Energy Policy 96 (2016) 241–250

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Changes of the carbon dioxide emissions and the overshoot ratio resulting from the implementation of the 2nd Energy Master Plan in the Republic of Korea

M.J. Yeo [a], Y.P. Kim [a,b,*]

[a] Department of Environmental Science and Engineering, Ewha Womans University, 52, Ewhayeodae-gil, Seodaemungu, Seoul, Republic of Korea
[b] Department of Chemical Engineering and Materials Science, Ewha Womans University, 52, Ewhayeodae-gil, Seodaemungu, Seoul, Republic of Korea

HIGHLIGHTS

- The overshoot ratio will increase in 2035 even if the 2nd EMP is fully implemented.
- Power mix configuration changes would not be enough to achieve the GHG target.
- Increasing the conversion efficiency is good in long-term to achieve the GHG target.

ARTICLE INFO

Article history:
Received 13 January 2016
Received in revised form
29 May 2016
Accepted 2 June 2016
Available online 10 June 2016

Keywords:
Overshoot ratio
Carbon footprint
Energy consumption
2nd Energy Master Plan
National greenhouse gases emission reduction target

ABSTRACT

Based on the national greenhouse gas emission reduction target for 2030 ("GHG target for 2030") and the 2nd Energy Master Plan ("2nd EMP"), several power mix configuration scenarios were tested to estimate the sensitivity of the carbon dioxide emissions and the 'overshoot ratio', which is the ratio of ecological footprint to biocapacity. It would be only possible to achieve the GHG target for 2030 if the fraction of non-emission energy be more than 70% of the total input primary energy for power generation with the current conversion efficiency (40%). Even the conversion efficiency is changed to 50%, still the carbon dioxide emissions are larger than the targeted carbon dioxide emissions from the energy sector. The overshoot ratio would still increase from 5.9 in 2009 to 7.6 in 2035 even with the successful implementation of the 2nd EMP. Thus, additional efforts to reduce the carbon dioxide emissions and the overshoot ratio from the energy sector are required beyond adjusting the supply mix configuration for power generation and the conversion efficiency. Policies and programs encouraging the changes in consumer behavior toward reduction of goods consumption and energy savings are expected to impact on reducing the carbon dioxide emissions and the overshoot ratio.

© 2016 Elsevier Ltd. All rights reserved.

1. Introduction

The Republic of Korea (Korea) was the lowest ranked country in the 2005 Environmental Sustainability Index (ESI) among the Organisation for Economic Co-operation and Development (OECD) countries (Esty et al., 2005). Also, Korea's demand on natural resources such as energy and food, and its ecological footprint have experienced a steep increase as a result of rapid industrialization (Wackernagel et al., 2004). The real per capita Gross Domestic Product (GDP) was 1.13 million KRW (956 USD in 2016 dollars) in 1961 and 28.3 million KRW (23,942 USD in 2016 dollars) in 2014 (KOSTAT, 2016a) as a result of rapid growth in Korean economy. Thus, 'overshoot' situation, where the total demand for ecological goods and services exceeds (ecological footprint) the available supply (biocapacity) for a given location (Borucke et al., 2013), is intensifying. In 2009, the ecological footprint was about 5.9 times higher than the biocapacity in Korea as shown in Fig. 1 (Yeo and Kim, 2014). 'Ecological footprint' is defined as the area used to support a defined population's consumption. The consumption footprint (in gha) includes the area needed to produce the materials consumed and the area needed to absorb the carbon dioxide emissions. 'Biocapacity' is the capacity of ecosystems to produce useful biological materials and to absorb waste materials generated by humans, using current management schemes and extraction technologies (GFN, 2015).

The carbon footprint has been the primary part of the ecological footprint over the last 50 years in Korea as shown in Fig. 1.

* Corresponding author at: Department of Chemical Engineering and Materials Science, Ewha Womans University, 52, Ewhayeodae-gil, Seodaemungu, Seoul, Republic of Korea.
E-mail address: yong@ewha.ac.kr (Y.P. Kim).

http://dx.doi.org/10.1016/j.enpol.2016.06.004
0301-4215/© 2016 Elsevier Ltd. All rights reserved.

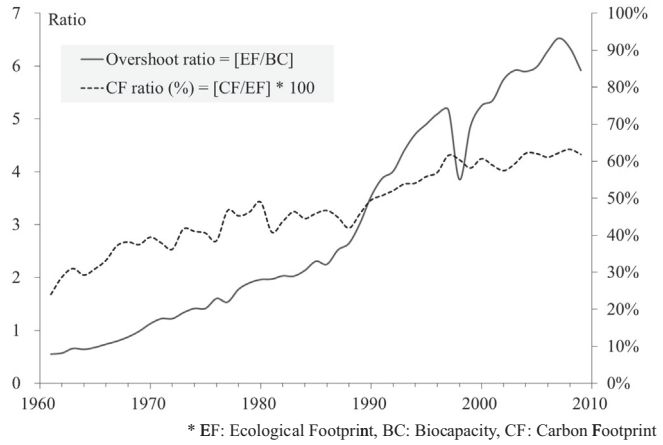

Fig. 1. Overshoot ratio and carbon footprint ratio in Korea between 1961 and 2009 (data from GFN (2014)).

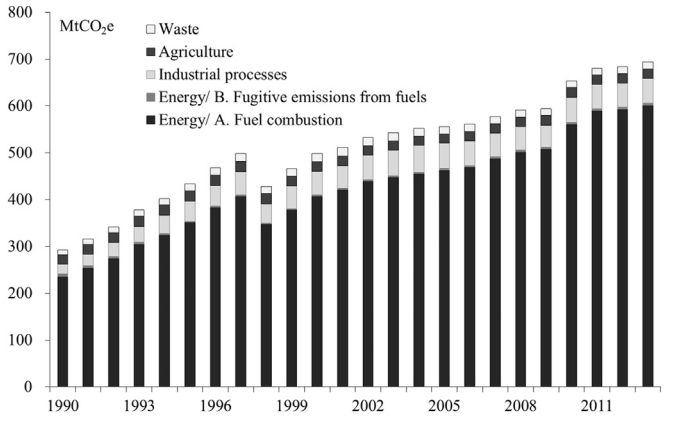

Fig. 2. Trend of the national greenhouse gas emissions by sector in Korea between 1990 and 2013 (data from KOSTAT (2016b)).

The definition of the carbon footprint varies (Wiedmann and Minx, 2008), and the concept from the Global Footprint Network (GFN) was adopted in this study. GFN defines 'carbon footprint' as the demand on biocapacity required to sequester the carbon dioxide emissions from fossil fuel combustion (GFN, 2015). GFN sees the carbon footprint as a part of the ecological footprint. An ecological footprint consists of the cropland footprint, grazing land footprint, forest land footprint, built-up land footprint, fishing grounds footprint, and the carbon footprint (Lazarus et al., 2014; Monfreda et al., 2004).

The carbon footprint depends on the carbon dioxide emissions calculated based on energy consumption. Thus, the carbon footprint has been increasing as a result of the increase in fossil energy usage. Changes in industrial structure and changes in consumption behavior have resulted in the increased fossil energy usage in Korea. As a result, the portion of the ecological footprint attributed to the carbon footprint was over 60% in the 2000s, whereas it was under 30% in 1961 (See Fig. 1). The carbon footprint has also contributed to the overshoot ratio over the last 50 years in Korea. In this study, the 'overshoot ratio' is defined as the ratio of ecological footprint to biocapacity when the ecological footprint is larger than the biocapacity.

In overshoot situation, many environmental problems could occur, such as air pollution, resource depletion, and the most well-known case, the climate change. Currently, the world population is increasing, so concerns about the sustainability of the environmental resource such as food supply have been raised (WRI, 2013). And the self-sufficiency of environmental resources such as food and energy in Korea has decreased with the rapid increase of the overshoot ratio. As a result, Korea is now very heavily dependent on imported environmental resources. Thus, it is essential to predict future trend of the overshoot to manage the environmental resources, such as, energy and food in national level in Korea and in global level.

Recently, there have been many studies on carbon dioxide emissions based on the consumption of energy due to climate change concerns and on various environmental effects (e.g., carbon dioxide emissions, air pollutant emissions, and monetizing environmental costs by energy policies) (Shim and Hong, 2016; Yeo and Kim, 2016; IEA, 2013; Dhakal, 2009; Jacobson, 2009), and several studies on the ecological footprint or land use for energy use in country level (Konadu et al., 2015; Chen and Lin, 2008; Chen et al., 2007). Studies on the ecological footprint as an environmental indicators have also increased significantly in country or local level such as Beijing in China (Gao and Tian, 2016), Andalusia in Spain (Cano-Orellana and Delgado-Cabeza, 2015), Canada (Kissinger, 2013), and southern Colorado (Hopton and White. 2012) in the USA. Also, there are several studies on the environmental impacts from energy consumption in Korea (Zhang et al., 2013; Oh et al., 2010; Chung et al., 2009; Choi and Ang, 2001). However, studies on environmental impacts from future Korean energy consumption and studies on the carbon footprint, the ecological footprint, and the overshoot ratio expected from various energy policies or energy consumption are rare in Korea.

Korea was one of the top ten carbon dioxide emitting countries (7th in the world) (IEA, 2015). Carbon dioxide emission from fuel combustion in energy sector in 2013 in Korea was 572.2 million tonnes of CO_2 (IEA, 2015) and are increasing. In order to reduce the GHG emissions, the Korean government has set the national greenhouse gas emission reduction target for 2030 ("GHG target for 2030") which is 37% reduction from the BAU emission level by 2030 (850.6 $MtCO_2e$) (UNFCCC, 2016). Carbon dioxide emission from fuel combustion in energy sector including energy industries, manufacturing industries and construction, transport, and others has contributed over 80% in the total GHG emissions in Korea as shown in Fig. 2. GHG emissions from other sectors such as industrial processes, agriculture and waste have been below 20% in the total GHG emissions. Thus, the reduction of GHG emissions from fuel combustion in energy sector is very important in Korea.

In 2014, the Korea Ministry of Trade, Industry and Energy (KMOTIE) announced the 2nd Energy Master Plan ("2nd EMP") which is the highest level of energy policy and the most relevant policy to the national carbon dioxide emissions in Korea (KMOTIE, 2014). The Business As Usual (BAU) demand the final energy consumption and even the targeted demand for the final energy (for example, coal, natural gas, and electricity) consumption in 2035 forecasted in the 2nd EMP will increase comparing to 2011. Thus, both the carbon dioxide emissions and overshoot ratio are expected to increase and policies for the reduction of them are required.

The objectives of this study are to predict the change in the overshoot ratio resulting from the implementation of the 2nd EMP quantitatively and to suggest the direction for the overshoot reduction. To estimate the overshoot ratio, we estimated the changes of the carbon footprint and the carbon dioxide emissions. We discussed the results of our predicted carbon dioxide emissions in terms of consistency with another policy, the GHG target for 2030.

The study was carried out as follows: (1) The scenario-based carbon dioxide emissions were predicted, (2) the scenario-based carbon dioxide emissions were compared with the GHG target for 2030, (3) the resulting changes in the carbon footprint and the

Download English Version:

https://daneshyari.com/en/article/7398930

Download Persian Version:

https://daneshyari.com/article/7398930

Daneshyari.com