacool et al. 2011).

Along with the traditional concept of “security”, energy security has been construed as a part of a national security issue. So in a simple traditional sense, as one country’s dependence on imported oil increases, in contrary, the country’s security declines. In other words, a country’s energy security could be improved if it moves from its current way of dependency on imported energy such as oil, fuel, or natural gas. Moreover, improving efficiency and promoting diversifying and flexibility within the energy sectors will take the pressure off a country’s energy prices and security.

Energy security ‘covers many concerns linking energy, economic growth and political power’ (Westminster Energy Forum, 2006a: 9). In a narrower sense, it is defined as the ’reliable and adequate supply of energy at reasonable prices’ (Bielecki, 2002: 237), or ‘securing adequate energy supplies at reasonable and stable prices in order to sustain economic performance and growth’ (APERC, 2003: 4).

The concept of energy security is often based on the concept of security in general (PARES, 1998) and usually defined as “reliable supplies

at a reasonable price, or in a commonly cited definition is "the availability of adequate, reliable, and affordable energy supplies"[11]. However, energy security is more than sustainability, competitiveness and secure supply (Baumann, 2008), and the problem lies that most analyses typically focus on isolated energy security concerns, such as oil import dependence or electric reliability, rather than a broader notion of energy security (Britt et al, 2009).

Although many authors describe the definition of energy security in various ways, it still seems difficult to define energy security in one sentence. However, Von Hippel's approach is fundamental yet interesting. Hippel argues that oil remains the dominant fuel in the total primary energy supply picture. And therefore, it is the dominant "what" to be protected in conventional energy security thinking. Moreover, sudden oil disruption or sudden price shock is a critical risk to be protected from ("what risks to be protected from"). And since prevention is the best way to minimize the risk, keeping a friendly diplomatic relations with oil supplier countries (stable oil supply), while at the same time shifting away from heavy dependence on oil are the major policy measures of large oil-consuming countries (reducing oil dependency) is critical.

[11] Organizations that have used this or similar definitions for energy security include: the International Energy Agency, the European Commission, the Energy and Natural Resources Committee of the United States Senate, along with many others.

1-2. Expanded Comprehensive Concept of Energy Security

Those who define the concept of energy security in a narrow sense tend to concentrate on the "security of supply". Thus, they focus mainly on the security issues concerning the access to the energy sources, transport routes, power plants, etc. This aspect is reflected in NATO's approach as well (Shea, 2006). And Energy security is just one of many foreign policy objectives for many countries, especially the Organisation for Economic Cooperation and Development (OECD) countries. Their energy security objectives must be balanced against combating terrorism, slowing the spread of weapons of mass destruction; and encouraging democracy and human rights, economic growth and environmental protection. Energy dependence, therefore, constrains the OECD countries from pursuing other important foreign policy objectives (May, 2010):

> *At present, almost two billion people do not have access to commercial forms of energy and another billion have only periodic unreliable access. If about half of the world's population continues in this condition, the world as a whole faces a significant threat to stability and the quality of life everywhere (WEC 2007: 72).*

In other words, global energy security depends on the pace with which these numbers are reduced. With billions joining the energy market,

supplies have to expand exponentially. The expansion of energy supplies from new sources becomes the necessary condition for global energy security (Pant, 2010). And the value of energy security issue is, as May puts it, because 'energy is life, and no life is possible without energy' (May2010).

There were, however, many attempts to expand the concept of energy security by a number of authors. Ciuta points out that the energy security issue has been an inauspicious terrain for security theory. And that the proliferation of energy security discourses has established the legitimate association of energy and security, and prevented a closer conceptual and normative attention to energy security. However, as Ciuta argues, the study of energy security suggests that categories and practices of security cluster contextually according to different meanings produced by situated actors. Moreover, Von Hippel argues that national energy policies in the new century are facing challenges on multiple fronts. The substances of such challenges need to be incorporated into a new concept of energy security. And it is important to note that energy security policies in various countries are now showing trends of "convergence" rather than "divergence", despite the basic differences in concepts of energy security (D. von Hippel et al., 2011).

Pant argues that increasing integration and interdependence among the energy suppliers and consumers and the location of the energy industry in the globalizing market has necessitated the re-definition of energy security

both at the conceptual and policy level (Pant, 2010). Furthermore, Baumann argues that defining energy security not only from the normative end but from the input side where private or political actors can add to a higher level of safety, four dimensions can be identified: i) International policy dimension, ii) Economic dimension, iii) Geopolitical dimension, iv) Security policy dimension. (Baumann, 2008).

Nagy mentions, however, according to a number of authors, the definition of energy security is related to the category of "macro-level security." This means that definitions can be connected to the security of energy supply and satisfying the energy needs of a given state or country (Nagy, 2010). And I agree that it seems essential that the energy security should be given a broader definition, in a way that it would suit global relations. While Nagy suggests that the solution to the problem may be found by expanding the concept of society's needs, it leaves room for questions whether it is enough. Agreeing with the idea that the concept of energy security shall be expanded from the traditional approach, the question remains whether it will be expanded enough by expanding the concept of society's need alone.

In the same context, Von Hippel argues that many of the existing definitions of energy security begin, and usually end, with a focus on maintaining energy supplies—and particularly supplies of oil. And that this

supply-based focus has as its cornerstones reducing vulnerability to foreign threats or pressure, preventing a supply crisis from occurring, and minimizing the economic and military impact of a supply crisis once it has occurred. Hippel also mentions that current national and international energy policies, however, have been facing many new challenges, and have at their disposal new tools that need to be considered as key components of new energy security concepts.

The approach by Nagy, as mentioned above, suggests as follows:

> *At the micro level (energy suppliers, industrial and residential consumers), the concept of energy security is usually interpreted as the security of the supply systems. At the macro level, energy security is related to the existence of conditions necessary for the satisfaction of objective social needs (for example, access to energy sources, such as natural gas, oil, etc.). However, if we consider the concept of energy security from the aspect of global security, it will become apparent that we should also take into consideration the effects resulting from need satisfaction, which are primarily environmental in nature.*

Thus, the necessary conditions to meet such challenges will be provided by the development of a global network of energy security centers. We need to adopt a global approach in order to guarantee energy security. And such approach will require a new culture of cooperation and the

development of problem solving capacities based on qualitatively new foundations (Nagy, 2006).

While some authors mention nuclear energy as the renewable energy source or to exemplify an energy dependency reduction, not many authors directly mention the gravity of nuclear energy as the component of energy security itself. The link between nuclear power and energy security, however, should not be overlooked. According to Ilnyckyj, nuclear power is a more divisive issue than any other amongst those who are concerned with climate change and with driving the push towards a low-carbon global society. Advocates of a nuclear revival consider support for nuclear energy to be a badge proving genuine concern about climate change. And those who disagree assert both that nuclear power has unacceptable problems associated with it and that climate change can be managed without the need to build more nuclear capacity (Ilnyckyj, 2007).

It should be noted that slowing the expansion of nuclear power will harm efforts to fight climate change, push up energy prices and set back goals to secure power supplies. And cutting in half the projected new nuclear installations during the next 25 years may add 500 million tons of carbon dioxide output to the global total in 2035, equivalent to five years of extra

emissions growth[12]

Furthermore, as Ilnyckyj argues, the political support for nuclear energy exists for several reasons: among them, concerns about maintaining secure access to energy and with low-carbon energy production. And a low-carbon way to provide large amounts of electricity to national grids, as well as an important 'wedge' in the drive towards stabilizing global concentrations of greenhouse gasses. Nuclear energy is a low-carbon way to produce electricity and nuclear energy has strong potential as a climate-friendly option. Therefore, this paper attempts to put more weight on nuclear energy issue as one of the components to discuss energy security.

2. Dimensions of Energy Security

This paper establishes an 'Energy Security Indicator' to study Korea's energy security. Several energy security assessment instruments were referred. Building on work by Von Hippel et al. (2009), Vlado Vivoda (2010), and Staley et al (Center for Strategic and International Studies and

[12] *Nuclear Curbs Will Hurt Climate, Energy Security Goal, IEA Economist Says*, Bloomberg (March 30, 2011), http://www.bloomberg.com/news/2011-03-30/nuclear-curbs-will-hurt-climate-energy-security-goal-iea-economist-says.html, (Last visited December 15, 2012)

the World Resources Institute) (2009), this paper establishes an 'Energy Security Indicator' in attempt to assess- or at least compare- the energy security of Korea between the three year periods of pre-low carbon green growth and low carbon green growth.

First, *Energy security conceptual framework*[13] and *Dimensions and measures/attributes of energy security*[14] by David von Hippel, et al. were referred. In the framework for evaluating and measuring the relative attributes of different approaches to energy sector development, Hippel focuses on six dimensions—energy supply, economic, technological, environmental, social-cultural, military-security. He notes that while *Energy security conceptual framework* provides what is intended to be a broad, but by no means complete, list of policy issues, even the categories shown are not necessarily independent.

Moreover, *Energy Security Assessment Instrument*, established by Vlado Vivoda was referred. In his recent work, "Evaluating energy security in the Asia-Pacific region: A novel methodological approach (2010)", Vivoda introduces a systematic interrogative tool for evaluating energy security of individual states. Based on a new and expanded conceptualization of energy security, the instrument that was built on work by Von Hippel et al. (2009)

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[13] *Energy security and sustainability in Northeast Asia (2011)* -p. 6726

[14] *Energy security and sustainability in Northeast Asia (2011)* -p. 6727

and Sovacool (2011) consists of twelve broad national energy security dimensions and 46 attributes associated with the current global energy system. They include both traditional energy security concerns associated with the security of supply and many new factors, such as environmental, socio-cultural and technological, but at the same time recognize that the importance of international dimension and energy security policy.

Lastly, *the Energy Security Lens* provided by Center for Strategic and International Studies (CSIS) and the World Resources Institute (WRI) in their January 2009 Issue Brief *Evaluating the Energy Security implications of a carbon-constrained U.S. Economy* was referred. Throughout eleven factors; diversity of energy sources; diversity of suppliers; import levels; security of trade flows; geopolitics and economy; reliability; risk of nuclear proliferation; market/price volatility; affordability; energy intensity (energy used per unit of gross domestic product) and feasibility, the authors attempt to assess how eight certain scenarios affect each factors that are closely associated with energy security.

Based on these three assessments, 'Energy Security Indicator' will be used for assessing Korea's energy security (See Table 1). Some of dimensions from Von Hippel's, Vivoda's and CSIS/WRI's assessment instrument were eliminated for objectivity and effectiveness of the study. And sectors emphasized in both of the studies are more focused. As

mentioned before, with its significance in discussing energy security, a new dimension ‘nuclear energy’ is introduced.

As the study defines the period of “pre-green growth” and “green growth” from year 2006 to 2008, and year 2009 to 2011 respectively, concerns that such period of time is not sufficient to examine one government’s policy might naturally arise. However, in hopes to further expand and intensify the evaluation with copious evidence that will have occur within time in the near future, this paper puts its value in its attempt to meticulously and empirically exam the relation between “Low Carbon Green growth” energy security of Korea within the purview of the given period. Table 1 shows the Energy Security Indicator Assessment that will be used for the study.

(Table 1) Energy Security Indicator Assessment

Dimensions	Attributes
1. Energy Supply	1) Energy Dependency (Primary Energy Import/Total Energy Consumption) 2) Energy Supply by Renewable Energy
2. Efficiency	1) Energy Efficiency (mtoe/US$1,000 of GDP) 2) Energy Consumption Growth/Economic Growth Ratio
3. Economy	Import Fuel Costs /GDP
4. Environment	1) Reliance on Fossil Fuels as a Fraction of Primary Energy Consumption 2) Greenhouse Gas Emission (CO2, CH4)/GDP 3) Acid Gas Emissions (Sox, NOx)/GDP
5. Technology	Total Energy-Related R&D Spending/GDP
6. Nuclear Energy	The Ratio of Korea's Nuclear Power Amount to Korea's GDP
7. International Cooperation	Commitment to Regional and Other International Cooperation on Energy-Related Issues
8. Policy	1) Existence of Energy Security Policy 2) Policy on Energy Supply 3) Policy on Efficiency 4) Policy on Economy 5) Policy on Environment 6) Policy on Technology 7) Policy on Nuclear Energy

3. Analytical Framework

Multiple dimensions discussed above will be utilized to assess the impact of Korea's green growth policy on Korea's energy security. It should be noted, that throughout this paper the term "energy" refers to the definition stated in Article 2 Section 1 of Korea's "Energy Act"[15] that was enforced on October 26, 2011 and has been revised six times until today.

Firstly, in "Energy Supply" dimension, energy dependency (the ratio of primary energy import to total energy consumption) and energy supply by renewable energy will be assessed. To improve energy supply both energy diversification and energy independence should be assured. Korea is the one of the most energy consuming countries in the world. Since Korea is not an oil producing nation, most of its primary energy resources—oil, coal, gas, are imported from overseas. Accordingly, Korea is the world's fifth largest importer of oil (2007) and the second largest importer of coal (2008) (UNEP 2010). Energy diversity and energy independence are major attributes of energy supply. During the years of green growth, the transformation of Korea's national energy policy has been building institutional and program

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[15] Energy Act
Article 2 (Definitions)
The terms used in this Act shall be defined as follows:
1. The term "energy" means fuel, heat and electricity;

infrastructures to diversify energy sources by inducing the development of renewable energy. As mentioned before, many of the existing definitions of energy security begin, and usually end, with a focus on maintaining energy supplies—and particularly supplies of oil (D. von Hippel et al., 2011). Thus energy supply is a significant dimension in assessing a nation's energy security. Developing renewable energy and relying on nuclear energy will improve Korea's energy diversity and independence. According to a new study done by Greenpeace International, South Korea's energy supply could switch to nearly 60% renewable by 2050, phasing out nuclear power by 2030, creating jobs, reducing the cost of energy and generating massive savings in electricity supply[16]. Improving efficiency and diversifying fuel choices will take the pressure off energy prices, while enabling the country to make diplomatic and security decisions based on American interests and values rather than the relentless need to protect access to oil (World Watch Institute, 2006). In this paper, energy dependency (the ratio of imported energy by total energy consumption), energy independency (the ratio of domestic production by total energy consumption), and energy supply by renewable energy are evaluated in order to assess Korea's energy security.

Secondly, in "Efficiency" dimension, energy efficiency—the ratio of

[16] Green Peace http://www.greenpeace.org/eastasia/press/releases/climate-energy/2012/south-korea-clean-energy/ (Last visited November 28, 2012)

mtoe to US $1,000 of GDP— of Korea's pre-green growth and green growth period will be each calculated and compared by the rate of metric ton oil equivalent (mtoe) over US$100million of Korea's gross domestic product (GDP). Moreover, energy consumption growth over economic growth ratio of each three year will be calculated and compared as well. An expected outcome will be that both categories result in low (or lower).

Thirdly, in "Economy" dimension, the total fuel costs to GDP ratio will be assessed. And the ratio of import fuel costs to Korea's GDP will be assessed as well. It should be noted that throughout the paper, the term "fuel" refers to the definition of "fuel" stated in Article 2 Section 2 of "Energy Act"[17]. Therefore, it will be limited to "petroleum, gas, coal and other heat sources generating heat: Provided, that those used as raw materials of products shall be excluded". And the s outcome of these two evaluations are that they both result in low (or 'lower').

Fourthly, in "Environment" dimension, the reliance on fossil fuels as a fraction of primary energy consumption, the ratio of greenhouse gas emission to GDP, and the ratio of acid gas emissions to GDP will be assessed. Under the United Nations Framework Convention on Climate Change

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[17] Energy Act
Article 2 (Definitions)
The terms used in this Act shall be defined as follows:
2. The term "fuel" means petroleum, gas, coal and other heat sources generating heat: Provided, That those used as raw materials of products shall be excluded herefrom;

(UNFCCC) and the Kyoto Protocol, two different sets of data are made available on the data interface: one is data Under the Convention, data include anthropogenic emissions by sources and removals by sinks of the six principal GHGs (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride) that are not controlled by the Montreal Protocol. In addition, the GHG data interface also includes data on population, gross domestic product (GDP) and country area[18].

In this study, however, following the definition of "green house gas" stated in Article 2 Section 9 of "Framework Act on Low Carbon, Green growth"[19], green house gas includes carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbon (PFCs), and sulphur hexafluoride (SF6). Due to the limitation of data, the paper evaluates the change of the green house gas emission from 2006 to 2009.

Fifthly, in "Technology" dimension, the ratio of total energy-related R&D spending to Korea's GDP will be assessed. The expected outcome is

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[18] United Nations Framework Convention on Climate Change (http://unfccc.int)

[19] Framework Act on Low Carbon, Green growth

Article 2 (Definitions)

For the purposes of this Act:

9. The term "greenhouse gases" means carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbon (HFCs), perfluorocarbon (PFCs), sulfur hexafluoride (SF6), and other substances specified by Presidential Decree in the form of gas in the atmosphere, which absorb or reemit radiant heat to cause a greenhouse effect;"

that the both categories are interpreted high (or higher). A key challenge when it comes to energy security is to create the technological basis for a global economy that operates not on fossil fuels but increasingly on alternative and renewable energy sources; 'as the world moves rapidly toward a technologically intensive energy society, a new energy security concept must address the various issues associated with the development of new technologies' (Von Hippel et al.,in press-b).

Taking the United States for example, as with oil dependency, the broader energy security threats cannot be eliminated overnight. But immediate steps to invest in a diverse, decentralized energy system that relies more heavily on domestic renewable resources will allow the United States to steadily enhance its security enhance its security in the years ahead (World Watch Institute, 2006). Korea, on the other hand, being the world's fifth largest importer of oil (118 Mt of imports in 2007 and second largest importer of coal (100 Mt of hard coal imports in 2008),[20] realizing the gravity to continue to develop and invest in renewable energy, is expanding the foundation for growth through the expansion of green technology and green industries such as solar.

Renewable technologies can be coupled with traditional backup

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[20] IEA (2009), Key World Energy Statistics 2009 Paris; International Energy Agency

diesel generators to extend the fuel supply and increase the total power available. Renewable power can also come back on line much more quickly than coal or nuclear power plants can, helping to reduce economic losses associated with lower power failures and minimize the time that critical facilities such as hospitals and emergency communication centers must go without power, thus saving lives (World Watch Institute, 2006).

The distributed nature of many renewable energy technologies helps reduce the risk of accidental or premeditated grid failures cascading out of control (World Watch Institute, 2006). The problem, however, is that these renewable energy sources demand an expensive infrastructure in some cases—like dams or solar power stations—or they cannot yet replace the oil, gas and coal-fired power stations to produce electricity (May, 2010).

The first goal of the National Strategy for Green Growth aimed at developing an extensive application of alternative energy technologies. This could also help to achieve its national goal of reducing GHGs to 244 million tons in 2020 (a 30% decrease compared to a business as usual projection). The South Korean government, thus, prioritized the following ten strategic-energy technologies in order to support and invest in their Research and Development (R&D). These technologies are: high-efficiency photovoltaic (PV) cells, fuel cells, advanced nuclear power, green cars, smart grid, advanced carbon capture and storage (CCS), water treatment, rechargeable

batteries, Light Emitting Diodes (LED), Green IT (Zelenovskaya 2012).

Sixthly, in "Nuclear Energy" dimension, Korea's nuclear energy present condition will assessed. With the resource depletion that the world faces, shifting towards nuclear power is one way to ensure long-term energy security. Nuclear power is a more economic and large-scaled energy resource and perhaps the most promising energy resource in discussing energy security.

> *"Nuclear power is the only industry that can open up new opportunities to us in the midst of climate change crisis," and said, "It's the most practical alternative to reduce carbon emissions and the most economic and cost-effective eco-friendly measure," (President Lee, December 2009)*

Nuclear energy has also been an important source of energy supply in Korea. And under the green growth strategy, Korea aims to develop its nuclear technology by gradually increasing the proportion of nuclear energy in power generation from 24 per cent in 2009, to 27 per cent in 2013, and to 32 per cent in 2020 (United Nations Environment Programme, 2006).

Seventhly, in "International Cooperation" dimension, commitment to regional and other international cooperation on energy-related issues will be assessed. The importance of international cooperation in the issues of energy security cannot be emphasized enough. Then the question should be why it is so difficult to draw the cooperation. Many countries face a dilemma: on the

one hand, it is recognized that to improve the energy security situation of a country, more and better international cooperation is necessary. On the other hand, the necessary domestic support for this kind of international cooperation is not there. In many countries, therefore, a situation that political figures seem unable to resist is the temptation to tell the public what they want to hear (May, 2010).

World Economic Forum (WEF) Global Agenda Council on Energy Security defines energy security, is reliable, stable and sustainable supply of energy at affordable prices and at an acceptable social cost. And this definition recognizes that environmental and other issues are inexorably linked with those of energy. Therefore, energy security can only be achieved efficiently through global cooperation and not isolation (Yueh, 2010).

Moreover, if a capable political leaders are a prerequisite for producing successful cooperation in global governance, the kind would be the driving force for coping with the world's most pressing challenges (See May, 2010:29). Since the policy declaration of national green growth, the active role of Korean government is noteworthy.

Energy cooperation in Northeast Asia requires multilateral cooperation with many countries. As the possibilities for benefits from energy cooperation in this region is, the creation of institutional framework is necessary great (Doh, 2003). As an important part of the low carbon green

growth policy, Korea initiated the East Asia Climate Partnership (EACP) in December 2008 and has been leading the Seoul Initiative for Low Carbon Green Growth in East Asia, which inevitably encompasses energy security issues.

Finally, in "Policy" dimension, existence of policies such as energy security policy, regular policy review, efficiency issues addressed in policy, economic issues addressed in policy, environmental issues addressed in policy, human security issues addressed in policy, military /security issues addressed in policy, technological issues addressed in policy, international cooperation issues addressed in policy will be examined. An expected outcome of these evaluations is that it proves each policy's existence ('yes').

Chapter 3

Low Carbon Green Growth Policy and Energy Security

1. Low Carbon Green Growth

In 2008, the Korean government has announced a new paradigm of national development in the age of global climate change. On the day of 60th anniversary of the founding of the Republic of Korea, former President Lee Myung-bak declared 'Low Carbon Green Growth' as the country's new vision to lead the country's development for the next 60 years.

> *"...Today, on the occasion of the 60th anniversary of the founding of the Republic of Korea, I want to put forward 'Low Carbon, Green growth' as the core of the Republic's new vision... If we make up our minds before others and take action, we will be able to lead green growth and take the initiative in creating a new civilization ..."* -Excerpt from the Address by President Lee Myung-bak, on the 60th anniversary of the founding of the Republic of Korea (Aug.15, 2008)[21]

Green growth is an action-oriented paradigm which promotes a mutually supportive relationship between growth and the environment by

[21] *Green growth Korea*, http://www.greengrowth.go.kr (Last visited December 15, 2012)

holistically embracing the framework of sustainable growth[22]. It is also a concept that emphasizes the decrease in environmental pressure due to economic growth, along with the security of resources for the future generation, and steady economic and social growth. Moreover, green growth is a policy focus for the Asia and Pacific region that emphasizes environmentally sustainable economic progress to foster low-carbon, socially inclusive development[23]. Table 2 is the chronicle table of Korea's green growth footprint.

(Table 2) Korea's Major Green Growth Footprints

Year	Date	Green Growth Footprints
2008	July 8	Declaration of Korea as an "Early Mover" in fighting global climate change at the G8 Summit in Tokyo, Japan
	Aug. 15	Low Carbon Green Growth announced as a national vision for the next 60 years.
	Dec. 30	East Asia Climate Partnership(EACP) commenced with its first 17 projects kicked off
2009	Jan. 6	Establishment of a green new deal policy Facing the global financial crisis, Korea initiated a Green New Deal in order to create jobs and secure new growth engines
	Jan. 8	Appointed as lead country for smart grid technology development
	Jan. 13	Roadmap for green R&D released
	Feb.16	Launch of the Presidential Committee on Green growth

[22] *Green growth Korea,* http://www.greengrowth.go.kr, (Last visited December 15, 2012)

[23] *Green growth Korea,* http://www.greengrowth.go.kr, (Last visited December 15, 2012)

		The Presidential Committee on Green Growth which supervises and coordinates green growth policies across the government was launched in order to secure a strong framework for implementing the nation's green growth strategy.
	July 6	National Strategy and Five-Year Plan for Green Growth released among other things, Korea decided to allocate 2% of the nation's annual GDP to green investments from of 2009 to 2013, double the 1% of GDP recommended by the UN.
	Nov.17	Korea's mid-term GHG mitigation target of 30% reduction declared
	Dec. 17	Proposed the spirit of "Me First" at UNFCCC COP15
2010	Jan. 13	The Framework Act on Low Carbon Green Growth is the world's first-ever comprehensive law which broadly embraces al key aspects of low carbon green growth such as climate change, energy, and sustainable development.
	June 16	Launch of GGGI at the East Asia Climate Forum 2010
	July 13	Official announcement of vitalization of green market, green finance and green investment
	Sep.9	Launch of the mass-production system for electric car
	Oct.13	Establishment of a sustainable water industry policy.
	Nov.11	G20 Seoul Summit on green growth In the leader's declaration, the G20 Seoul Summit addressed and elaborated on cooperation for green growth at Korea's proposal.
	Dec.6	Establishment of a green car supply policy
2011	March 14	President Lee wins the Zayed international prize for the Environment
	April 6	Completion of the world's largest electric car battery plant in Ochang, Korea
	June 20	Global Green Growth Summit 2011 Korean green growth Adopted by OECD report
	August	World's largest Sihwa tidal plant opens, generating 5552.7GWh annually

In March 2005, at ‘The Ministerial Conference on Environment and

Development in Asia and the Pacific (MCED)', the new paradigm, "green growth", was adopted in order to meet with the three policy objective— 'enhancing the sustainability of the environment', ' promoting environmental performance', ' improving the role of the environment as the engines of economic growth'. With its declaration in March 2005, Korea has promoted a 60-year national vision, "green growth", as a national strategy in August 15, 2008. The National Strategy for green growth envisages three main objectives and ten policy directions, based on a consensus between social, business, academic and government stakeholders. The three objectives include mitigation of climate change and the strengthening of the country's energy independence, creation of new growth engines, improvement in the quality of people's lives and enhancement of Korea's international standing[24].

> *"A successful execution of the green growth strategy, such that it delivers low-carbon growth entails a decoupling of economic growth from carbon emissions and intensive-energy use. This, in turn, requires significant reductions in the carbon-intensity and the energy-intensity of growth. Korea faces challenges in that regard, given that despite important progress in the past several years, energy-intensity remains high in comparison with other OECD countries. The 2006 OECD Review noted that "Korea is one of the few OECD countries, which has not improved its energy intensity*

[24] Green growth Korea, http://www.greengrowth.go.kr
(Last visited December 15, 2012)

energy use per unit of GDP relative to 1990"[25]

As part of its Five-Year Plan, implemented in 2009, Korea committed 2% of its GDP through 2013 to create a knowledge and technological foundation to sustain a green growth economy for generations. The investment fuels some ambitious goals, including: i) Developing the world's first nationwide "smart grid" system by 2030, ii) Increasing the country's renewable energy to 11% of energy supplies by 2030, iii) Reducing its greenhouse gas emissions 30% by 2020, and iv) Building 1 million green homes by 2020.[26]

In July 2009, Korean government announced the National Strategy for Green Growth (Table 3).

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[25] Overview of The Republic of Korea's National Strategy for Green growth (United Nations Environment Programme April 2006).

[26] The World Bank, http://go.worldbank.org/NR18WLLIV0 (Last visited November 22, 2012)

(Table 3) The National Strategy for Green Growth

Three objectives: 1. Promote a synergistic relationship between economic growth and environmental protection. 2. Improve people's quality of life and promote a green revolution in their lifestyles. 3. Contribute to international efforts to fight climate change and other environmental threats. Three strategies: 1. Mitigating climate change and promoting energy independence. 2. Creating new engines for economic growth. 3. Improving the quality of life and enhancing Korea's international standing. Ten policy agendas to achieve the three strategies: 1. Effective mitigation of greenhouse gas emissions: the government will pursue mitigation strategies for buildings, transport and industry, require reporting on emissions and promote forestation. 2. Reduction in the use of fossil fuels and the enhancement of energy independence: Korea will reduce energy intensity to the OECD average, increase the use of renewable energy and expand nuclear power capacity. 3. Strengthening the capacity to adapt to climate change: Korea will launch the "Four Major Rivers Restoration Project" and increase the share of "environmentally friendly" agricultural products to 18% by 2020. 4. Development of green technologies: The government will pursue the development of important green technologies, boosting its world market share in the relevant sectors to 8% within five years. 5. The "greening" of existing industries and promotion of green industries: Exports of green goods in the major industries will rise from 10% in 2009 to 22% in 2020 and the government will help small and medium-sized enterprises (SMEs) green their business. 6. Advancement of the industrial structure to increase the role of services: the government will develop health care, education, finance, contents industry, software and tourism as the core of high value-added services. 7. Engineering a structural basis for the green economy: The government will gradually introduce an emissions trading system, make the tax system greener and extend public credit guarantees to green industry.

8. Greening land and water and building the green transport infrastructure: The share of passenger travel by rail will rise from 18% in 2009 to 26% in 2020, and metropolitan mass transit from 50% to 65% over the same period.
9. Bringing the green revolution into our daily lives: Carbon footprint labeling will be enacted, the government will increase mandatory procurement of green goods and education on green growth will be expanded.

10. Becoming a role-model for the international community as a green growth leader: Korea will actively engage in international climate-change negotiations and increase the share of green ODA from 11% to 30% in 2020.

2. Energy Security

The national green growth policy has become a watershed in Korea's energy security. As energy security has been placed in the center of international competitions and corporations, Korean government has been both a follower and a leader in the international energy regime in responding to global energy crisis.

In September 2008, after the president's proclaim of the green growth vision, the 'Master Plan for National Energy' (2009~2030), the ever first comprehensive energy plan at the national level, was introduced to strengthen renewable energy development and supply and to increase the energy efficiency and independency. And in January 6, 2009, facing the global financial crisis, the establishment of the green growth policy was made as Korea initiated a green new deal in order to create jobs and secure

new growth engines.

The energy security is among the prime goals of Korea's green growth and national energy policy. The emergence of active energy diplomacy during the years of green growth to secure energy and resources is the tangible performance of the Lee Myung-bak Administration.

Nuclear energy lies in the center of Korea's energy security policy. And the intimate relation of Korea's energy security policy with nuclear energy export attracts both international interests and criticism.

> *Pure economic motivations or possessing technical knowhow cannot alone justify Seoul's engagement in the sensitive business of transferring nuclear technology to the volatile region of the Middle East… South Korea's recent energy deals in the Mideast are closely connected to the long-term strategic goal of achieving energy security (Azad, 2011).*

Chapter 4

The Impact of Low Carbon Green Growth Policy on Energy Security in Korea

1. Energy Supply

1-1. Energy Dependency (Imported Energy/Total Energy Consumption)

As shown in Table 4, the amount of imported primary energy (including nuclear power) in year 2006, year 2007, and year 2008 (pre-Green Growth) was 225,180(1000TOE), 228,313(1000TOE), 232,199(1000TOE) respectively. So far it shows increase during the three years by comparing the numbers itself.

Korea's total energy consumption, on the other hand, was 233,372(1000TOE), 236,454(1000TOE), 240,752(1000TOE) in year 2006, 2007, and 2008. Accordingly, the ratio of the imported energy to the total energy consumption of Korea from in year 2006 was 0.9648, which means 96.48percent of the primary energy (including nuclear power) consumed was imported. In year 2007 the ratio was 0.9655, meaning 96.55percent of the primary and nuclear energy consumed was imported. Moreover, in year 2008 the imported energy to the total energy consumption ratio was 0.9644,

showing that 96.44percent of the energy consumed was imported as well (See Table 5). As the data shows, the rate of dependence on import fuels in Korea is tremendous, reaching 96.49 percent in average during the three year period of pre-green growth.

(Table 4) Primary Energy Supply Structure (2006-2008) Unit: 1000toe

Energy	Sort	2006	2007	2008
Total Energy Consumption	Total Energy Consumption	233,372	236,454	240,752
Domestic Production	Total (1000TOE)	8,192	8,141	8,552
	Total (1000TOE)	45,380	38,873	41,008
	Anthracite (1000M/T)	4,596	4,035	4,134
	LNG (1000M/T)	355	271	181
	Water Power (GWh)	5,219	5,042	5,563
	Renewable etc.(1000M/T)	4,358	4,856	5,198
Import	Total (1000TOE)	225,180	228,313	232,199
	Total (1000TOE)	187,992	197,581	199,743
	LNG(1000M/T)	24,264	26,392	27,257
	Coal (1000M/T)	83,231	90,093	100,065
	Gas (1000bbl)	765,520	794,945	760,641
	Nuclear Energy (GWh)	148,749	142,937	150,958

(Source: Korean Statistical Information Service)[27]

[27]Korean Statistical Information Service http://kosis.kr/themes/themes_04List.jsp?parentId=101_B77&listnm=%EB%85%B9%EC%

(Table 5) The Ratio of Imported Energy to Total Energy Consumption (2006-2008)

2006	0.9644 (96.44%)
2007	0.9655 (96.55%)
2008	0.9648 (96.48%)

However, the amount of imported primary energy (including nuclear power) in year 2009, year 2010, and year 2011 (green growth period) was 234,672(1000TOE), 253,448(1000TOE), and 261,773(1000TOE). Interestingly, even with the launch of the Korea's Low Carbon Green Growth policy the amount of imported fuel shows steady increase, compared by numbers itself.

Korea's total energy consumption from 2009 to 2011 was 243,311 (1000TOE), 262,609 (1000TOE), 271,346 (1000TOE). The ratio of the imported energy to the total energy consumption of Korea during the first three years of green growth period was 0.9645, 0.9651, and 0.9647. In other words, total 96.45percent of the total primary energy consumption in year 2009 was imported. Accordingly, it was 96.51percent in year 2010 and 96.47percent in year 2011. Contrary to the expectation, it still shows that

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even after the start of the green growth, Korea's energy dependency towards imported fuels is excessively high, reaching 96.48percent in average.

(Table 6) Primary Energy Supply Structure (2009-2011) Unit: 1000toe

Energy	Sort	2009	2010	2011
Total Energy Consumption	Total Energy Consumption	243,311	262,609	271,346
Domestic Production	Total (1000TOE)	8,639	9,161	9,572
	Total (1000TOE)	40,410	41,109	41,858
	Anthracite (1000M/T)	3,114	2,508	2,242
	LNG (1000M/T)	383	415	347
	Water Power (GWh)	5,641	6,472	7,978
	Renewable etc.(1000M/T)	5,480	6,064	6,364
Import	Total (1000TOE)	234,672	253,448	261,773
	Total (1000TOE)	202,901	221,500	229,488
	LNG(1000M/T)	25,699	32,668	35,473
	Coal (1000M/T)	105,264	116,813	122,552
	Gas (1000bbl)	765,520	794,945	760,641
	Nuclear Energy (GWh)	148,749	142,937	150,958

(Source: Korean Statistical Information Service)[28]

[28]Korean Statistical Information Service http://kosis.kr/themes/themes_04List.jsp?parentId=101_B77&listnm=%EB%85%B9%EC%83%89%EC%84%B1%EC%9E%A5 (Last visited December 16, 2012)

(Table 7) The Ratio of Imported Energy to Total Energy Consumption (2009-2011)

2009	0.9645 (96.45%)
2010	0.9651 (96.51%)
2011	0.9647 (96.47%)

For reference, in year 2012 the total primary energy is 158,913(1000TOE) and the total of imported primary energy is 153,797(1000TOE) (See Table 8). Thus the ratio of imported energy to total energy consumption was 0.9678, showing increase with even higher increase rate. Figure 1 below shows the change in Korea's energy dependency. Even with the declaration of Green Growth, between year 2011 and 2012 the graph show a sharp steep. The paper will look into the backgrounds of such retrogressive outcome in Chapter 5.

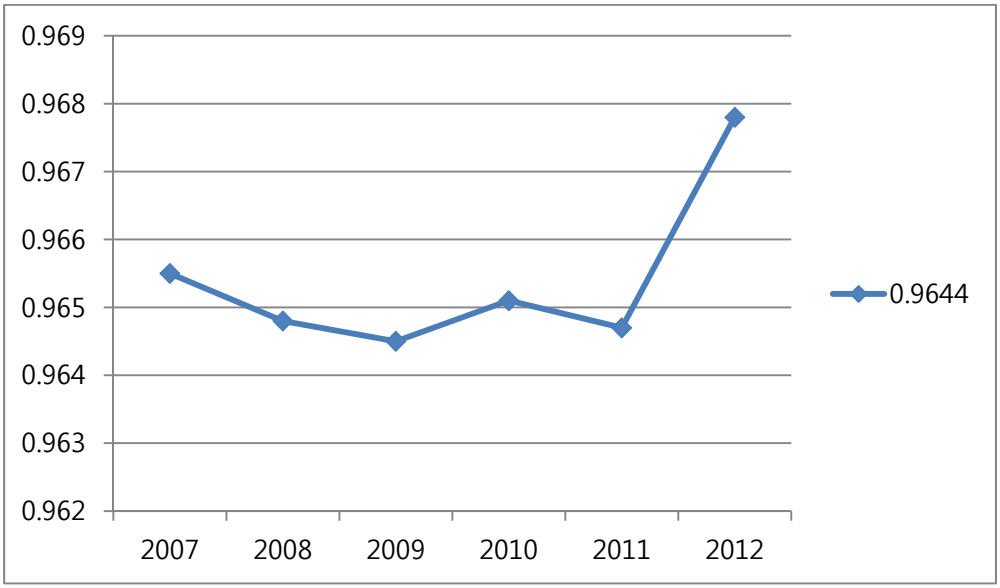
(Table 8) Primary Energy Supply Structure (2012) Unit: 1000toe

Energy	Sort	2012
Total Energy Consumption	Total Energy Consumption	158,913
Domestic Production	Total (1000TOE)	5,116
	Total (1000TOE)	23,482
	Anthracite (1000M/T)	935
	LNG (1000M/T)	216
	Water Power (GWh)	4,007
	Renewable etc.(1000M/T)	3,568
Import	Total (1000TOE)	153,797
	Total (1000TOE)	135,431
	LNG(1000M/T)	22,594
	Coal (1000M/T)	68,369
	Gas (1000bbl)	478,966
	Nuclear Energy (GWh)	87,045

(Source: Korean Statistical Information Service)[29]

[29]Korean Statistical Information Service http://kosis.kr/themes/themes_04List.jsp?parentId=101_B77&listnm=%EB%85%B9%EC%83%89%EC%84%B1%EC%9E%A5 (Last visited December 16, 2012)

(Figure 1) Energy Dependency (Imported Energy/Total Energy Consumption)



(Expected Outcome: Higher)

1-2. Energy Supply by Renewable Energy

As shown in Table 9, Korea's renewable energy-including solar power, bio, wind power, water power, fuel cell, waste, geothermal power, and ocean-indicates steady increase in supply. The renewable energy supply rate has increased each year from year 2006 to 2010 (Figure 2). In year 2010, however, a new renewable energy has been developed, as scientists in Korea have successfully developed a technology of converting carbon monoxide

(CO), major ingredient of gases emitted from steel mills, to a renewable energy[30].

(Table 9) Korea's Renewable Energy

Energy	2006	2007	2008	2009	2010
Total Primary Energy Consumption	231,520	236,454	240,752	243,311	262,609
Renewable Energy Supply (%)	2.26	2.37	2.43	2.50	2.61
Renewable Energy (toe)	5,225,192	5,608,776	5,858,481	6,086,249	6,856,284
Solar Power	33,018	29,375	28,036	30,669	29,257
Bio	274,482	370,159	426,760	580,419	754,623
Wind Power	59,728	80,763	93,747	147,351	175,644
Water Power	867,058	780,899	660,148	606,629	792,294
Fuel Cell	1,670	1,832	4,367	19,193	42,346
Waste	3,975,272	4,319,309	4,568,568	4,558,131	4,862,296
Geothermal Power	6,208	11,114	15,726	22,126	33,449
Ocean	-	-	-	-	223

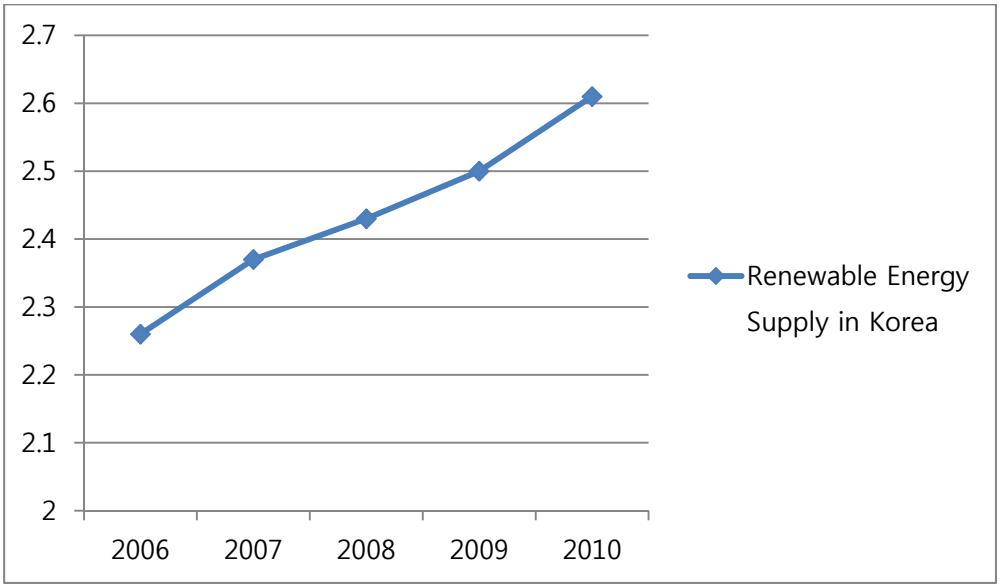
(Source: Korea Energy Management Corporation Renewable Energy Center Office of Renewable Energy)[31]

[30] *New Technology Can Convert Steel Mill-Emitted CO to Hydrogen*

http://energy.korea.com/archives/30168?cat=25 Retrieved December 17, 2012

[31]http://kosis.kr/themes/themes_04List.jsp?parentId=101_B77&listnm=%EB%85%B9%EC%83%89%EC%84%B1%EC%9E%A5 searched by keyword "Renewable Energy" (Retrieved December 17, 2012)

(Figure 2) Renewable Energy Supply in Korea



(Expected Outcome: Higher)

2. Efficiency

2-1. Energy Efficiency

To reflect *Energy Efficiency* dimension of the three years of Korea's pre-green growth and green growth energy security, energy efficiency by the ratio of metric ton oil equivalent (MTOE) to US 100 million dollar of GDP in the period from 2006 to 2008 and 2009 to 2011 was assessed. First, the

MTOE from year 2006 to 2008–the pre-green growth period- was 233,372(1000 TOE), 246,454 (1000 TOE), 240,752 (1000 TOE), respectively.

(Table 10) Primary Energy Consumption (2006-2008)

Year	Primary Energy Consumption Million MTOE
2006	233,372
2007	246,454
2008	240,752

(Source: The World Bank's Data) [32]

Table 11 shows Korea's gross domestic product (GDP) from year 2006 to 2008. In year 2006, Korea's GDP was $9,518 (100 million dollar). In 2007 it was $10,492 (100 million dollar), and in 2008 $9,314 (100 million dollar)[33].

[32] Korean Statistics Information Service (http://kosis.kr) by the keyword "primary energy consumption" in Korean (Last visited September 23 2012)
[33] http://www.dfat.gov.au/geo/fs/rkor.pdf (Last visited September 23 2012)

(Table 11) Korea's Gross Domestic Product (2006-2008)[34]

Year	Korea's GDP (100 million)
2006	$9,518
2007	$10,492
2008	$9,314

Accordingly, the ratio of metric ton oil equivalent (mtoe) to US $100 million of GDP in the pre-Green growth period was 24.5190 in year 2006, 23.4897 in year 2007, and 25.5738 in year 2008. Despite the 4.20% decrease from year 2006 to 2007, from year 2007 to 2008 the percentage increases by 8.87%. However, the energy efficiency of year 2008, compared to year 2006 has increased 4.30%. The average energy efficiency of the pre-Green growth period is 24.573, with the total GDP of $29,324(100million) and total million toe of 720,578(1000mtoe).

On the other hand, the mtoe from year 2009 to 2011 –the green growth period- was 243,311(1000 toe), 262,609(1000 toe), 271,346(1000 toe) respectively, while Korea's GDP was $8,341 (100million dollar) in year 2009. In 2010 it was $10,149 (100million dollar), and in 2011 $11,635

[34] The World Bank's Data
http://data.worldbank.org/indicator/NY.GDP.MKTP.CD?page=1
(Last visited November 28,2012)

(100million dollar).[35] And the ratio of metric ton oil equivalent (mtoe) to US$100million of GDP in the Green growth period was 29.1704 in year 2009, 25.8753 in year 2010, and 23.3215 in year 2011. The energy efficiency decreased 11.29 percent from year 2009 to 2010, and again by 9.87 percent from year 2010 to year 2011. The average energy efficiency of the post-Green growth period is 25.801, with the total GDP of $30,125 (100million) and total million toe of 777,266 (1000mtoe).

(Table 12) Primary Energy Consumption (2009-2011)[36]

Year	Primary Energy Consumption Million Toe (1000 MTOE)
2009	243,311
2010	262,609
2011	271,346

(Table 13) Korea's Gross Domestic Product (2009-2011)[37]

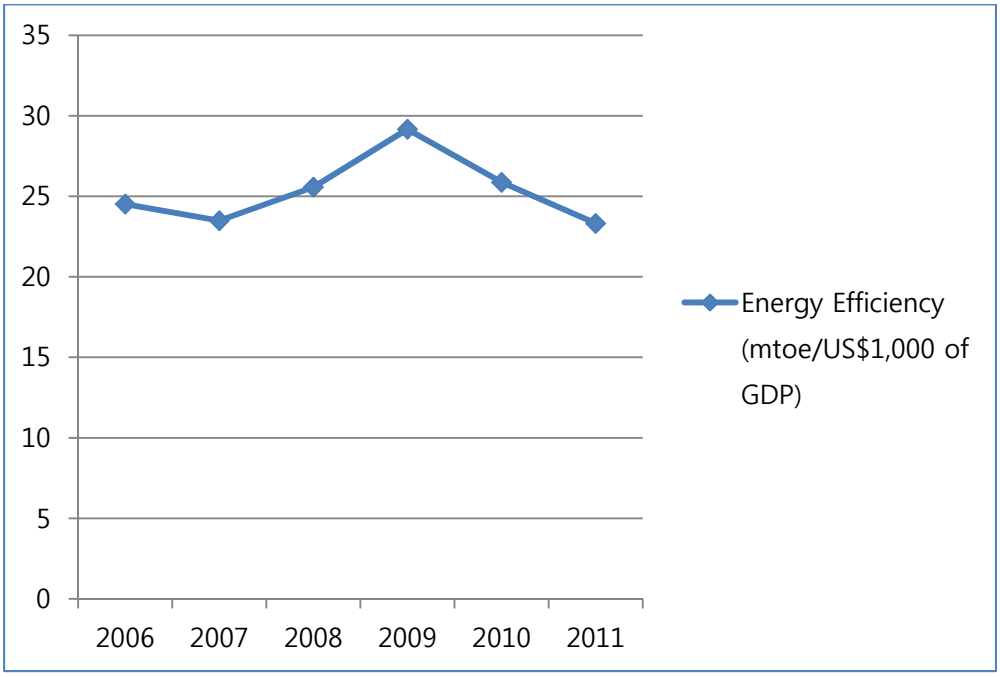
Year	Korea's GDP (100 million)
2009	$8,341
2010	$10,149
2011	$11,635

[35] http://www.dfat.gov.au/geo/fs/rkor.pdf (Last visited September 23, 2012)

[36] Korean Statistics Information Service, http://kosis.kr, searched by the keyword "primary energy consumption" in Korean –(Last visited September 23, 2012)

[37] The World Bank's Data, http://data.worldbank.org/indicator/NY.GDP.MKTP.CD?page=1, (Last visited November 28, 2012)

(Figure 3) Energy Efficiency (mtoe/US$1,000 of GDP)



(Expected Outcome: Lower)

Comparing the two periods—pre-green growth and green growth, energy efficiency has increased by 1.264. Since the expected result should be "decrease", it can be interpreted that Korea's green growth's E*nergy Efficiency* of the *Efficiency* category has weakened compared to pre-green growth period.

2-2. Energy Consumption

Moreover, to assess Korea's pre-green growth and green growth energy security, energy consumption growth to economic growth ratio was evaluated. Since the term "energy" refers to the definition of fuel stated in Article 2 Section 1 of Korea's "Energy Act", it is limited to fuel, heat source or electricity, and the term "fuel" is limited to "oil, gas, coal, and any other heat source", as stated in Article 2 Section 2[38] of Energy Act. Accordingly, for 'energy consumption', oil gas, coal, any other heat source, electricity will be evaluated. The tables below show energy consumption growth and economic growth of Korea from year 2006 to 2011.

The energy consumption growth to economic growth ratio of each year is 0.307 in year 2006, 0.882 in year 2007, and 0.260 in year 2008. For the three years of pre-green growth period, the energy consumption growth to economic growth ratio of each year is 0.4 with 5.18 energy consumption increase rate and 12.95 economic growth rate (See Figure 4).

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[38] Article 2 (Definitions) For the purpose of this Act:

> 2. the term "fuel" means the petroleum, coal, substitute energy, and other heat sources producing the heat (excluding the nuclear fuel), except those used as raw materials of products;

(Table 14) Energy Consumption Growth to Economic Growth Ratio (2006-2008)

2006	0.307
2007	0.882
2008	0.260

With the advent of the national low-carbon green growth policy, however, Korea's energy consumption growth to economic growth ratio of each year is -1.000 in year 2009, 1.032 in year 2010, and 0.889 in year 2011 (See Figure 4). During the three years of green growth period, the energy consumption growth to economic growth ratio of each year is 0.162 with 9.90 energy consumption increase rate and 16.16 economic growth rate.

(Table 15) Energy Consumption Growth to Economic Growth Ratio (2009-2011)

2009	-1.000
2010	1.032
2011	0.889

(Table 16) Total Energy Consumption Increase (Unit: 1000 toe)

Energy	Sort	2006	2007	2008	2009	2010	2011
Total Energy Consumption	Total Energy Consumption	173,584	181,455	182,576	182,066	193,832	200,086
Increase (%)	Increase (%)	1.6	4.5	0.6	-0.3	6.5	3.2
Coal	Total	22,660	24,249	26,219	23,895	27,968	29,297
	Anthracite	4,313	4,583	4,994	5,180	5,751	6,645
	Bituminous Coal	18,347	19,666	21,225	18,715	22,217	22,652
Oil	Total	97,037	100,622	97,217	98,369	100,381	101,904
	Energy Oil	47,088	45,946	42,971	41,893	43,002	41,782
	LPG	9,608	10,052	10,432	10,840	10,448	9,684
	Non-energy oil	40,342	44,623	43,814	45,636	46,931	50,438
Gas	Gas	18,379	18,955	19,765	19,459	21,081	22,397
Electricity	Electricity	29,990	31,700	33,116	33,925	37,338	39,139
Heat Energy	Heat Energy	1,425	1,438	1,512	1,551	1,718	1,698
Renewable Energy	Renewable Energy	4,092	4,491	4,747	4,867	5,346	5,653

(Source: Korean Statistical Information Service)[39]

(Table 17) GDP and Economic Growth Rate

(Unit: billion won)

	2006	2007	2008	2009	2010	2011
Gross Domestic Product (Nominal GDP)	908,744	975,013	1,026,452	1,065,037	1,173,275	1,237,128
Economic Growth Rate (Real GDP Growth Rate)	5.2	5.1	2.3	0.3	6.3	3.6

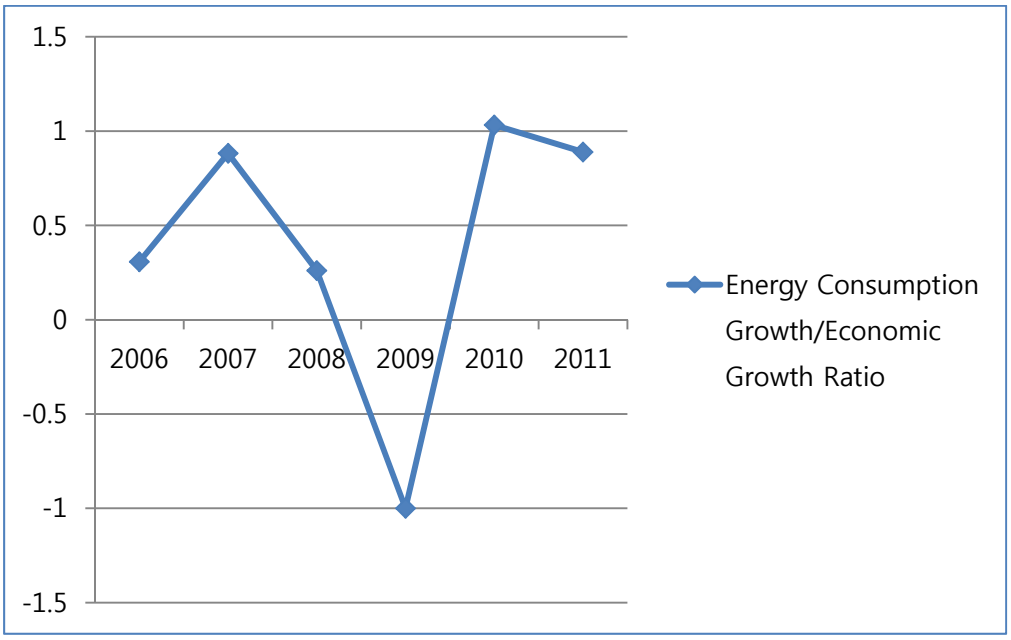
(Source: Bank of Korea 「National Income」)

[39]Korean Statistical Information Service http://kosis.kr/themes/themes_04List.jsp?parentId=101_B77&listnm=%EB%85%B9%EC%83%89%EC%84%B1%EC%9E%A5 (Last visited December 16, 2012)

To sum up, in energy consumption growth to economic growth ratio part, the ratio in Green growth period has decreased from pre-Green growth's 0.400 to 0.162. As the expected result is "decrease", the 59.5% decrease from pre-Green growth to post-Green growth is seen as a desirable outcome.

The *Efficiency* dimension of pre green growth and green growth period is as shown in Figure 4. The efficiency seems to become lower with the start of green growth as expected. Shortly after however, follows a sudden rise. The paper will look into the background of this interesting outcome in Chapter 5.

(Figure 4) Energy Consumption Growth to Economic Growth Ratio



(Expected Outcome: Lower)

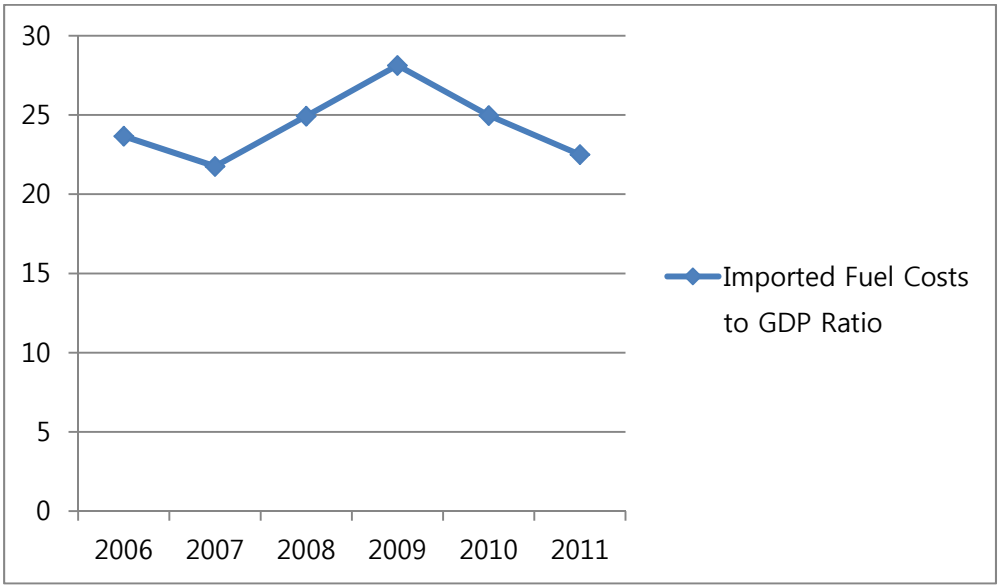
3. Economy

To assess Korea's energy security in economy dimension, the import fuel costs to GDP ratio was assessed. As seen in Table 11 and Table 13, Korea's GDP from year 2006 to year 2008 was $9,518(100million), $10,492(100million), and $9,314(100million). In year 2009 it was $8,341(100million), along with $10,149 in year 2010 and $11,635(100million) in year 2010. Compared to Korea's imported fuel costs in the six year period, the ratio of total fuel costs (See Table 4, Table 6) to GDP in Korea is as below (Table 18, Figure 5).

(Table 18) Imported Fuel Costs to GDP Ratio

	2006	2007	2008	2009	2010	2011
Imported Fuel Costs to GDP Ratio	23.66	21.76	24.93	28.13	24.97	22.50

(Figure 5) Imported Fuel Costs to GDP Ratio



(Expected Outcome: Lower)

Before green growth (pre-green growth period) the imported fuel costs to GDP ratio in Korea has decreased and then increased. However, after the start of green growth, from year 2009 to 2011 the ratio steadily declines. Furthermore, in year 2012 Korea's dependence on oil for its energy needs is expected to further decline despite the anticipated growth of its overall consumption of energy. And the country's consumption of oil is expected to grow 0.7 percent in 2012 from 2011, but that the proportion of oil consumption in the country's total energy use will shrink to 37.7 percent

from about 40 percent two years ago[40].

4. Environment

4-1. Reliance on Fossil Fuels as a Fraction of Primary Energy Consumption

To reflect *environmental* dimension of Korea's energy security, first the reliance on fossil fuels as a fraction of primary energy consumption in the period of 2006 to 2008 was evaluated. As this paper limits the meaning of "fossil fuel" to "oil, gas, coal", the percentage of oil, gas, and coal of the primary fuel was calculated. Moreover, as mentioned before, in this study "primary energy" includes coal, oil, gas, water energy, nuclear energy, renewable energy and etc.

In year 2006, the oil consisted of 43.6 percent, whereas coal 24.3 percent and gas 13.7 percent in year 2007, oil was 44.6 percent, coal was 25.2 percent and gas 14.7 percent. In year 2008, oil took 41.6 percent, while coal took 27.4 percent and gas 14.8 percent. However, with the advent of the Green growth period, in year 2009, the oil was 42.1 percent, whereas coal

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[40] *S. Korea's oil dependence to shrink despite growing energy needs: report* http://english.yonhapnews.co.kr/business/2012/01/18/48/0501000000AEN20120118009600320F.HTML (Last visited December 17, 2012)

was 28.2 percent and gas was 13.9 percent. In year 2010, oil was 39.7 percent, coal was 28.9 percent, and gas was 16.4 percent. And in year 2011 oil was 38.7 percent, coal was 29.3 percent, and gas was 17.2 percent.

(Table 19) Total Energy Consumption in Percentage

Energy	Sort	2006	2007	2008	2009	2010	2011
Total Energy Consumption	Total Energy Consumption	100	100	100	100	100	100
Coal	Total	24.3	25.2	27.4	28.2	28.9	29.3
	Anthracite	2.2	2.4	2.5	2.4	2.3	2.5
	Bituminous Coal	22.1	22.9	25.0	25.8	26.6	26.7
Oil	Total	43.6	44.6	41.6	42.1	39.7	38.7
	Energy Oil	22.2	21.5	19.0	18.7	17.7	16.3
	LPG	4.2	4.3	4.4	4.6	4.2	3.8
	Non-energy oil	17.3	18.9	18.2	18.8	17.9	18.6
Gas	Gas	13.7	14.7	14.8	13.9	16.4	17.2
Electricity	Electricity	0.6	0.5	0.5	0.5	0.5	0.6
Heat Energy	Heat Energy	15.9	13.0	13.5	13.1	12.2	11.9
Renewable Energy	Renewable Energy	1.9	2.0	2.2	2.3	2.3	2.3

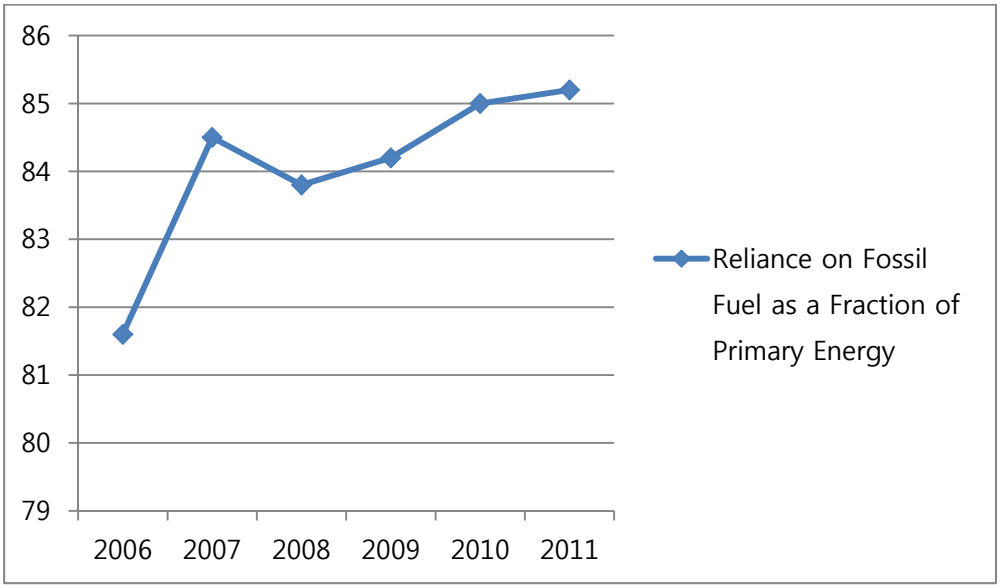
(Source: Korean Statistical Information Service)[41]

Thus the reliance on fossil fuel as a fraction of primary energy consumption in year 2006 was 81.6percent. In year 2007 it was 84.5percent

[41]Korean Statistical Information Service http://kosis.kr/themes/themes_04List.jsp?parentId=101_B77&listnm=%EB%85%B9%EC%83%89%EC%84%B1%EC%9E%A5 (Retrieved December 16, 2012)

and 83.8percent in year 2008. However, in green growth period, the reliance on fossil fuel as a fraction of primary energy consumption from year 2009 to year 2011 was 84.2percent, 85.0percent, and 85.2percent respectively (Figure 6). Contrary to expectation, during the green growth period the reliance on fossil fuel as a fraction of primary energy shows steady increase. In Chapter 5 the paper looks into the background of this unexpected outcome.

(Figure 6) Reliance on Fossil Fuel as a Fraction of Primary Energy



(Expected Outcome: Lower)

4-2. Greenhouse Gas Emission to GDP Ratio

To compare the energy security of both pre-green growth and green growth in environment dimension, the ratio of greenhouse gas emission to Korea's GDP was also assessed. As noted before, by "greenhouse gas", this paper refers to the definition of "green house" stated in Article 2 Section 9 of "Framework Act on Low Carbon, Green growth"[42] And by "fossil fuel", the paper refers to the same definition as "fuel" stated in Article 2 Section 2 of "Energy Act" –petroleum, gas, coal and other heat sources generating heat. An expected outcome of these evaluations is that it results in low (or 'lower').

(Table 20) Greenhouse Gas Emission (unit: ppb)

	2006	2007	2008	2009	2010
CO2	500.6	522.1	536.1	541.7	595.9
CH4	27.1	27.0	27.0	26.8	28.1
N2O	22.3	13.8	13.8	13.8	14.4
HFCs	6.1	7.4	6.9	5.9	8.2
PFCs	2.9	3.1	2.9	2.3	2.7

[42] Framework Act on Low Carbon, Green growth
Article 2 (Definitions)
For the purposes of this Act:
9. The term "greenhouse gases" means carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbon (HFCs), perfluorocarbon (PFCs), sulfur hexafluoride (SF6), and other substances specified by Presidential Decree in the form of gas in the atmosphere, which absorb or reemit radiant heat to cause a greenhouse effect;"

SF6	16	16.9	17.4	18.6	19.7
Total	575.4	590.3	604.1	609.1	668.8
GDP	9,518 (100million)	$10,492 (100million)	$9,314 (100million)	$8,341 (100million)	$10,149 (100million)

(Source: Korean Statistical Information Service)[43]

The greenhouse gas emissions to GDP ratio of each year was 6.05percent, 5.63percent, 6.49percent, 7.30percent, and 6.59percent in year 2006, 2007, 2008, 2009, and 2010 respectively (Table 20, Figure 7). Data of 2011 was not available. According to Yale Center for Environmental Law & Policy Webinar Series "Climate Change Solutions: Frontline Perspectives from Around the Globe" (Climate Policy & Emissions Data Sheet: South Korea)[44], South Korea saw rapid economic growth and a doubling of its greenhouse gas emissions from 1990 to 2005—the fastest growth in emissions among OECD nations. And South Korea is one of the few OECD countries to have no binding emissions reduction obligations under the Kyoto Protocol, and has thus advocated for the continuation of the Protocol and a formalization of the Copenhagen pledges in international climate

[43]Korean Statistical Information Service http://kosis.kr/themes/themes_04List.jsp?parentId=101_B77&listnm=%EB%85%B9%EC%83%89%EC%84%B1%EC%9E%A5 (Last visited May 11, 2013)

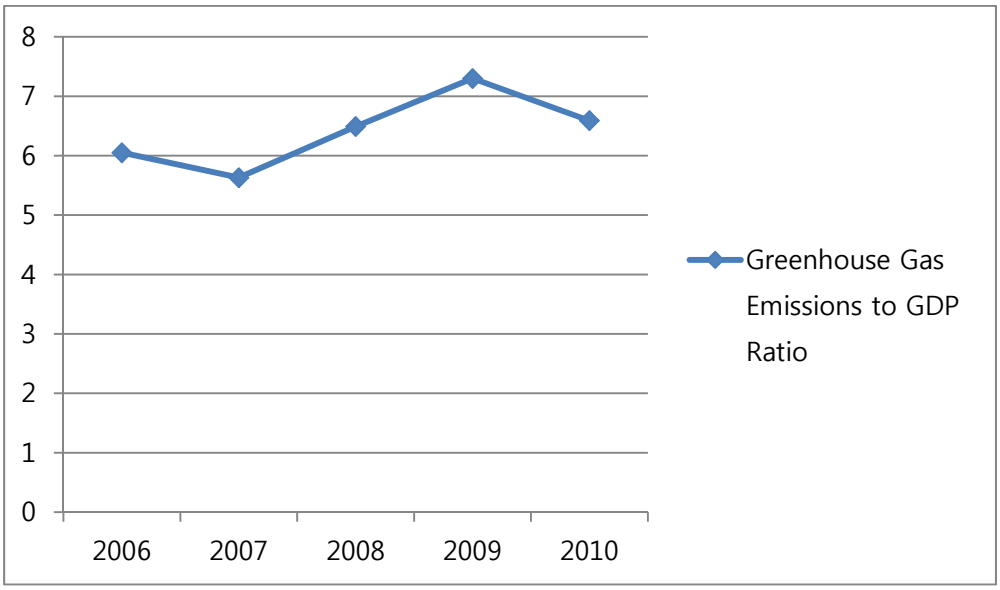
[44] *"Climate Change Solutions: Frontline Perspectives from Around the Globe" (Climate Policy & Emissions Data Sheet: South Korea)* http://envirocenter.yale.edu/uploads/pdf/South_Korea_Climate_Policy_Data_Sheet.pdf (Retrieved December 17, 2012)

negotiations.

(Table 21) Greenhouse Gas Emissions to GDP ratio (Unit: %)

	2006	2007	2008	2009	2010
Greenhouse Gas Emissions to GDP ratio	6.05	5.63	6.49	7.30	6.59

(Figure 7) Greenhouse Gas Emissions to GDP Ratio



(Expected Outcome: Lower)

4-3. Acid Gas Emission to GDP Ratio

Moreover, assessing acid gas emissions to GDP ratio was held. By acid gas emissions, the study researched Nitrogen Oxides (NOx) and Oxides of Sulfur (SOx). Due to the limitation of data, the study evaluates Nitrogen Oxides (NOx) and Oxides of Sulfur (SOx) emissions from the period of 2006 to 2010. As shown in Table 22, the acid gas emissions to GDP ratio of year 2006 to 2010 was 182.965, 151.587, 157.084, 168.091 and 144.147 respectively (Table 23, Figure 8). While the expected outcome is "low/lower", the acid gas emissions to GDP ratio shows increase after the start of green growth policy.

(Table 22) Acid Gas Emission and GDP

	2006	2007	2008	2009	2010
NOx(ton)	1,274,969	1,187,923	1,045,103	1,014,318	1,061,210
Sox(ton)	466,488	402,525	417,980	387,727	401,741
GDP (100 million)	9,518 (100million)	$10,492 (100million)	$9,314 (100million)	$8,341 (100million)	$10,149 (100million)

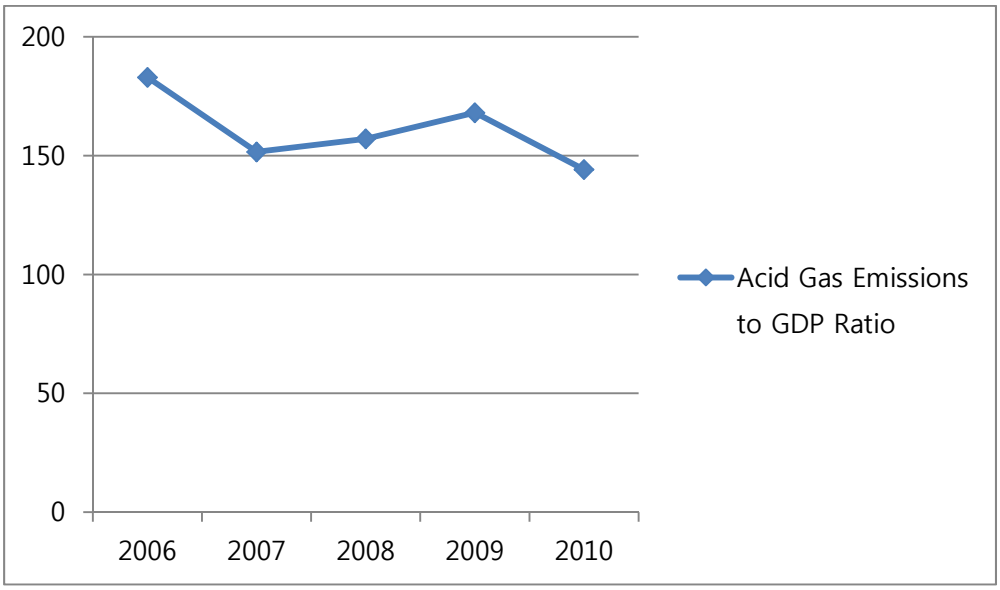
(Source: Korean Statistical Information Service)[45]

[45]Korean Statistical Information Service http://kosis.kr/themes/themes_04List.jsp?parentId=101_B77&listnm=%EB%85%B9%EC%83%89%EC%84%B1%EC%9E%A5 (Last visited May 11, 2013)

(Table 23) Acid Gas Emissions to GDP Ratio

	2006	2007	2008	2009	2010
Acid Gas Emissions to GDP Ratio	182.965	151.587	157.084	168.091	144.147

(Figure 8) Acid Gas Emissions to GDP Ratio



(Expected Outcome: Lower)

5. Technology

To reflect *Technological* dimension of Korea's energy security, the study looked at Korea's R&D cost for "environmental energy technology. The statistics from *National Science and Technology Information*[46] shows that Korea's R&D cost for 'environmental energy technology' in year 2006 was 17,408(100million won) whereas Korea's GDP was 908,744 (billion won). And in year 2007 energy related R&D cost was 23,680(100million won) when GDP was $9,314(100million). In year 2008 it was the ratio of 29,330(100million won) to $8,341(100million). Moreover, in year 2009 it was 34,651(100million won) whereas Korea's GDP was $10,492 (100million). And in year 2010 energy related R&D cost was $48,196 (100million won) when GDP was $9314 (100million). The date of year 2011 was not fully provided by the time of research (Table 24).

[46] National Science and Technology Information, http://sts.ntis.go.kr (Last visited November 28, 2012)

(Table 24) Korea's Energy Related R&D Cost for 'Environmental Energy Technology' (2006-2010) (Unit: 100 million)

	2006	2007	2008	2009	2010	2011
GDP	$951,800	$975,013	$1,026,452	$1,065,037	$1,173,275	$1,237,128
R&D Spending	$174,080	$236,800	$293,300	$104,920	$481,960	N/A

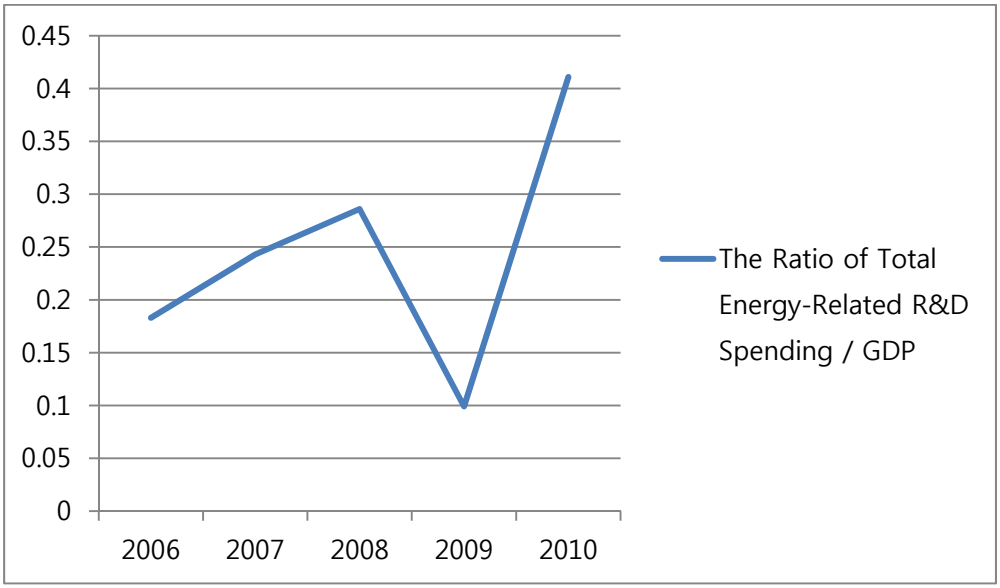
(Source: e-National indicators) [47]

(Table 25) The Ratio of Total Energy-Related R&D Spending to GDP

	2006	2007	2008	2009	2010	2011
Ratio	0.183	0.243	0.286	0.099	0.411	N/A

[47] http://www.index.go.kr/egams/stts/jsp/potal/stts /PO_STTS_IdxMain.jsp?idx_cd=2736&bbs=INDX_001 (Last visited November 28, 2012)

(Figure 9) The Ratio of Total Energy-Related R&D Spending / GDP



(Expected Outcome: Higher)

The fact that that Korea's ratio of R&D spending to GDP ranked 3rd-highest worldwide in September 2011[48] is noticeable as well. South Korea plans to inject more than 5 trillion won (US$4.2 billion) into pushing its technology capabilities up to 96 percent of those of advanced industrialized countries, to develop renewable energy[49].

Renewable energy can play an important role in providing power to

[48] Yonhap News Agency http://english.yonhapnews.co.kr/business/2011/09/13/72/0501000000AEN20110913004400320F.HTML (Last visited November 28, 2012)

[49] Yonhap News Agency http://english.yonhapnews.co.kr/n_techscience/2010/09/01/4501000000AEN20100901007700320.HTML (Last visited November 28, 2012)

critical infrastructure in the aftermath of catastrophes as well (World Watch Institute, 2006). Most renewable energy sources add little or no carbon dioxide (CO2) to the atmosphere. Atmospheric CO2 concentrations have climbed 20 percent since measurements began in 1959 and nearly 36 percent since the dawn of the Industrial Revolution (World Watch Institute, 2006). The examples of concrete alternative resources would be the expansion of solar and wind development, and the improvement in large renewable energy development, green energy development such as bio fuels and non-pollution coal, high-efficiency and non-polluting coal and the development of energy technologies such as LED lighting, the composition of the green city, and the increase in the production of environment-friendly, clean agricultural products.

Moreover, with Korea's goal of achieving 10 percent of the world's green energy industry in 2020 by cultivating 50 small and mid-sized enterprises specialized in the rapidly growing market, it has injected the money into R&D, and Seoul aimed to increase the renewable energy exports to 8.61 trillion won in 2012, up from 6.92 trillion won tallied in the previous year, while creating jobs and causing investment from the private sector.[50]

Korea also aims to increase the country's energy efficiency by 12

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[50] From the November 17, 2011 article of *The Korea Herald*, *"Korea aims for 10 percent share in clean energy market in 2020"*

percent by then and curb the energy sector's greenhouse gas emissions by 15 percent based on business-as-usual (BAU)[51] levels over the same period. The plans are part of a 10-year framework for research and development in energy, which entails accelerating technological advancement, creating a symbiotic environment between large firms and SMEs, upgrading R&D schemes and enhancing infrastructure. In August 2009, Korean government set the goal of cutting greenhouse gas emissions by 21-30 percent by 2020, relative to the BAU scenario (Korea Times. August 4, 2009).

The development of tidal power is a notable change in the country's energy matrix. It is expected that the tidal power generation will expand to 5.2 per cent in 2020, representing a 50 per cent annual increase. Hydropower generation is also expected to increase, with the construction of new dams and 42 hydroelectric plants that would generate 278,471 MWh per year. Nonetheless, the share of hydropower in the total renewable energy supply will decrease, as a result of larger increases in the other renewable resources such as bio energy, wind, tidal power, and solar PV and solar thermal (UNEP April 2010). Other targets include building fourteen "Environment Energy Towns" in eight areas nationwide by 2020. Such towns will employ efficient use of waste resources, green power, and biomass. In small regional

[51] BAU(business as usual) refers to the level of greenhouse gas emissions the country is forecast to reach by a certain year if emissions grow at their current pace.

communities, a total of 600 low-carbon green villages are expected to be built. The government plans to build one million energy-saving green homes by 2020 and to refurbish one million existing houses using new and renewable energy.

6. Nuclear Energy

With the resource depletion that the world faces, shifting towards nuclear power is one way to ensure long-term energy security. Nuclear power remains a pillar of Korea's energy policy, providing 30% of its electricity needs[52]. This policy position stands in contrast to that of some other IEA countries, but is consistent with that of China and India. Given the demand for energy and its lack of indigenous resources, this is a logical policy. Korea has been very effective in building a strong nuclear industry, with high levels of availability and reliability, putting it as one of the leaders in efficient operation and low-cost construction. As a result, nuclear has been the main contributor to providing affordable energy, given Korea's large

[52] *IEA applauds Korea's green growth strategy* http://www.iea.org/newsroomandevents/pressreleases/2012/november/name,33763,en.html (Retrieved December 17, 2012)

dependence on imports[53]

Nuclear energy has also been an important source of energy supply in Korea. And under the green growth strategy, Korea aims to develop its nuclear technology by gradually increasing the proportion of nuclear energy in power generation from 24 per cent in 2009, to 27 per cent in 2013, and to 32 per cent in 2020 (United Nations Environment Programme, 2006).

The present condition and prospect of Korea's nuclear power amount is as shown in Table 26. And the ratio of Korea's nuclear power amount (present condition and prospect) to Korea's GDP is as shown in Table 27.

[53] *Energy Policies of IEA Countries - Korea 2012 Review p.9* http://www.iea.org/Textbase/npsum/Korea2012SUM.pdf (Retrieved December 17, 2012)

(Table 26) Korea's Nuclear Power Amount (Present and Prospect)

(Unit: GWh%)

Year		Total	Nuclear	Coal	Oil	LNG	Water Power	Alternative
2006	Power Amount	381,181	148,749	139,205	16,598	68,302	5,219	3,108
	Balance	100	39	37	4	18	1	1
2008	Power Amount	422,355	150,958	173,508	10,094	75,809	5,561	6,426
	Balance	100	36	41	2	18	1	2
2010	Power Amount	474,660	148,596	197,916	12,878	96,734	6,472	12,064
	Balance	100	31	42	3	20	1	3
2012	Power Amount	497,676	169,077	193,723	16,875	105,272	1,607	11,123
	Balance	100	34	38.9	3.4	21.2	0.3	2.2

(Source: Korea Electric Power Corporation, Ministry of Knowledge Economy)[54]

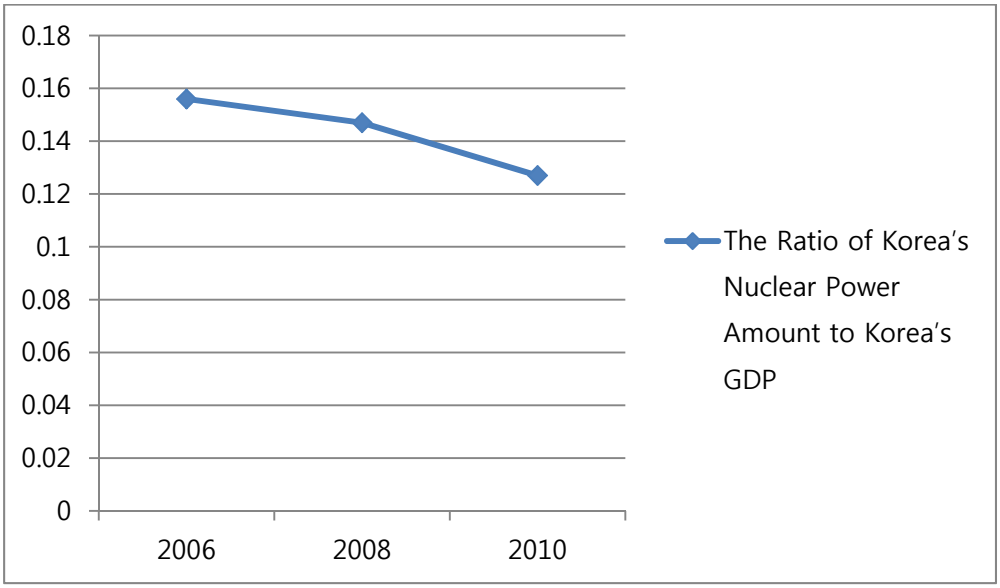
(Table 27) The Ratio of Korea's Nuclear Power Amount to Korea's GDP

	2006	2008	2010	2012
GDP	$951,800	$1,026,452	$1,173,275	N/A
Nuclear Power	148,749	150,958	148,596	169,077
Ratio	0.156	0.147	0.127	N/A

[54] Index Korea http://www.index.go.kr/egams/stts/jsp/potal/stts/PO_STTS_IdxMain.jsp?idx_cd=1339&bbs=INDX_001 (Retrieved December 17, 2012)

Contrary to expectation, the ratio of Korea's nuclear power amount to Korea's GDP shows decrease even after the green growth policy.

(Figure 10) The Ratio of Korea's Nuclear Power Amount to GDP



(Expected Outcome: Higher)

7. International Cooperation

Jan 8, 2009 Appointed as lead country for smart grid technology development

June 16, 2010 Launch of GGGI at the East Asia Climate Forum 2010

Nov.11, 2010 G20 Seoul Summit on green growth In the leader's declaration, the G20 Seoul Summit addressed and elaborated on cooperation for green growth at Korea's proposal

March 14, 2011 President Lee wins the Zayed international prize for the environment

April 6, 2011 Completion of the world's largest electric car battery plant in Ochang, Korea

June 20, 2011 Global Green Growth Summit 2011 Korean green growth Adopted by OECD report

August, 2011 World's largest Sihwa tidal plant opens, generating 5552.7GWh annually

Above are the major international cooperation footsteps of Korea after green growth. The creation of the Global Green Growth Institute (GGGI) represents the institutionalization of Korea's leading role in international environmental and energy cooperation. The GGGI held inaugural meetings of its newly formed Assembly and Council in Korea. As part of the organization's new governance structure as a multi-stakeholder,

hybrid international organization, representatives from all 18 founding member nations[55].

Also in October 2012 Korea was selected as a host country of the secretariat of the Green Climate Fund (GCF). The main purpose of the GCF is to channel money from industrialized nations to developing countries, helping them tackle global warming and other problems related to climate change[56].

In June 2012 at the UN Sustainable Development Summit (Rio+20), the way how to develop and intensify international cooperation between Korea and Australia in energy and resources as well as in climate change and green growth was discussed.

Korea's active role in international energy and environmental cooperation is the direct result of Korea's green growth policy. However, the impact of green growth policy on energy security cannot be analytically assessed.

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[55] The 18 founding members of the GGGI include Australia, Cambodia, Costa Rica, Denmark, Ethiopia, Guyana, Indonesia, Kirabati, Korea, Mexico, Norway, Papua New Guinea, Paraguay, Philippines, Qatar, United Arab Emirates, United Kingdom, and Vietnam.

[56] The Korea Times, Korea selected as host of GCF secretariat, 2012-10-20, http://www.koreatimes.co.kr/www/news/nation/2013/05/117_122718.html (Last visited December 27, 2012)

8. Policy

8-1. Existence of Energy Security Policy

Vivoda (2010) argues that a final challenge to the traditional energy security thinking is the actual existence of energy security policy; if a state does not have a clearly stated energy security policy, which addresses in detail, the traditional and new energy security challenges, this shows that this state may not have the capacity and/or commitment to ensure energy security (Vivoda 2010).

Korea has been initiating substantive policies and programs relevant to national energy security. A year later after former president Lee Myung-bak announced a “low carbon, green growth” vision for Korea’s economic future the government introduced the National Strategy for Green Growth. And in January 2010 South Korea’s National Assembly passed the Framework Act on Low-Carbon Green Growth, codifying a 50-year plan to address climate change and achieve greater energy independence without compromising the country’s economy. Although skepticism around the details of low carbon, green growth remain, particularly mega scale power generating projects and a proposed carbon-trading system, Korea has made

considerable efforts in recent years to back green growth[57].

Moreover, article 39 of Framework Act on Low Carbon, Green Growth mentions energy policy by stating 'Basic Principles of Policies on Energy'. This is, however, a legislation inadequacy in that the act is insufficient to lay a foundation for Korea's overall energy security policy. Moreover, more systematic attention is necessary and an energy security indicator should be arranged. This research was held in hopes to contribute to the formation of Korea's energy security indicator.

8-2. Policy on Energy Supply

Almost entirely dependent on imported energy, Korea has made efforts to enhance energy security by taking measures to diversify energy sources, reduce the use of fossil fuels, and foster the development of renewable energy. The contribution of renewable sources to total primary energy supply (TPES) in Korea is the lowest in the OECD. To address this anomaly, the government has established an 11% target of new and renewable energy in TPES by 2030 (IEA 2012). Efforts to diversify energy sources require a fundamental transformation of Korea's consumption

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[57] *Korea's Green Growth Strategy: A Washington Perspective* http://keia.org/publication/korea%E2%80%99s-green-growth-strategy-washington-perspective (Retrieved December 17, 2012)

patterns. In 2008, oil accounted for nearly 50 percent of the country's total consumption mix, nuclear power nearly 30 percent, coal 7 percent, natural gas 12 percent, and renewable accounted roughly 2 percent of total usage. With 57 percent of these resources consumed in heavy industry, a shift from energy-intensive sectors to low-carbon ones will undoubtedly be necessary. However, given that South Korea is the global leader in shipbuilding and is the fifth-largest steel and auto producer and that heavy industry accounts for 30 percent of overall GDP, reaching reductions targets will be no easy feat[58].

The government also specified several key technologies (photo-voltaic, solar thermal, geothermal and bio energy) in the Third Renewable Basic Plan. In 2012, the government replaced the existing feed-in tariff mechanism with a renewable portfolio standard (RPS) applicable from 2012 for the purpose of meeting its new and renewable energy targets (IEA 2012).

8-3. Policy on Efficiency

Korea's energy intensity, adjusted for purchasing power parity, has been declining relatively steadily since its peak in 1997, falling at an average annual rate of 0.3% between 1990 and 2010. Despite this declining trend, Korea's energy intensity is still expected to remain above that of most IEA

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[58] *Korea's Green Growth Strategy: A Washington Perspective* http://keia.org/publication/korea%E2%80%99s-green-growth-strategy-washington-perspective (Retrieved December 17, 2012)

countries in the near future[59].

The Ministry of Commerce, Industry and Energy (MOCIE), through Korea Energy Management Corporation (KEMCO), operates three energy efficiency programs to facilitate products embodying low energy input. These three programs are "Energy Efficiency Standards & Labeling Program", "Certification of High Efficiency Energy-using Appliance Program", "Energy-Saving Office Equipment & Home Electronics Program". The objective of these programs is to stimulate manufacturers to improve their products' efficiency by giving incentives and to induce consumers to purchase more energy efficient products available in the market place[60].

Moreover, national efforts for energy efficiency improvements in four major sectors—industry, transportation, buildings, appliances and equipment, are required to achieve significant energy efficiency. In particular, energy efficiency in the appliances and equipment sector is very important in the sense that it is at the root of the energy efficiency. Energy efficiency labeling

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[59] *Energy Policies of IEA Countries - Korea 2012 Review p.13* http://www.iea.org/Textbase/npsum/Korea2012SUM.pdf (Retrieved December 17, 2012)

[60] *Energy Efficiency Programs in Korea* http://www.google.co.kr/url?sa=t&rct=j&q=korea%20energy%20efficiency%20policy&source=web&cd=6&ved=0CEQQFjAF&url=http%3A%2F%2Fwww.ieadsm.org%2FFiles%2FExco%2520File%2520Library%2FCountry%2520Publications%2Fprograms.doc&ei=psLPUKqWOdHZigKh0oCADw&usg=AFQjCNH3ttvxcNu7LSdRuE3sD1yFgxll2Q&sig2=N9UtKyYzMA660-U5pDuVpg&bvm=bv.1355534169,d.cGE&cad=rjt (Retrieved December 17, 2012)

schemes (Energy Efficiency Label and Standard Program, High efficiency Appliance Certification Program, e-Standby Program) play a key role in carrying out the energy efficiency improvement policy in the appliances and equipment sector in Korea[61].

8-4. Policy on Economy

As of the end of the Korean War, Korea's economy and infrastructure, to the extent that it had survived the ravages of the conflict, was largely agricultural, with most energy provided by biomass (wood and crop wastes) and from Korea's modest reserves of anthracite coal. The country's rapid industrialization, particularly in the last 30 years, has been fueled largely with imported energy, such that as of now only a small percent of energy is supplied from domestic sources, and much of that is combustion of municipal and other wastes. By 2010, domestic coal constituted only about 1.8 percent of total Korea's coal use, and much less than one per cent of total energy use (Sun-Jin YUN et al., 2011).

President Lee Myung-bak's green growth strategy was the first time an KOREA administration has linked domestic economic growth policies with environmental considerations. His approach rests on the premise that

[61] *Korea's Energy Standards & Labeling* http://www.kemco.or.kr/nd_file/kemco_eng/KoreaEnergyStandards&Labeling.pdf (Retrieved December 17, 2012)

significant, real reductions in domestic greenhouse gas emissions need not curtail the country's economic growth; in fact, the strategy proposes that investing in the development of new and renewable energy sources can create jobs and spur the economy while bringing the country closer to an energy secure future. Given the country's history of sidelining and providing minimal budgetary support for environmental issues, low carbon, green growth is a welcome departure from development approaches of the past However, while policies aiming at renewable energy development vary, policies that are directly linked to energy economy are hard to track down (Korea Economic Institute and the Korea Institute for International Economic Policy, 2011).

8-5. Policy on Environment

Korea, which has had the highest growth rate of greenhouse gas emissions in the OECD area since 1990, adopted an ambitious Green Growth Strategy in 2009. It aims at reducing emissions by 30% by 2020 relative to a "business as usual" scenario, implying a 4% cut from the 2005 level[62].

The Strategy also includes a Five-Year Plan with public spending of

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[62] Randall S. Jones and Byungseo Yoo 2012, ACHIEVING THE "LOW CARBON, GREEN GROWTH" VISION IN KOREA
ECONOMICS DEPARTMENT WORKING PAPERS No. 964 http://search.oecd.org/officialdocuments/displaydocumentpdf/?cote=ECO/WKP(2012)41&docLanguage=En

2% of GDP per year to promote green growth (Jones, 2012). This strategy has been transposed into law by the enactment of the Framework Act on Green Growth, whose implementation is coordinated by a Presidential Committee[63]. And Korea is planning to establish a carbon price through a cap-and-trade emissions trading scheme. Such an approach, combined with a carbon tax in sectors not covered by the scheme, is necessary to reduce emissions in a cost-effective manner and foster innovation in green technology.

In addition, each sector should face the same electricity price based on production costs to promote efficient energy use. Given market failures, the government has a role to play in green R&D, particularly for basic research, in fostering green finance and in developing renewable energy resources (Jones, 2012).

8-6. Policy on Technology

Green growth has been one of President Lee's trademark policies. It calls for lessening South Korea's dependence on fossil fuels and promoting the development of alternative energy sources, such as solar and wind power, and other technologies that increase energy efficiency. And former president

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[63] *Energy Policies of IEA Countries - Korea 2012 Review p.9* http://www.iea.org/Textbase/npsum/Korea2012SUM.pdf (Retrieved December 17, 2012)

Lee believed the strategy will provide Korea with fresh growth engines for its economy and help the country -- one of the world's biggest greenhouse gas emitters -- reduce its emission of carbon dioxide and other heat-trapping gases amid growing calls to curb global warming[64]. To speed up green growth, Korea has established 'Green Technology Center' in March 2012[65].

A task force comprising the top researchers at the Korea Institute of Science and Technology (KIST), the Korea Advanced Institute of Science and Technology (KAIST) and the Korea Institute of Energy Research has been working on the establishment[66]. The move underscores South Korea's commitment to green growth, one of President Lee's trademark policies. It calls for lessening South Korea's dependence on fossil fuels and promoting the development of alternative energy sources, such as solar and wind power, and other technologies that increase energy efficiency[67].

The renewable portfolio agreement (RPA) was implemented in 2006

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[64] The Korea Times, Korea to establish 'Green Technology Center' to speed up green growth (2012-01-26) ,http://www.koreatimes.co.kr/www/news/nation/2012/01/116_103471.html (Last visited May 9, 2013)

[65] Green Technology Center Korea, http://www.gtck.re.kr/information/history.php (Last visited May 9, 2013)

[66] Yonhap News Agency, S. Korea to establish 'Green Technology Center' to speed up green growth (2012/01/26) http://english.yonhapnews.co.kr/national/2012/01/26/98/0301000000AEN20120126004600315F.HTML (Last visited May 10, 2013)

[67] Yonhap News Agency, S. Korea to establish 'Green Technology Center' to speed up green growth (2012/01/26) http://english.yonhapnews.co.kr/national/2012/01/26/98/0301000000AEN20120126004600315F.HTML (Last visited May 10, 2013)

and its main content was voluntary agreement between Korean government and large public utilities to invest 737 million dollars in renewable energy technologies. Also first Renewable portfolio standard (RPS) was introduced in second basic plan for renewable energy deployment in 2003 and in third basic plan for Renewable energy in 2008. The starting year is 2012 and this act will obligate all electricity suppliers to produce a certain portion of electricity by renewable energy. This portion will be 2% in 2012 and will increase to 10% in 2022[68].

As former president Lee Myung-bak believed the green technology strategy will provide South Korea with fresh growth engines for its economy and help the country — one of the world's biggest greenhouse gas emitters — reduce its emission of carbon dioxide and other heat-trapping gases amid growing calls to curb global warming, such movement and establishment is well paced[69]. The attainments, however, are to be observed.

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[68] *Energy Policies to promote Renewable Energy Technologies; Learning from Asian Countries Experiences*
http://eneken.ieej.or.jp/3rd_IAEE_Asia/pdf/paper/110p.pdf
(Retrieved December 17, 2012, Last visited May 9, 2013)

[69] The Korea Herald, *'Lee calls for continued pursuit of green growth'*, 2012-01-26, http://www.koreaherald.com/view.php?ud=20120126001076 (Last visited May 9, 2013)

8-7. Policy on Nuclear Energy

Limited domestic energy resources, a growing manufacturing base in industries highly relevant to nuclear power development, and the desire to develop expertise in nuclear technologies, among other considerations, led Korea to emphasize nuclear power as an energy supply security measure. 21 nuclear reactors are now under operation, with ongoing expansion expected to result in 28 operating reactors as of 2016. Nuclear generation accounted for 34.1 percent of generation in 2009, and plans call for an additional 6 reactors to be constructed by 2023 (Sun-Jin YUN et al., 2011).

The government's green growth plan also entails heavy investment in nuclear power, a low-carbon energy source not always regarded by critics as green, given its associated environmental disadvantages. Seoul has targeted a doubling of nuclear energy consumption by 2030, from 29 percent of total national electricity-generating capacity to 59 percent, driven by the construction of 10 nuclear plants alongside 7 that are currently being built and 21 already in operation[70].

Korea has also become a major nuclear technology exporter, securing in December 2009 a $20 billion contract to develop civil nuclear

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[70] *Korea's Green Growth Strategy: A Washington Perspective* http://keia.org/publication/korea%E2%80%99s-green-growth-strategy-washington-perspective (Retrieved December 17, 2012)

power plants in the United Arab Emirates. The increasing use of nuclear energy and the concomitant production of nuclear waste have distressed South Koreans. Especially given the recent disaster at the Fukushima Daiichi plant in Japan, concerns about the safety of handling, processing, and storing spent nuclear fuel and the placement of nuclear power plants and waste disposal facilities have come to the fore (Korea Economic Institute and the Korea Institute for International Economic Policy, 2011).

According to Poirier, South Korea has aggressively invested in nuclear and renewable energy at home. Since 1977, South Korea has produced and consumed small amounts of nuclear energy, but it is only in the late 1980's that data suggests that it began playing an important part in South Korea's energy mix. Today, it represents 14 percent of all energy consumed in the country, and it is primarily reserved to produce electricity. With 20 nuclear power plants, South Korea is ranked sixth in the world in terms of nuclear infrastructure, and growth in this industry is not likely to stop either. Currently, six reactors are under construction. The Korea Hydro and Nuclear Power Corporation's most optimistic forecasts are that by 2030 nearly 60 percent of all electricity generation will be nuclear (Poirier 2011).

Chapter 5

Findings and Reviews of Unexpected Outcomes

In Chapter 5, the study reviews the dimensions that produced unexpected outcomes. By bringing the spotlight onto those dimensions, this study seeks the causal relations between the backgrounds and outcomes. Based on the study and along with the expected outcome to each dimension, Table 28 shows the outcome of Korea's Energy Security Assessment that was held in Chapter 4.

(Table 28) Korea's Energy Security Assessment Outcome

Dimensions	Attributes	Expected Outcome	Assessment
1. Energy Supply	1) Energy Dependency (Primary Energy Import/Total Energy Consumption)	-Low	-High
	2) Energy Supply by Renewable Energy	-High	-High
2. Efficiency	1) Energy Efficiency (mtoe/US$1,000 of GDP)	-Low	-Low
	2) Energy Consumption Growth/Economic Growth Ratio	-Low	-Low→High
3. Economy	Import Fuel Costs /GDP	-Low	-Low
4. Environment	1) Reliance on Fossil Fuels as a Fraction of Primary Energy Consumption	-Low	-High
	2) Greenhouse Gas Emission (CO2, CH4)/GDP	-Low	-High
	3) Acid Gas Emissions (Sox, NOx)/GDP	-Low	-High
5. Technology	Total Energy-Related R&D Spending/GDP	-High	-High
6. Nuclear Energy	The Ratio of Korea's Nuclear Power Amount to Korea's GDP	-High	-Low
7. International Cooperation	Commitment to Regional and Other International Cooperation on Energy-Related Issues	-Active	-Active
8. Policy	1) Existence of Energy Security Policy	-Yes	-No
	2) Policy on Energy Supply	-Yes	-Yes
	3) Policy on Efficiency	-Yes	-Yes
	4) Policy on Economy	-Yes	-Yes
	5) Policy on Environment	-Yes	-Yes
	6) Policy on Technology	-Yes	-Yes
	7) Policy on Nuclear Energy	-Yes	-Yes

1. Reviewing Unexpected Outcome of *Energy Supply* Dimension

In the first dimension *Energy Supply*, the outcome of the energy dependency—that is, the ratio of primary energy import to total energy consumption, showed "high" whereas the expected outcome was "low". With the nation continuously emphasizing the reduction of energy consumption, why is the primary energy import and total energy consumption steadily growing? The simple answer to this is that with nothing to be done on the supply side in the short term, South Korea can only work on demand. So far, that has mainly meant government officials penalizing themselves with thermostat settings that leave their offices cold in the winters and sweltering in the summers. And they occasionally go on a propaganda campaign urging shopping malls, office buildings and others to conserve[71]. Meanwhile, renewable energy, more typically considered to be a form of green energy, will continue to occupy a minor proportion of the total energy consumption during the forthcoming 50 years or so rising from about 2.7 percent in 2009 to only 6.08 percent in 2020, and only then to a more substantial 30 percent in 2050. Concern for energy independence as manifested in the Korea's green power policies is not so acute: Korea's rate of energy independence (the fraction of energy supplies from domestic

[71] The Wall Street Journal, South Korea Flirts With Another Power Disaster, December 26, 2012, http://blogs.wsj.com/korearealtime/2012/12/26/south-korea-flirts-with-another-power-disaster (Last visited May 10, 2013)

sources) excluding nuclear power in 2007 was 3.4%, but rose to 16 percent if nuclear power is considered a domestic resource (though Korea's imports nuclear fuel and licenses some nuclear technologies from other nations) (Sun-Jin Yun et al., 2011). According to Calder, oil demand may well be slowing in Korea as the transportation market matures, as industrial consumers economize, and as electric power providers shift to natural gas and nuclear power. Overall, South Korean energy demand will continue to rise, fueling a deepening of Korea's energy insecurities. Korea must supply its rapidly rising thirst for energy in what is arguably the most competitive energy neighborhood in the world. One neighbor, Japan, has been the largest liquefied natural gas (LNG) importer and the second-largest oil importer on Earth. And next-door China alone accounted for more than one-third of world oil-demand growth during 2000–04. In tight global markets, Korea's energy-security tasks are indeed sobering in their scale, scope, and intensity (Calder 2005).

2. Reviewing Unexpected Outcome of *Energy Efficiency* Dimension

In the second dimension *Efficiency*, the outcome of the energy efficiency—the ratio of mtoe to US$1,000 of GDP, stayed 'low' prior to and with the start of the green growth. While this is an expected result, contrary to the anticipation however, the energy consumption growth to economic

growth ratio retrogressed. Between year 2007 to 2008 there was a 3.9 percent decrease in the energy consumption rate. In year 2009 with the introduction of green growth Korea's total energy consumption decreased by 0.3 percent. It almost looked as if the green growth and energy reduction policy were going harmoniously, until year 2010 when the total energy consumption of Korea bounced back with the 6.5 percent increase. And although the next—year 2011, it decreases to 3.2 percent, in numbers, in fact, Korea's total energy consumption had nothing but steadily increased—from 182,066 (year 2009) to 193,832 (year 2010) to 200,086 (year 2011).

Then what was the cause of the increase of Korea's total energy consumption despite nation's growing concern about energy efficiency? Should the simple "supply and demand" matter be blamed? Or is there something else? An ambitious target of curbing greenhouse emissions by 30 percent by 2020 was announced in 2010 by the Korean government. And to achieve this emission limit, the plan will be implemented for 470 Korean companies which produce 60% of the country's CO2 emissions[72]. So once again admittedly it is premature to assess Korea's green growth policy and to expect for an immediate outcome. This could only explain however, why the energy consumption rate is, hypothetically, merely "decreasing" but could

[72] IPEEC (International Partnership for Energy Efficiency Cooperation), http://www.ipeec.org/member_south_korea.aspx (Last visited May 11, 2013)

not explain the sudden increase—it is too much of contradiction. Was the skepticism right then? Was the government's indoor temperature regulations for offices and the subway system, as the energy saving measure is feared to lower productivity and efficiency by forcing people to work under sweltering conditions effortless[73]? Having public offices such as those for central and local governments, public organizations and courts having to keep the indoor temperature at 28 degrees Celsius or above during the summers was a challenging and questioning enough for many individuals.

First of all, what is interesting is that the winter from in year 2010 was unusually cold. The snowfall in central parts of the country broke Korea's 73-year-old record. And in Seoul the mercury dropped to minus 15.3 degrees Celsius in January 2010, challenging the lowest temperature in the capital city of -16.7 degrees, set on Jan. 22, 2004[74]. Perhaps it was the heating demand problem. The unexpected inclement weather had triggered the extreme usage of power and gas. It should be noted, however, that the energy consumption of the public offices has decreased by 8.8 percent, corresponding to the "10% Energy Saving" movement held by the

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[73] The Korea Times, 2012-06-18, *Temperature limits add to heat stress*, http://www.koreatimes.co.kr/www/news/nation/2012/06/117_113333.html (Last visited May 11, 2013)

[74] The Korea Times, 2010-01-13, *Is Current Cold Winter Ushering In Mini-Ice Age?*, http://www.koreatimes.co.kr/www/news/nation/2010/01/117_58948.html (Last visited May 11, 2013)

government[75].

Though the unusually cold winter played its role in Korea's energy consumption in year 2010, another reason provides a better explanation—the economic recovery. With its GDP increasing approximately by 7.8 percent compared to the year before (year 2009), the base effect recovering from the negative growth was the largest. And as the more industrial activities took place with the GDP growth, the more energy was consumed[76].

3. Reviewing Unexpected Outcome of *Environment* Dimension

The two factors— greenhouse gas emission (CO2, CH4) to GDP ratio, and acid gas emissions (Sox, NOx) to GDP, in the fourth dimension *Environment* showed downturn after the start of green growth. And as Korea will limit the burden on manufacturers and reduce emissions by "non industries" such as transportation and building to keep carbon dioxide output below the level it may rise to by 2020 in the absence of preventive

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[75] KTY Government Broadcasting System for the people, 2010.5.18, *경기 회복세 타고 에너지 소비 증가*, http://www.ktv.go.kr/program/contents.jsp?cid=338916 (Last visited May 11, 2013)

[76] KTY Government Broadcasting System for the people, 2010.5.18, *경기 회복세 타고 에너지 소비 증가*, http://www.ktv.go.kr/program/contents.jsp?cid=338916 (Last visited May 11, 2013)

measures[77], it is expected to be kept this way.

However, the result of reliance on fossil fuels as a fraction of primary energy consumption shows "higher" while its expected outcome is "lower". The status of fossil fuel being the major energy resource in Korea will remain as it is unless Korea could shift its primary energy resources from the existing ones to renewable energy resources. Since the Korean government and businesses aimed to bolster their share in the world's renewable energy market to 18 percent by 2030, and create 1.5 million jobs to cut reliance on fossil fuels, given that this plan is successfully carried out, lowering Korea's reliance on fossil fuel seems promising. On the other hand, the new President Park Geun-hye and her officials are openly skeptical toward former president Lee's green packages, saying they were too oriented toward economic growth. They hinted at a shift back to the goal of sustainable development, which Lee had ditched as outdated[78]. So by harmonizing environmental protection and economic development Korea's energy security in the sense of "environment" will become more secure.

Moreover, according to the Knowledge Economy Ministry the government selected solar and wind power, fuel cells, biogas, energy storage

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[77] Bloomberg, November 17, 2009, South Korea to Cut Greenhouse Emissions 30% by 2020, http://www.bloomberg.com/apps/news?pid=newsarchive&sid=aTCt6NfyRFDo (Last visited May 12, 2013)

[78] ANN (Asia News Network), March 03, 2013, South Korea ditching 'green growth', http://www.asianewsnet.net/South-Korea-ditching-green-growth-44753.html (Last visited May 12, 2013)

and nuclear energy as 15 key "green energy" industries to provide technology research support to companies, aid in an e-mailed statement that carried details of a 20-year roadmap. The government's drive to reduce its reliance on fossil fuels is spurring companies to boost their investments in renewable energy. They invested 3.56 trillion won in 2010, compared with 719 billion won in 2007, according to the statement. Their sales from clean energy rose to 8.1 trillion won in 2010 from 1.25 trillion won in 2007[79].

4. Reviewing Unexpected Outcome of *Nuclear Energy* Dimension

In the eighth dimension *Nuclear*, the ratio of Korea's nuclear power amount to Korea's GDP showed "lower" while the expected outcome is "higher". The last decade has seen some transitions in Korea's energy sector, including a partial restructuring of the electricity sector, expanded investment in oil and gas producer nations, and a drive to export nuclear technologies (Yun et al 2011). And according to Calder, Korean consumers have five basic choices among varieties of fuel: oil, natural gas, nuclear power, hydroelectric power, and alternative forms of energy. Each choice is to some extent historically embedded—the absence of pipelines, for example, makes a short-run choice of natural gas more difficult in Korea than it would

[79] Bloomberg, Jun 6, 2011, S. Korea Aims to Create 1.5 Million Jobs in 'Green Energy', http://www.bloomberg.com/news/2011-06-07/s-korea-aims-to-create-1-5-million-jobs-in-green-energy-.html (Last visited May 12, 2013)

be in the United States, Canada, or Western Europe And the optimal strategy for Korea, from an energy-security perspective, is to move from coal and oil toward natural gas, nuclear power, and alternate energies.

As Sun puts it, limited domestic energy resources, a growing manufacturing base in industries highly relevant to nuclear power development, and the desire to develop expertise in nuclear technologies, among other considerations, led Korea to emphasize nuclear power as an energy supply security measure. 21 nuclear reactors are now under operation, with ongoing expansion expected to result in 28 operating reactors as of 2016. Nuclear generation accounted for 34.1 percent of generation in 2009, and plans call for an additional 6 reactors to be constructed by 2023. By 2010, Korea's nuclear capacity and generation ranked sixth among the world's nations, its fraction of generation produced by nuclear power ranked fourth among the 10 countries with the largest installed nuclear capacity, and Korea was first by a wide margin among the top 10 nuclear power users when considering its nuclear capacity per unit of land area. Korea has also been actively promoting nuclear technology exports, including a recent deal to build reactors in the United Arab Emirates (Sun et al 2011).

As for nuclear energy, the nuclear power itself has grown from year 2006 to 2012 from with a slight retreat in year 2010. And promisingly, the installed nuclear power already comprises approximately 28 percent of

Korea's electric generating capacity, and its marginal costs of production are the lowest of any energy alternative. The only needed raw material, after all, is uranium, potentially available rather inexpensively even on the Korean peninsula itself (Calder 2005).

5. Reviewing Unexpected Outcome of *Policy* Dimension

In *Policy* dimension, the lack of energy security remains an issue. What should be noted, above all, is that while Article 39 of Framework Act on Low Carbon, Green Growth mentions energy policy by stating 'Basic Principles of Policies on Energy', it is a legislation inadequacy in that it is insufficient to lay a foundation for Korea's overall energy security policy.

Chapter 6

Concluding Remarks

Many scholars have studied Korea's low carbon green growth policy and energy security. However, with the difficulty to find from these studies the direct link of Korea's low carbon green growth policy to Korea's energy security, this paper tried to discover how the low carbon green growth policy has affected and changed Korea's energy security.

Energy security in a traditional sense is usually defined as "reliable supplies at a reasonable price". To build a conceptual framework of the study, an expanded comprehensive concept of energy security was first introduced and the analysis of the impact of Korea's national green growth policy on Korea's energy security was attempted.

The study set up established eight dimensions and eighteen attributes as an analytical framework and the outcome of the impact assessment was as shown in Table 28. While it could be argued that it is still premature to assess a Korea's perhaps incipient stage of green growth policy, the assessment in Chapter 4 and the reviews in Chapter 5 were held in hopes to contribute to the formation of Korea's green growth and energy security indicator.

The study shows that Korea is going in accordance with the green growth policy and therefore is securing its energy security in energy supply

by renewable source, energy efficiency, energy economy, and technology. Through the assessment of the eight dimensions, thirteen factors out of eighteen showed expected outcomes, in accordance with green growth policy. However, five factors from *Efficiency* (second dimension), *Environment* (fourth dimension), *Nuclear Energy* (sixth dimension), and *Policy* (eighth dimension) were retrogressive to the expected results. The findings and reviews in Chapter 5 answer the reasons to this discrepancy.

While skepticism around the details of low carbon green growth remains, Korea has made considerable efforts in recent years to back green growth with vigorous steps toward international cooperation and by leading the way in low carbon green growth actions. However, the question remains whether such endeavor had a positive effect in Korea's low carbon green growth policy and energy security. Moreover, although article 39 of Framework Act on Low Carbon Green Growth mentions energy policy by stating 'Basic Principles of Policies on Energy', there is a legislation inadequacy. The act is insufficient to lay a foundation for Korea's overall energy security policy. Thus, more systematic attention is necessary and an institutional framework should be built in the name of energy security, such as an energy security indicator. And this research was held in hopes to contribute to the formation of Korea's energy security indicator.

In hopes to further expand and intensify the evaluation with copious

evidence that will have occur within time in the near future, this paper puts its value in its attempt to meticulously and empirically exam the relation between “Low Carbon Green growth” energy security of Korea within the purview of the given period.

Although this study accepts criticism of imprecise elaboration and analytical limitations as an impact assessment in terms of time scope and methodology, this endeavor expects to contribute to stimulate and diffuse analytical concerns on the impact of Korea’s globally known green growth policy stream on energy security in academic communities of international corporation and security as well as in relevant fields in social sciences.

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초록

저탄소 녹생성장 정책과 한국의 에너지 안보

: 저탄소 녹생성장의 한국 에너지안보에 대한 영향 연구 및 평가

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강연경

저탄소녹색성장이 한국의 에너지 안보에 어떠한 영향을 미치는지에 관한 경험적 분석인 이 연구는 저탄소녹색성장정책과 에너지 안보의 관계에 대한 개념적, 분석적 틀을 제시하고 이에 따라 실질적 영향의 분석을 시도한다. 이를 위해 이 연구는 이명박 정부의 "저탄소녹색성장"의 대한민국 에너지 안보에의 영향을 분석하기 위해 '저탄소녹색성장 이전 (2006-2008)'과 '저탄소 녹색성장 이후(2009-2011)'의 비교에 의한 영향분석을 시도한다.

에너지 안보의 개념적 틀 소개를 위해 에너지 안보의 전통적 정의와 개념을 살피고 현 국제 정세에 적합하도록 개념을 확대하기 위해 에너지 안보의 새로운 개념을 구성한다. 에너지 안보의 새로운 개념과 전통적 개념의 논의를 통해 분석 틀이 연역적으로 구성된다. 영향분석을 위해 본 연구는 에너지 안보의 8 개 항목을 제시하고

에너지 안보의 개념적 확장을 통한 통합적 접근을 시도한다.

본 연구는 이어서 한국의 저탄소녹색성장 정책의 출현과 그의 에너지 안보에 대한 연관성을 논의한다. 또한 한국의 에너지 수급, 효율, 경제, 환경, 기술, 국제 협력 및 정책의 에너지 안보의 각 항목들에 따른 저탄소 녹색성장의 영향을 밝히고 검토한다. 연구의 결과와 경험적 분석을 통해 한국의 에너지 안보를 강화하고 개발하기 위한 정책 권고를 함이 본 연구의 현실적 기여가 될 것이다.

연구의 결과 한국은 녹색성장 정책에 부합하고 있으며 재생가능자원, 에너지 효율성, 에너지 경제, 그리고 기술 부분에서 에너지 안보를 강화해가고 있는 것을 알 수 있다. 8개 항목의 검토를 통해 18개 중 13개의 요소가 녹색성장 정책에 부합하여 예상 결과를 보였다. 그러나 효율성, 환경, 핵에너지, 그리고 정책에서 5가지 항목은 예상 결과에 반하는 결과를 보였다. 제5장의 연구 결과와 검토는 이러한 불일치에 대한 해석이다.

비록 이 연구가 시간적 범위 및 방법론에 있어서 영향분석으로서 정밀성이 부족하고 분석적 한계가 있다는 비판을 받을 수는 있으나, 이 연구의 시도가 국제협력과 안보는 물론 사회과학 관련 부문의 학문공동체에 전 세계에 알려진 한국 녹색성장정책의 에너지 안보에의 영향에 대한 분석적 관심을 자극하고 확산시키는데 기여할 것으로 기대된다.

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Keywords: 에너지안보, 한국, 저탄소녹색성장
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