A Cost-Benefit Analysis of South Korea's Biodiesel Mandate

by

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Submitted to the Graduate Faculty of
North Carolina State University
In partial fulfillment of the requirements for the
Degree of Master of Natural Resources

Policy & Administration Technical Option

Raleigh, NC
2011

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05-09-2011

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1. Introduction

1-1. Background

Global environmental issues, such as climate change, have emerged as new challenges to people throughout the world. In the face of such challenges, the Korean government announced in 2008 "Low Carbon, Green Growth" as Korea's new vision for national development. Korea aims to become a low-carbon society through green growth achieved via green technologies and green industries.

Korea emitted 489 million tons of carbon dioxide in 2007, is the world's ninth largest emitter of carbon dioxide, and is the fastest growing emitter among OECD members. Korea is also mostly dependent on imported crude oil for transport fuels. Therefore, the Korean government must develop alternative energy sources because of concerns about climate change, and energy independency. In order to reduce the effects of greenhouse gas emissions, the Korean government has been trying to reduce fossil fuel usage by using low-

carbon renewable energy.

Biomass is the most used renewable energy source. There are two global biomass-based liquid transport fuels that might replace gasoline and diesel fuel. These are ethanol and biodiesel. Biofuels offer many benefits, including sustainability, reduction of greenhouse gas emissions, and security production (Demirbas, 2010).

Biodiesel is a diesel fuel consisting of long-chain alkyl esters. We can use biodiesel in any diesel engine because biodiesel has similar chemical properties as petroleum diesel. Biodiesel is the most developed form of biofuels in Korea.

It is not surprising that interest in biofuels - and biofuels production - has increased dramatically in this past decade. Countries all around the world are now looking seriously at increasing production and use of biofuels, and many have put policies in place to ensure that such an increase occurs. Biofuels for transport, including ethanol and biodiesel, have the potential to displace a substantial amount of petroleum around the world over the next few decades,

and a clear trend in that direction has begun (IEA, 2004).

Even though some authors have pointed out that the environmental consequences of biofuels may be negative, policymakers in many countries think that biofuels is an environmentally friendly, alternative liquid fuel due to less-polluting and renewable qualities as compared to the petroleum fuel. Due to its environmental merits, biofuels' share in the automotive fuel market will grow rapidly in the future (Demirbas, 2008). Compared to petroleum, the use of biofuels for transport is still quite low in nearly every country. Despite continuing improvements in biodiesel production efficiencies and yields, the relatively high cost of biodiesel remains a critical barrier to commercial development. In OECD countries, the production cost of ethanol and biodiesel is up to three times that of gasoline and diesel. Biofuels use around the world is increasing rapidly, driven largely by government policies. Given the current high cost of biofuels compared to petroleum fuels, it is clear that widespread use of biofuels will occur by strong policy intervention (IEA, 2004).

1-2. Objective

Korea has tried to promote the spread of biodiesel. As a part of this effort, the Korean government began tax exemption on biodiesel in 2007 so biodiesel came to constitute 2% of diesel oil consumption in the country in 2010. However, the government declared in December 2010 that it will cease tax exemption on biodiesel and require the oil industry to blend 2% of biodiesel with diesel from 2012.

The main objective of this study is to analyze the cost and benefit from the biodiesel mandate. I assessed cost and benefit when we blend 2% biodiesel with diesel without tax exemption in Korea and then estimated whether the biodiesel mandate is efficient or not.

I analyzed cost and benefit with 2006-2008 data which I could access and I attempted a cost - benefit analysis based on the numbers available for the financial analysis. The perspective of this study is not from a global or Korean government perspective but a Korean society perspective. I would like to make

clear that the analysis of this paper has limitation that it does not include costs and benefits that are hard to quantify. I also made the assumption that there was no tax exemption and the mandate was enforced so the oil industry should have blended 2% biodiesel with diesel in 2006-2008.

2. Costs

2-1. Gap of Market Price

Korea consumed 17,857,124kl of diesel in its transportation sector in 2006, bringing the total consumption of biodiesel to 364,431kl (Tab-1), all effected by the government's mandate.

Table-1 Consumption of Diesel and Biodiesel in Korea

	2006	2007	2008
Diesel (kl)	17,857,124	18,219,951	18,539,664
Biodiesel (kl)	364,431	371,836	378,360

Source: Ministry of Knowledge Economy (2010)

The average price of diesel in Korea was $0.528/liter in 2006, increased to $0.548/liter in 2007 and reached $0.862/liter in 2008. The average price of biodiesel in Korea was $0.968/liter in 2006, went up to $1.065/liter in 2007 and rose to $1.415/liter in 2008. Crude oil price was skyrocketing in 2007-2008, at the same time biodiesel price also increased. The price gap between diesel and biodiesel was $0.440/liter in 2006, $0.517/liter in 2007 and $0.553/liter in 2008 (Tab-2).

Table-2 Price Comparison of Diesel and Biodiesel in Korea

(UNIT: $/liter)

	2006	2007	2008
Biodiesel (A)	0.968	1.065	1.415
Diesel (B)	0.528	0.548	0.862
Price Gap (A-B)	0.440	0.517	0.553
Price Ratio (A/B)	1.83	1.94	1.64

Source: Korea Energy Economics Institute (2009), Currency exchange rate was assumed as 1,000 Korean won per USD during the analysis period.

The cost of biodiesel use is 160.3 million USD in 2006, 192.2 million USD in 2007 and 209.2 million USD in 2008 (Tab-3).

Table-3 Cost of Biodiesel Use

	2006	2007	2008
Biodiesel Consumption (kl)	364,431	371,836	378,360
Price Gap ($/kl)	440	517	553
Cost (million USD)	160.3	192.2	209.2

2-2. Environmental Cost

Global demand for biofuels has risen sharply over the last decade, driven initially by oil price hikes and the need for greater energy security. However, skepticism about the positive impact of biofuels has escalated as the trade-offs between food, feed, and fuels and their impact on global agricultural markets became more evident, eventually leading to the debate over the extent of the role of biofuels in the 2007-2008 food price crisis (IFPRI, 2010).

We saw dramatic increases in world food prices in 2007-2008, creating a global crisis and causing political and economic instability and social unrest in both poor and developed nations. Systemic causes for the worldwide increases in food prices continue to be the subject of debate. Some economists said that large increases in biofuels production are the main reason behind the steep rise in global food prices.

By competing with food production for land, water and financial resources, biofuels have contributed to higher food prices, lower food security, and increased hunger. In 2007, Jan Ziegler, a United Nations expert on food issues, described biofuels as a “crime against humanity” (IFDP, 2009).

Demand for biofuels may also radically alter global land-use patterns, resulting in detrimental environmental effects. So, notwithstanding the benefits of the emerging bio-economy, there are numerous challenges posed by this agricultural transformation, a fact elegantly captured by the phrases ‘the food, energy, and environment trilemma’ (S Raghu, 2010).

We should be considering the implications of tying our energy economy to the same fluctuating and volatile food system. Oil palm and soy plantations are already supplanting forests and grasslands in Brazil, Argentina. Soy cultivation has already resulted in the deforestation of 21 million hectares of forests in Brazil, 14 million hectares in Argentina (IFDP, 2009).

Korea's biodiesel relies on yellow grease, soybean oil, palm oil, rapeseed oil. Korean biodiesel companies import all raw materials except yellow grease. Soybean oil is imported from U.S. and Argentina, palm oil is from Indonesia and Malaysia, and rapeseed oil is from Europe (Tab-4).

Table-4 Portion of raw materials for biodiesel in Korea

	Yellow Grease	Soybean Oil	Palm Oil	Rapeseed Oil
Portion (%)	30	45	20	5

Source: Korea Energy Economics Institute (2009)

Korea's demand probably had a role in higher food prices and deforestation in tropical regions because it is producing 70% of biodiesel from imported raw

materials such as soybean oil and palm oil. I would like to take this environmental cost of biodiesel into my analysis but it is very difficult to quantify the whole cost and the contribution of Korea. We need to study on this issue more.

3. Benefits

3-1. Air Pollution Reduction

Biodiesel can provide certain air quality benefits when blended with petroleum-diesel. Benefits from biodiesel blending include lower emissions of carbon monoxide (CO), sulfur dioxide (SO2), particular matter (PM) and lower hydrocarbon emissions (IEA, 2004)

There are many important goods and services in our everyday lives that are not bought and sold. There are two general categories of methods for measuring how much compensation people require in order to accept a non-monetary cost, or how much they are willing to pay in order to experience a

non-monetary benefit. The first approach is to measure the effect of non-marketed costs or benefits on the choices people make. The other general method for measuring the value of non-marketed benefits or costs involves the use of surveys to assess people's maximum willingness to pay for a benefit or the minimum they are willing to receive in compensation for a cost. Such surveys are often referred to as Contingent Valuation Methods (William K. Bellinger, 2007).

There are two Korean reports which analyze the environmental value of biodiesel on the basis of Contingent Valuation Methods. The KEEI report in 2008 says that the willingness to pay for switching diesel to biodiesel is $63.31 per kilo liter. The SERI report in 2007 says that the willingness to pay is $69.12 per kilo liter. I used the mean value of $66.22 per kilo liter as the willingness to pay for environmental value of biodiesel.

The benefit from air pollution reduction of biodiesel use is 24.1 million USD in 2006, 24.6 million USD in 2007, 25.1 million USD in 2008 (Tab-5).

Table-5 Air Pollution Reduction Benefit

	2006	2007	2008
Biodiesel Consumption (kl)	364,431	371,836	378,360
Air Pollution Reduction Value ($/kl)	66.22	66.22	66.22
Total Value (million $)	24.1	24.6	25.1

Source: Korea Energy Economics Institute (2008), Samsung Economic Research Institute (2007)

3-2. CO2 Emissions Reduction

The effect of using biodiesel for transportation is that there is a total reduction in emitted quantities of CO2, thus helping in the reduction of greenhouse gas emissions. Biodiesel has 78% lower CO2 emission than that of diesel in Life Cycle Assessment. 1kl of diesel emits 3.18 tons of CO2 in combustion, whereas 1kl of biodiesel emits 0.78 tons (Tab-6).

Table-6 Reduction Effect of CO2 in Biodiesel

Type	CO2 Emissions (ton/kl)

Diesel	3.18
Biodiesel	0.78
Reduction	2.48(78.0%)

Source: U.S. Energy Information Administration (2002)

Korea consumed 364,431kl of biodiesel in its transportation sector in 2006. The reduction of CO2 was 903,789 tons by switching diesel to biodiesel. The consumption of biodiesel increased to 371,836kl in 2007, 378,360kl in 2008. This could lead to the reduction of CO2 by 922,153 tons in 2007, and 938,333 tons in 2008.

Carbon market is the trading system specifically for carbon dioxide. It is one of the ways countries can meet their obligations under the Kyoto Protocol to reduce carbon emissions. The European Union Emission Trading Scheme (EU ETS) is the largest multi-national, greenhouse gas emissions trading scheme in the world. The average price of carbon was 12.99 euros (16.29 USD) per ton at EU ETS in 2006 and increased to 16.37 euros (22.42 USD) per ton in 2007, 19.00 euros (27.94USD) per ton in 2008.

Even though CO2 emissions reduction could be included in air pollution reduction so environmental benefits could be double-counted, I think that it is reasonable to count CO2 emissions reduction benefit separately. It is because carbon reduced can be bought and sold in the market. I made an assumption that Korea is under the obligation to reduce CO2 by Kyoto Protocol.

In result, the benefit of CO2 emissions reduction from the mandate is 14.7 million USD in 2006, 20.7 million USD in 2007, 26.2 million USD in 2008 (Tab-7). In order to match the cost of biodiesel with only CO2 reduction benefit, carbon price would need to be $177/ton in 2006, $208/ton in 2007 and $223/ton in 2008.

Table-7 CO2 Reduction Benefit

	2006	2007	2008
Biodiesel Consumption (kl)	364,431	371,836	378,360
CO2 Reduction (ton)	903,789	922,153	938,333
CO2 Price (euro/ton)	12.99	16.37	19.00

Currency Exchange Rate ($/euro)	1.2543	1.3696	1.4707
CO2 Price ($/ton)	16.29	22.42	27.94
CO2 Reduction Value (million $)	14.7	20.7	26.2
Cost matching CO2 price ($)	177	208	223

Source: Pointcarbon.com

3-3. Job Creation

Korean biodiesel policy promoted biodiesel industry and at the same time created related jobs. MKE (Ministry of Knowledge Economy) estimated that the number of employees in the biodiesel industry in 2009 was about 600 people in Korea. The average annual salary of Korean workers was $30,600 in 2006, $31,200 in 2007 and $31,800 in 2008. I made an assumption that other jobs would not be available for these people so this benefit is an upper bound of job creation benefit. I calculated the value of job creation from biodiesel mandate using this data. The benefit of job creation is 18.4 million USD in

2006, 18.7 million USD in 2007 and 19.1 million USD in 2008.

Table-8 Job Creation Benefit

	2006	2007	2008
Employee	600	600	600
Average Annual Salary($)	30,600	31,200	31,800
Total Value (million $)	18.4	18.7	19.1

Source: Ministry of Knowledge Economy (2010)

3-4. Energy Security Improvement

Increasing the use of biofuels can improve energy security. Because these benefits are difficult to quantify, the market price of biofuels does not adequately reflect them.

The Korean government has sought to reduce petroleum import dependence

to improve energy security. There are few agreed methods for evaluating energy security or quantifying the cost of insecurity (IEA, 2004). I could not include the improvement of energy security from biodiesel mandate in my analysis but I think that we need more research on this method.

4. Results and Recommendations

4-1. Results of Cost and Benefit Analysis

This study shows that the net benefit of the Korean biodiesel mandate is all negative below -100 Million USD per year. The net benefit from biodiesel use is mainly affected by the cost. The range of cost is from 160.3 million USD to 209.2 million USD whereas the range of benefit is from 57.2 million USD to 70.4 million USD. Even though there are many secondary impacts that are hard to quantify, the direct financial net benefits are negative.

Table-9 Results of Cost and Benefit Analysis

(Unit: Million USD)

	2006	2007	2008
Net Benefit	-103.1	-128,2	-138.8
Cost	160.3	192.2	209.2
Benefit	57.2	64.0	70.4
- CO2 Reduction	14.7	20.7	26.2
- Air Improvement	24.1	24.6	25.1
- Job Creation	18.4	18.7	19.1

Even though this study concludes the biodiesel mandate is not cost-efficient, I don't think the Korean government has to abandon the mandate. From the costs and benefits considered here, the costs exceed the benefits unless the value of energy security is included.

Biofuels can be a suitable solution against international energy crisis and obligation for the reduction of greenhouse gases. Biofuels can play a significant role in climate change policy and in measures to reduce

greenhouse gas emissions. Biofuels market is emerging and will be profitable in a few decades. Korea has to endeavor to take part in the new clean industry so the government needs to choose an appropriate strategy to foster biodiesel industry.

4-2. Recommendations for the Korean Government

(1) Raise the blending rate after the net benefit becomes positive

If the government raises the blending rate in the situation where the price gap doesn't become smaller than those of 2006-2008, the net loss will be greater than that of 2% blending rate. In this analysis, if the price gap is smaller than about $0.17 per liter, the net benefit can be positive. I suggest that the government raise the blending rate when the price gap becomes below $0.17 per liter.

(2) Keep tax exemption until the price gap disappears

If the government discontinues the tax exemption on biodiesel use, the consumer price of diesel containing biodiesel will rise sharply. I guess that the oil company will transfer most increase of cost to consumer due to inelastic demand curve. The increase of diesel price will make consumers' complain and it can be an obstacle against the promotion of biodiesel industry. The benefit from biodiesel use belongs to most Korean people so the government has to continue the tax exemption on biodiesel until the price gap between diesel and biodiesel disappears. I made an assumption that the price of diesel would increase by 10% annually from 2006 and the price of biodiesel would rise by 5% annually from 2006. Under the assumption, the price gap turned out to 0 in 2019 because the price of both is the same as $1.82 per liter.

(3) Find ways to lower cost to produce biodiesel

There are two ways for the Korean government to make the net loss smaller. One is to lower costs. The other is to raise benefits. According to this

study, benefits are stable because air pollution reduction value is constant, employee numbers in the biodiesel industry and average annual wage of workers varies little. CO2 price is not affected by the Korean government. According to IEA, the value of CO2 in 2020 will range from $26 to $37 per ton. This value is not different, compared to the present value of CO2.

The available option for the government to raise net benefit from biodiesel is just to drop the cost to make biodiesel. The big demand for soybean as an energy source has raised prices of the crop high on the global market. To resolve the problems, it is important that we should find new sources of biofuels. Algae fuel is a biofuel from algae. Algae are low-input, high-yield feed stocks that produce biofuels. It produces 30 times more energy per acre than land crops such as soybeans (Eviana Hartman, 2008). The Korean government should make an investment for R&D to improve algae fuel technology.

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