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BENEFIT-COST ANALYSIS OF BIODIESEL PRODUCTION IN KOREA

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Abstract
The purpose of this study is to take a close look at Korea`s biodiesel developing trends and assess economic feasibility based on benefit-cost analysis. This study finally presents directions to actively promote the biodiesel in Korea.

The role of bio-energy is significantly emphasized due to the continuous rise in oil price and environmental problems. According to some researches that have considered various factors such as breed, productivity, production costs and levels of technology, the most feasible bio-ingredients are rape and barley. By means of the benefit-cost analysis, rape has positive values in the net profits when considered with indirect benefits. Also, it is estimated that rape is feasible when produced in place of barley for double-cropping. Soybean is feasible when cultivated in fallow grounds. When all factors are taken into consideration, the government's support has to be continued in order to reduce a burden of production costs at the initial stage of the biofuel's introduction. It is necessary to develop technology to minimize environmental impact and the requirement of grain production to the extent of the existing cultivation system. Moreover, considering the characteristics of each crop and a detailed strategy on each crop for improving productivity and reducing production cost are required.

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Ⅰ. Introduction

Bioenergy, such as methane, LFG(landfill gas), bioethanol, biodiesel, or biogas, is made from various biomass, and it is used for transportation, heating and generating power. Besides fossil energy, bioenergy is made of renewable and environmentally friendly resources. It reduces greenhouse gas emissions and mitigates the concerns about future energy security. The most interesting feature of bioenergy in the agricultural sector is that it helps rural development by increasing the demand for agricultural feedstock and opening new markets for agricultural crops. The growth of bioenergy production will cause a transition in agriculture from its traditional role as a producer of food and fiber to a producer of energy in addition to food and fiber.

The development of bioenergy, however, is not an easy task because of the difficulty in securing feedstock and the difficulty of developing a variety of technologies needed to process numerous types of feedstock to be used. Also, the development of bioenergy could destroy the environment if resources are overused.

Bioenergy may be gaseous, liquid or solid. The worldwide interest in biofuel, a liquid type of bioenergy, is growing because it is a feasible substitute for the conventional fuels, while the price of crude oil increases and global warming, due to the heavy dependence on fossil fuels, causes environmental problems. Bioethanol and biodiesel are representative biofuels, which replace gasoline and diesel. Biodiesel is produced through a relatively simple chemical reaction called transesterification which involves the mixing of methanol with vegetable oils, animal and fish fats, or recycled cooking oils. Grain-based biodiesel results in life-cycle greenhouse gas as well as carbon dioxide (CO_2) reductions compared to conventional diesel. European countries are the main producers of biodiesel.

Bioethanol is made from biomass containing transferable starch or fiber into sugar. Another way of producing bioethanol is converting cellulosic and lignocellulosic biomass, such as wood, straw and grass, into sugar for fermentation. Since it requires more complex mechanical and enzyme-based processes than processing the starches from grains or processing the sugars in sugarcane and sugarbeets, it is not commercially viable yet. Cellulosic and lignocellulosic ethanol, called the second generation biofuel, would be one solution for the problems that arise in using grains for biofuel feedstock.

It may be said that Korea's development of bioenergy, particularly biofuel, is at the beginning stage. And with a sudden rise in the price of a fossil fuel, bioenergy is in the limelight.

Economic feasibility studies have been recently conducted by Lee, et al.(2005) Kang(2007), and Bae(2006, 2007). Lee, et al.(2005) analyzed economic estimations involving direct and indirect benefits, environmental benefits based on 5 scenarios of barley for the double-cropping case, or fallowness of set-aside fields. Kang(2007) calculated social benefits on the assumption that existing fuels are replaced by biodiesel and bioethanol. Bae(2006, 2007) forecasted future prices of biodiesel under the different scenarios of various cultivation areas from 2007 to 2017.

This study introduces the current production situations and affiliated policies concerning mainly biodiesel, which is in the early stages of commercialization. It also conducts an benefit-cost analysis of biodiesel when rape and soybeans are used as feedstock, and finally introduces the prospects of biodiesel from an agricultural perspective.

Ⅱ. Biodiesel Production

In 2006, the global production of biodiesel amounted to 5.5 million tons, and ethanol production was estimated to be 51 billion liters(ℓ)[1]. Most of the biodiesel, about 4.9 million tons, were produced by the members of EU, and partly by the U.S., about 600 thousand tons. Germany appeared to be the largest biodiesel producer among EU members with 2.68 million tons, or the equivalent of 48.5% of all EU production. Italy produced about 0.86 million tons of biodiesel, while France produced 0.76 million tons.

The feedstock for biodiesel production are liquid vegetable oil extracted from rapeseeds, sunflower seeds, palms, peanuts, soybeans, recycled cooking oil, or animal fats. Rape is the most widely used oilseed plant for the production of biodiesel because of its higher oil content than other seeds.

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[1] Renewable Fuels Association (http://www.ethanolrfa.org). Martin Van Vaals (2007).

TABLE 1. Biodiesel production by country

Unit: Thousand tons

Country	2004	2005	2006
Germany	1,035	1,669	2,681
France	348	492	775
Italy	320	396	857
Austria	57	85	134
Spain	13	73	224
U.S.A.	100	300	600

Sources: European Biodiesel Board, The National Biodiesel Board (http://www.biodiesel.org)

Notice: The original data of the U.S. by the gallon has been converted to the ton for convenience, and the applied number for conversion is 0.004 ton per gallon.

Korea produced 23,229 kiloliters(kℓ), or the equivalent to 20,546 tons[2], of biodiesel during the pilot project period from 2002 to 2005. The production in 2006 amounted to 50 thousand to 60 thousand kℓ(44 thousand to 53 thousand tons), and it is expected to rise to 90 thousand kℓ in 2007. The estimated production capacity is about 300 thousand to 400 thousand kℓ.

Based on a forecast of the total biodiesel consumption in 2007, an MOU(memorandum of understanding) was signed between oil refiners and the government on taking a 0.5% blend of diesel. It amounted to 90 thousand kℓ of biodiesel. When the demand for diesel increases, the consumption of biodiesel also goes up. A 1% blend of diesel, which is planned for 2008, would raise the biodiesel consumption to 180 thousand kℓ.

The number of biodiesel companies registered in 2007 was 18, and 7 companies are actually producing biodiesel currently. Originally, all the factories were not designed to produce biodiesel, but they have been remodeled to produce biodiesel recently. The main feedstock for Korea's biodiesel production is the imported soybean oil, which accounts for 77% of all feedstock while recycled cooking oil accounts for the rest.

[2] The conversion factor from volume to weight is 0.8845, such that 1kg=1 ℓ × 0.8845

III. Korean Policy

The research on alternative energy in Korea started during the oil crisis in the 1970s. Eleven sources of energy, such as solar heat and sun light, were developed in the 1980s, and advancing technologies led to the development of new devices such as solar water heating devices and waste incinerators from the mid 1980s. An integrated and systematic technology development plan was prepared in 1997. The plan set up a target to substitute 2% of the total primary energy production with new and renewable energy(NRE) by 2006[3]. In the second National Energy Basic Plan of 2002, the target was revised upward to 3%.

The growth rate of bioenergy production was 43.8% over the 11-year period from 1995 to 2005. This was a remarkable feat given that the production of primary energy grew by 52.4% during the same period. However, the proportion of NRE to the primary energy increased only by 1.5% points from 0.6%. The share of bioenergy(including biodiesel) in NRE was just 3.7% in 2005. As for biodiesel, the total production volume accounted for just 0.006% of the primary energy and 0.3% of the NRE.

The government set the goal to supply NRE at 13.33 million tonnage of oil equivalent(TOE), which is 5.8% of the total primary energy supplied in 2005 or 5% of the expected supply of 2011. The plan requires a decrease in the share of waste and hydro power and an increase of bioenergy to make the supply rate of NRE at 7.9% of the total primary energy. This would be an increase of 5.8% points from 2005.

A bioenergy supply plan is also devised, and the production target of biofuel is set at 552 thousand kℓ for 2011, which is a 200% increase from the 2005 supply of 184 thousand kℓ.

The government implements various policy measures for NRE to activate and achieve such a goal. Typical measures focus on four key areas:

- Influencing demand: biofuel blending mandates,
- Influencing supply: reduction or elimination of motor fuel taxes and capital grants for the facilities,

[3] New and renewable energy includes eleven types of energy from different sources such as solar energy, bioenergy, wind power, hydro power, ocean energy, waste energy, geothermal, fuel cell, hydrogen cell, coal liquefaction and gasification and coal-mixed oil.

TABLE 3. Trend of NRE and primary energy productions

Unit: Thousand TOE

		1995	2000	2001	2002	2003	2004	2005
Total primary energy		150,438	192,888	198,410	208,636	215,067	220,238	229,334
New and Renewable Energy (NRE)	Total	906.9	2,127.3	2,453.3	2,917.3	4,437.4	4,582.4	4,879.2
	Solar thermal	22.1	41.7	37.2	34.8	32.9	36.1	34.7
	Photovoltics	0.6	1.3	1.5	1.8	1.9	2.5	3.6
	Bioenergy (others)	59.2	82.0	82.5	115.9	129.4	129.5	167.9
	Biodiesel	-	-	-	0.8	1.7	5.4	13.4
	Wind power	0.1	4.2	3.1	3.7	6.2	11.9	32.5
	Hydro	20.4	20.5	20.9	27.6	1,225.6	1,082.3	918.5
	Fuel cell	-	-	-	-	-	-	0.5
	Waste	804.5	1,977.7	2,308.0	2,732.5	3,039.3	3,313.3	3,705.5
	Geothermal	-	-	-	0.1	0.4	1.4	2.6
Proportion of NRE		0.6	1.1	1.2	1.4	2.1	2.1	2.1

Note: Large hydro has been included in the summation of hydro energy since 2003.

- Ensuring agricultural participation: research and capital investment on agricultural feedstock,
- Influencing technology: government funding for science and innovation.

The representative measures implemented in Korea are feed-in-tariff, tax incentives, loans, and fiscal support to rape producers. In a feed-in-tariff program, the government compensates for the differences between the power generating prices of NRE and fossil fuels. Since 2002, the tariff has been applied to photovoltaic, wind, small hydro, waste, ocean and landfill gas electricity, and the tariff ranges from ₩61/kWh to ₩716/kWh.

The government provides supports to the factors used in the production, especially capital plant. A ten percent of total capital investment is deducted from income tax. The tariffs with a 65% reduction are applied to the imported production inputs used for solar thermal, photovoltaic, wind, hydrogen, fuel cell, and bioenergy. There are also government loans(totaling 15 billion won or 14.6 million dollars in current exchange rate with a 3.75% interest rate) for production facilities and management cost. The loans provided in 2005 were over 10 billion won(9.8 million dollars).

The fiscal support to the farmers who grow rape is also related to the biofuel policy program, and this was proposed to build a foundation for a reliable and efficient feedstock supply network. From 2007 to 2009, the farmers who grow rape in the designated areas of 1,500 hectares will be paid 1.7 million won per hectare annually by the central government.

Like most biofuel-producing countries, Korea set up government-funded programs to support the research into the different stages of the supply procedure. The development of feedstock, especially agricultural products, is recognized as an important pending issue. Various agricultural products are considered as feedstock and rape is one of the most suitable ones for biofuel production in Korea. The feedstock would minimize the opportunity cost of alternative uses, since it substitutes for barley, the consumption of which gradually decreases recently. It also enriches the rural landscape to help increase farmers' income with tourism.

Other crops are also examined to find out their feasibility to be used as the feedstock for biodiesel, and soybeans and peanuts are found to be good candidates. As for soybeans, the production structure is well mechanized, and it is relatively easy to produce seeds and distribute the final products. Weather is unlikely to be a limiting factor of cultivating soybeans in this country. Soybeans, however, have relatively low oil content and are a very important food crop heavily dependent on imports. Peanuts contain a lot of oil. In addition, the productivity per unit area is 2.4 times higher than soybeans. They can, however, be cultivated in set-aside areas or paddy fields to substitute for rice, since their cultivation period is long enough.

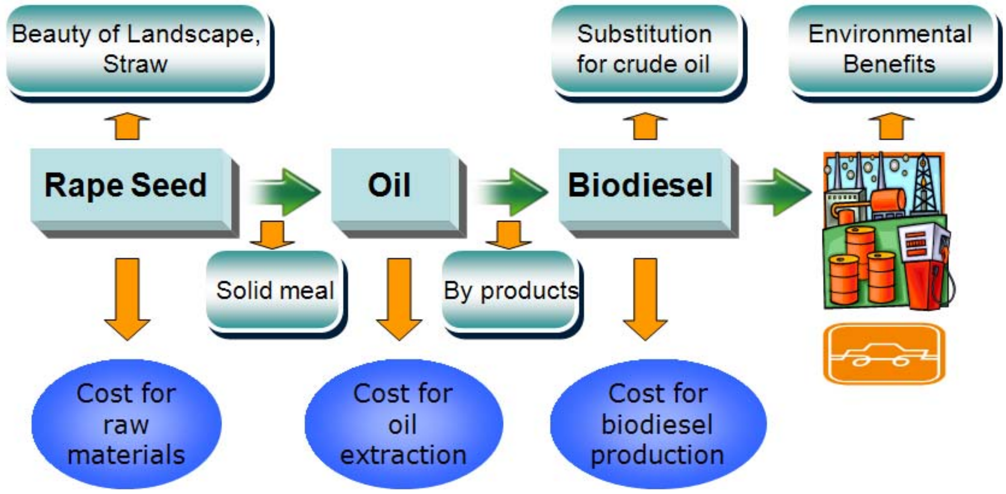
Ⅳ. Benefit-cost analysis of biodiesel production in Korea

1. Rapeseed

The items of the benefit-cost analysis of biodiesel in production stages are reviewed in accordance with the following figure.

It is assumed that rape is domestically cultivated and biodiesel is made from it. First of all, the production cost accrues when rapeseeds are produced. However, straw, the by-product of rapeseed, can be the raw material for wood

FIGURE 1. Benefits and costs accrued in biodiesel production process from rape seed



chips. In addition, the associated benefit of adding beauty to the rural landscape by growing rape creates an aesthetic value that is hard to measure. A large and important co-product in the production of biodiesel is solid meal that remains after extracting oil from oilseeds. The extracting cost also accrues at this stage. At the final stage of the process, another cost accrues while the important by-product glycerine and the substitution effects for crude petroleum bring about benefits. At the consumption stage, the society will derive great environmental benefits from the reduction of CO_2 and other greenhouse gases.

Since the subsidies, tax reductions, and other payments transfer from the government or consumers to producers, they are excluded from the social benefit-cost analysis.

The analysis should compare the flow of costs and benefits under the conditions with the project and without the project. The project in this case is the production of rapeseed as a biodiesel feedstock, and it should be compared with the production of barley for the double-cropping case or compared with the fallowness of set-aside fields.

Previously studied[4] and newly researched data are as follows: For every 1 ha, about 3 tons of rapeseed is produced. For every ton of rapeseed crushed, 1.26 tons of oil and a half ton of solid meal are obtained. The ex-

[4] Lee, et al. (2005), Bae (2006).

traction cost of oil from oilseed is assumed for the difference of import prices between oilseed and oil, and it is 142 won per every kilogram of rapeseed in terms of the average price for 2002~2006. The price of solid meal was estimated to be 200won/kg. Straws, another important co-product, are obtained at a 98% rate of rapeseed in terms of weight. It is estimated that the price of straws is 10 thousand won per ton[5]. A ton of rapeseed produces about 0.3982kℓ of biodiesel[6].

The production cost of rapeseed was 673 won per kg[7]. To compare it with the production cost of barley, the average income data of barley from 2000 to 2002 was adjusted to the value of 2006, and it was 147,650won/10a. Additional expense on the production of barley for the double-cropping case has been considered as production cost, assuming social utility on production of barley as "0"[8]. The average cost of 307 won/liter to produce biodiesel was assumed in accordance with the data from Korea Biodiesel Association[9].

Five different kinds of gases were considered for the calculation of environmental benefits, and they are carbon dioxide(CO_2), sulfur oxides(SOx), nitrogen oxides(NOx), total suspended particulates(TSP), and carbon monoxides(CO). For every ton of diesel burnt, it discharges 3.07 tons of CO_2, 0.017 ton of SOx, 0.0023 ton of NOx, and 0.00025 ton of TSP[10]. As for BD100, an abatement rate of CO_2 is 78.45%, SOx 100% and TSP 47%. The emission of NOx, on the other hand, is estimated to increase by 10% over the conventional diesel[11]. For every ton of each gas emission, the environment costs amount to 3,431 thousand won for SOx, 2,661 thousand won for NOx, 9,117 thousand won for TSP, and 3,639 thousand won for CO[12]. For the cost of carbon dioxide,

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5 Bae (2006).

6 1kg of biodiesel equals 0.8845ℓ.

7 The last year that income data of the rape farming surveyed was 1992, and the average of three year (1990~1992) data was transferred into the current value of 2006 with price indexes.

8 This makes the production cost of rape 499 thousand won per kℓ in benefit-cost analysis.

9 Bae, et al. (2007).

10 Bae (2006), Park (1997).

11 Lee (2004).

12 Yoo (2000). In this study six different results of environment cost for each gas are applied. Four results are based on the assumption that the amount of discharge has linear relationship with the degree of pollution, and the target is Seoul. Another one

the emission trading price of EU is applied. The direct payment program for rural landscape preservation pays 1,700 thousand won per hectare for rape growing.

The flows of costs and benefits take place in a year. In the following year the society obtains the same amount of flows if a producer decides to plant rape instead of barley. Consequently, the interest rate does not have to be considered in this analysis.

The benefit accrued from the production and consumption of one kiloliter of biodiesel is 2,320 thousand won. Consequently, the social benefit is larger than the cost by 1,208 thousand won if rape substitutes for barley.

If the rape is cultivated in set-aside fields, on the other hand, the social cost accrued becomes larger than the benefit by 33 thousand won per kℓ.

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assumes that changes of air quality by pollution affect health, crops, materials and forests, and estimates those impacts on Korea in monetary terms. The last one takes account of the impacts on health, materials and crops in EU. Since deviations are so wide, the results are averaged after removing the highest and the lowest ones.

TABLE 4. Data for social benefit-cost analysis of rape

Productivity	Rapeseed 3 tons/ha	2.51 tons/BD kℓ
	Rapeseed oil 1.26tons/ha	1.06 tons/BD kℓ
	BD 0.3982kℓ[13]/rapeseed 1ton	
Switching cost to biodiesel	· 307won/ℓ[14]	
Area	· Area of production: 0.84ha/BD kℓ	
Production costs	· Production costs of rapeseed: 673won/kg[15]	
	· Production costs of unhulled barley: 147,650won/10a · To compare rape with the production cost of barley, the average income data of barley from 2000 to 2002 was adjusted to the value of 2006.	
By-product benefits	· Solid meal: 0.5ton/rapeseed 1ton · The price of solid meal: 200won/kg	
	· Straws: 0.98 ton/rapeseed 1ton · The price of straws: 10 thousand won per ton[16].	
	· Glycerin 0.1ton/rapeseed 1ton, (352 won/kg)	
Indirect benefits	· Direct payment program from the government for landscape preservation, growing rape: 1.7 million/ha, 128 thousand won per BDkℓ · Benefit of substituting petroleum: average price data of Dubai oil from Jan. to Oct. was adjusted to the value in 2007.	
Environmental benefits	· Coefficient[17] of carbon dioxide emissions: 3.07ton/gasoline 1 ton · Coefficient of sulfur oxides:0.017 ton/gasoline 1 ton · Coefficient of nitrogen oxides:0.0023 ton/gasoline 1 ton · Coefficient of TSP: 0.0025 ton/gasoline 1 ton · Decrement of carbon dioxide emissions:78.45%/BD100 · Decrement of sulfur oxides emissions:100%/BD100 · Decrement of TSP emissions:470%/BD100 · Increment of nitrogen oxides emissions:10%/BD100 · Environment costs of carbon monoxides[18]: 23 EURO · Environment costs of sulfur oxides: 3,431 thousand won · Environment costs of nitrogen oxides: 2,661 thousand won · Environment costs of TSP: 9,117 thousand won · Environment costs of carbon monoxides: 3,639 thousand won	

13 1kg of biodiesel equals 0.8845ℓ
14 Bae, et al. (2007).
15 The average cost data of barley from 1990 to 1992 was adjusted to the value of 2006.
16 Bae (2006).
17 Bae (2006), Park (1997).
18 The emission trading price of EU is applied, Yoo (2000).

TABLE 5. Social benefit-cost analysis of biodiesel per kiloliter

Unit: Thousand won/kℓ

		Barley for the double-cropping	Fallowness of set-aside fields
① Cost	Production costs of rape (A)	1,689	1,689
	Cost of substituting rapeseed for barley(B)	1,240	-
	Total production cost (C=A-B)	449	1,689
	Extraction cost of oil(D)	356	356
	Production costs of biodiesel.(E)	307	307
	Subtotal (F=C+D+E)	1,112	2,353
② Direct Benefits	Sales of straw	25	25
	Sales of solid meal	251	251
	Sales of glycerin	88	88
	Subtotal	364	364
③ Indirect Benefits	Direct payment program from the government	1,428	1,428
	Effects of crude oil substitution	380	380
	CO_2 abatement	80	80
	SOx abatement	66	66
	NOx abatement	-1	-1
	TSP abatement	1	1
	CO abatement	1	1
	Subtotal	1,956	1,956
	④ Net benefits(G=②+③)	2,320	2,320
Net Benefits	Direct net benefits(②-①)	-748	-1,989
	Total Net benefits(④-①)	1,208	-33

2. Soybean

The basic suppositions of social benefit-cost analysis on soybean are identical to the case of rape. The data used for analysis is illustrated at Table 6.

The assumptions for the economic analysis are that 1.7 tons of soybean is produced from per hectare and 0.33 ton of oil is extracted from it. To produce one kℓ of biodiesel, 0.74 ton of oil, which is extracted from 3.81 tons of soybean, is required. Consequently, 0.4kℓ of biodiesel could be produced from one hectare of soybean cultivation. The expenses are composed of the production cost of soybean, extracting cost of soybean oil, and switching cost to biodiesel. As for social benefits, several different sources have been considered to take account of direct and indirect advantages such as profits of selling by-products and benefits of cultivating the fallowness of set-aside field land[19], of environmental improvements, and of substituting domestically produced fuel for import fuel. Social benefits and costs are compared to measure the possibility of utilizing soybean for biodiesel feedstock.

Two different cases have been analyzed. The one is cultivating soybean from normal farmland, and the other is from fallow ground as less favored area. We assumed that the benefit of cultivating unfavorable land amounts to 400 thousand won per hectare[20].

TABLE 6. Data for social benefit-cost analysis of soybean

Productivity	Soybean 1.7tons/ha	3.81 tons/BD kℓ
	Soybean oil 0.33ton/ha	0.74 ton/BD kℓ
	BD: 0.446kℓ/ha	
Switching cost to biodiesel	· 307won/ℓ	
Area	· Area of production: 2.24(BD 1kℓ)	
Production costs	· 3,071,152 won/ha	
	· Production costs of soybean: 987won/ℓ[21] (raw material cost of 681 won included)	
By-product benefits	· Soybean cake: 1,367kg/ha, 500won/kg	
	· Glycerin 65kg/ha, (38.2kg/soybean 1ton)	
Indirect benefits	· Direct payment measures for unfavored land: 400 thousand won/ha	
Environmental benefits	· Same with rape	

19 We assumed that benefits through revitalization of the community, maintenance of agricultural utility function, and so forth are formed by cultivating the crops in less favoured land.

20 This is the amount of money paid by the government for unfavored land(fallowness of set-aside fields cultivation under the direct payment system.

21 Bae, et al. (2007).

TABLE 7. Benefit-cost analysis of domestic soybean production

Unit: Thousand won/BD kℓ

	Items	Normal farmland	Fallowness of set-aside fields
① Cost	Production costs of soybean oil(A)	1,527	1,527
	Production costs of biodiesel (B)	306	306
	Subtotal(C=A+B)	1,833	1,833
② Direct Benefits	Sales of soybean cake	840	840
	Sales of glycerin	87	87
	Subtotal	927	927
③ Indirect Benefits	Field farming direct payment for unfavorable land	-	897
	Effects of crude oil substitution	380	380
	CO_2 abatement	80	80
	SOx abatement	66	66
	NOx abatement	-1	-1
	TSP abatement	1	1
	CO abatement	1	1
	Subtotal	527	1,424
	④ Indirect net benefits(D=②+③)	1,454	2,351
Net benefits	Direct net benefits(②-①)	-906	-1,833
	Total net benefits(④-①)	-379	518

The cost of producing 1kℓ of biodiesel is about 1,833 thousand won. The direct benefit of comprising the sales of soybean cake and glycerin is 930 thousand won per kℓ of biodiesel. On the other hand, indirect benefit is 1,420 thousand won. However, it creates only 527 thousand won per kℓ of biodiesel if the direct payment measures for unfavored land are not taken into account. The net benefit per kℓ of biodiesel is -379 thousand won if one cultivates only soybeans in normal farmland consequently. It is 518 thousand won, however, if one cultivates soybeans in fallow ground.

Ⅴ. Conclusions

Development of biodiesel, which has been mostly driven by the EU, is urgently required to substitute fossil fuels in Korea, especially when international prices of crude oil and the dependence on energy imports are taken into account. In the near future, consequently, the biofuel industry, especially biodiesel, will make progress, and it is expected to take up quite a proportion of the Korean energy market.

As we have mentioned before, the biodiesel production with rapeseed or soybean leads to quite different results depending on scenarios. Social benefit is positive when rapes substitute for barley and soybeans cultivated at fallowness of set-aside fields. The most efficient way of producing bioenergy crops is to produce rape through double-cropping, and it is required to promote production of soybean in marginal farmland and rape in set-aside land additionally.

The model business is being promoted for rape which is a biodiesel raw material crop. The government should expand the cultivation area of the available fuel crop based on the results of the business, rather than to finish it as one-time business. Besides that, technical examinations of biofuel availability should be propelled focusing on the crops which are being cultivated or available to be cultivated in our country, such as peanuts and sunflowers in the short run.

In developing feedstock, a careful approach is required. First, we should find a way to minimize the environmental burden within the existing planting system, and to minimize government support for raw material production too. For this, it is necessary to cultivate a fuel crop that is available for mass cultivation within the country. The allowable support policies like direct payments should be introduced for cultivators to perform a stable production. The biofuel sector in most countries has been developing initially as a result of policy support and favorable tax regimes. Monetary supports, such as government loans, subsidies, and tax reductions, should focus on relevant participants to secure the supply of biofuels as well as feedstock in the short run, and these supports should be ceased as soon as possible to minimize the distortion of the market. The investment in the basic researches of advanced technologies and economic feasibilities, however, is essential for the sustainable development of biofuel in the long run. Secondly, it is also important to reduce the price difference between domestically produced and imported raw materials as the cost of raw materials forms a great portion of total cost.

Without technology development, we would have to adopt socially and economically unviable production methods for feedstock. Otherwise, we should keep importing feedstock such as soybean. The import of feedstock from abroad, however, causes problems to the environment, economy, and energy security. Environmentally, we would not have any advantage of CO_2 reduction, which is very important under the Kyoto Protocol. Economically, the import price of soybean oil is relatively high to lower the profit margins of biodiesel production. For energy security, feedstock import has the same effects as the import of crude petroleum and we are unable to secure the independence of energy.

The development of domestic feedstock is a key factor in solving the above problems. The grain-based biofuel, however, has a limitation for market growth, since the feedstock overlaps with food or livestock feed. And biofuel crops have a great impact on food supply and demand. The problems associated with the grain-based biofuel are already revealed in some leading countries of biofuel production. Oilseeds potentially also have these kinds of problems in the long run. It is required to develop various sources of feedstock other than grains or oil seeds for the future.

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