2002 fiscal year
Clean Development Mechanism Project for Countering Global Warming
Research on Ethanol Fuel Production from Molasses & Other Sources in India

Overview

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1 Research Implementation

1.1 Research Overview

India, along with Brazil, is world's leading producer of sugar. The sugar manufacturing process puts out huge amount of molasses (waste sugar juice) and bagasse (sugar cane trash) as by-products. The Indian Government announced the energy policy, which was to produce ethanol from those by-products through biochemical technology and to utilize that ethanol to produce gasohol (ethanol blended gasoline) for part of domestic gasoline consumption, and the policy has been in effect since 2002. Currently, as a pilot project, they are producing 5%-ethanol gasohol at a few domestic oil depots, and have started its distribution. In near future, their target is to produce gasohol of which ethanol content is increased up to about 10% and to distribute it steadily on commercial basis.

The aims of this policy are air pollution abatement in urban area, decreasing oil energy dependence on foreign supplier, and developing infrastructures and expanding employment in rural area where 60% of the nation's population lives in.

In this research, we selected Warana Sugar Factory, located in Kolhapur, Maharashtra State of India. As a major object of study, we examined the possibility of the project to produce ethanol by utilizing by-product from the factory, such as molasses and bagasse, and produce gasohol by blending the ethanol with gasoline, and also examined its effect toward the reduction of CO2 emission.

1.2 Ethanol Production Plan

We obtained the information about the technology to produce ethanol from sugar cane, one of the biomass resources, through researches in Japan on sugar factories and ethanol factories, literature searches, and interviewing experts, and also obtained the data from field researches in India. Based on those information and the data, we examined the possibility of the ethanol production project at the Warana Sugar Factory.

(1)Current Operational Status of the Sugar Factory

Cane Throughput: 1,425,000 t/year

Sugar Production: 150,000 t/year (10.5% of sugar cane)

Molasses Production: 57,000t /year (4% of sugar cane)

Bagasse Production: 399,000 t/year (28% of sugar cane)

Sugar Production Period: 180 days/year

(2)Ethanol Production Plan

We conducted a study for ethanol production plan on two cases; the case one is using molasses for producing ethanol, and the case two is using both molasses and bagasse for the production.

1)Case 1 (using molasses as an raw material)

Production volume of anhydrous ethanol with molasses as an raw material:

14,300kl (yield: 0.25kl/t molasses)

Required energy to produce anhydrous ethanol:

33,000 Gcal (energy consumption rate: 2.3 Gcal/kl ethanol)

Energy balance:

Calories available from bagasse: 574,560 Gcal

(Calorific value of bagasse: 1.8Gcal/t bagasse, boiler efficiency: 80%)

Required energy to produce sugar:183,825 Gcal (1.2255 Gcal/t sugar)

Required energy to produce anhydrous ethanol:33,000 Gcal

Thus, the surplus calorie from bagasse is 357,735 Gcal.

(Equivalent to 248,000t of bagasse)

2)Case 2 (molasses and bagasse as raw materials)

Supposing that A ton of bagasse is used as raw material to produce ethanol:

Energy available from bagasse:1.8 Gcal/t bagasse x 0.8 x A = 1.44A Gcal

Calculations of the amount of bagasse needed for covering all energy to produce ethanol.

Yield of ethanol from bagasse: 0.15 kl/t bagasse

Required energy to produce ethanol from bagasse:

16.3 Gcal/kl ethanol x A= 0.15 x 16.3 x A = 2.45A Gcal

Energy balance:

Calories available from Bagasse: 574,560 Gcal

The required energy to produce sugar: 183,825 Gcal

The required energy to produce ethanol with molasses as an raw material:

33,000 Gcal

Required energy to produce ethanol from bagasse:

1.44A + 2.45A = 357,735 Gcal

A = 91,963t (amount of bagasse)

Thus, we set the quantity of bagasse, allowing a margin for fudge factor, to 90,000 ton. The energy balance is:

Required energy to produce ethanol from bagasse:

129,600 + 220,500 = 350,100 Gcal

357,735 Gcal – 350,100 Gcal = 7,635 Gcal

Thus, we have a margin of 7,635 Gcal.

Ethanol quantity can be obtained: 90,000 x 0.15 = 13,500 + 14,300 = 27,800 kl

The amount of ethanol production and the required energy for both cases are in the table below:

Raw materials, Ethanol production and Energy required

Item	Case 1	Case 2
	Raw material: Molasses	Raw materials: Molasses & Bagasse
Sugar Cane	1,425,000t	1425,000t
Sugar	150,000t	150,000t
Molasses	570,000t	57,000t
Bagasse	399,000t	399,000t
Fuel	399,000t	309,000t
Raw materials for ethanol	0	90,000t
Calories available from Bagasse	574,560Gcal	574,560Gcal
Bagasse as raw material / caloric value		90,000t/ 129,600Gcal
Bagasse as fuel / caloric value		309,000t/ 444,960Gcal
Required Calories to produce sugar	183,825Gcal	183,825Gcal
Required calories to produce ethanol		
Molasses to ethanol	33,000Gcal	33,000Gcal
Bagasse to ethanol	0	220,500Gcal
Energy balance	357,735Gcal	7,635Gcal

In both cases, calories from bagasse can cover all the energy needed for producing sugar and ethanol.

2 Project evaluation

2.1 Emission reduction and sinks of target greenhouse effect gas

(1)Baseline Calculation

(a)CO2 emission during gasoline production= 360 kg – CO2/kl – gasoline

(b)CO2 emission during gasoline combustion= 2,360 kg – CO2/kl – gasoline

(c)Total CO2 emission related with gasoline

= 360 + 2360 = 2,720 kg – CO2/kl – gasoline

(d)CO2 emission during ethanol burning is offset by CO2 sinks during sugar cane growing.

(e)CO2 emission during ethanol production in Case 1 & 2:

Per the findings of this research, bagasse can cover all the energy needed for producing ethanol. In addition, regarding the CO2 emission volume such as from transportation of raw materials for ethanol production, it is lower than those from fermentation and distillation steps, so we consider it as negligible in amount. Hence, we assume that there is no CO2 emission during the production of ethanol.

(2)Production Volume of Ethanol

Assuming the operating rate of the Warana Sugar Factory (concerning sugar production) is at same level before and after starting ethanol production. (If the Warana Factory starts the production and successfully operates, other factories of the Warana Cooperative Complex seem to start ethanol production. But we leave the matter out of account.)

Case 1: Molasses as an raw material: 14,300 kl/year

Case 2: Molasses and bagasse as raw materials: 27,800 kl/year

(3)CO2 emission reduction during the production of ethanol.

Case 1: 14,300kl /year x 2,720kg – CO2/kl = 38,896t/year

Case 2: 27,800kl/year x 2,720kg – CO2/kl = 76,616t/year

(4)Period of the Effect

The start of ethanol production will be at the end of 2005. Therefore, the CO2 emission reduction will go into effect from 2006. Taking into account the depreciation of its equipments, the emission reduction effect lasts for 10 years.

(5)Total Reduction

Assuming that the CO2 emission reduction effect lasts for 10 years by taking into account the

depreciation of its equipments.:

Case 1 14,300kl/year x 2,720 kg – CO2/kl x 10 = 388,960t

Case 2 27,800kl/year x 2,720 kg – CO2/kl x 10 = 756,160t

2.2 Project Effectiveness

(1)Project Cost-Effectiveness

We evaluated the cost-effectiveness regarding implementation of this project in terms of the budget per 1-ton reduction of CO2 emission. The result is as below:

Case 1 Total Budget: 13,900,000 US$

CO2 emission reduction for 10 yrs: 388,960t

The effect of reducing greenhouse gas: 36 US$/t

Case 2 Total Budget: 42,244,000 US$

CO2 emission reduction for 10 yrs: 756,160t

The effect of reducing greenhouse gas: 56 US$/t

(2)Effect on Payout

In Case 1, if we assume that the market price of ethanol keeps current level and the price of molasses is 5US$/kl and exclude the market price of CO2, the payout period would be about 4 years and 4 months. (IRR: 17.29%).

In a similar way, the payout period of Case 2 would be 7 years and 3 months. (IRR: 6.73%).

(3)Effect on Controlling Foreign Currency Outflow

Assuming that the crude oil price is 25 US$/barrel = 157 US$/kl,

Case 1: 14,300 kl/year x 157 US$/kl = 2,245,100 US$/year

Case 2: 27,800 kl/year x 157 US$/kl = 4,364,600 US$/year

Assuming that this project spreads throughout India and the gasoline consumption is 10,811,000 kl/year, the possible reduction of gasoline consumption would be 1,810,000 kl/year by blending 10% ethanol.

Thus, the amount of foreign currency for importing crude oil in 2005 fiscal year can be saved would be:

1,081,000 kl x 157 US$/kl = 1.70×10^8 = 170 million US$/year (20.4billion US$ as 120 yen / US$)

(4)Increasing Job Opportunity for Farmers

Per VK WARANA project that has been planned by The Warana Corporative Complex, 75,000 farmers would receive the benefit from newly started sugar cane production, and from founding and

operating of anhydrous ethanol factory of 800,000t/year capacity. Additionally, they would get job opportunities to be a worker of that alcohol factory.

3 Feasibility of Project

The rising use of motor vehicle is causing serious air pollution mainly in urban areas. Because of it, they are facing an urgent need to develop clean fuel for motor vehicle.

Sugar cane is produced throughout India and remains to be a major income source for the farmers. Moreover, in India, rural population is 60% of whole population of the nation. We can see urbanization in the capital city, but it is not obvious in provincial cities.

Until about 20 years ago, the domestic oil production had been approximately the same with the domestic oil demand, and thus they had been depending on imports for only about 20% of their consumption. However, because of recent increasing oil demand, they have to depend on imports for 70% of the consumption.

Under the circumstance like above, the gasohol policy acts like a triple-purpose solution for curbing air pollution, agriculture promotion, and decreasing energy dependence on foreign supplier, and it calls attention as use of renewable for countering global warming.

Therefore, we deem that the Indian government will advance the gasohol policy.

It is very possible that the Warana Ethanol Project, when using molasses as an raw material, will be profitable where preferential treatment concerning taxes is obtainable, which lowers the ethanol price to the level of gasoline.

4 Indirect Influence from the Project Implementation

4.1 Influence on Environment

In a sugar factory, we get spent wash as liquid waste. For pollution prevention, we collect methane as an energy source through its fermentation, and return its liquid residue to the sugar cane field as a fertilizer.

Moreover, for preventing air pollution by enhancing boiler system, we setup dust collectors and the like. In addition, there would be little SOx emission, because of low sulfur content in the fuel.

4.2 Influence on Economic Aspect

In this project, we extract ethanol out of molasses and bagasse, which are from existing sugar

factory. Where we can't use the existing molasses and bagasse, we would need to increase the yield of sugar cane so that we can get enough molasses and bagasse. In the later case, huge amount of sugar will be produced along with them. If this is implemented all over India, the sugar production from it will achieve 30% of the nation's total output of sugar. This will cause weakening in sugar market, and so is not realistic. Therefore, in the later case, it is realistic to extract sugar juice from newly obtained sugar cane yield and use it directly as an raw material for ethanol.

4.3 Influences etc. on Social and Cultural Aspects

The ethanol production factory is the processing Industry. Therefore, by courting those factories to the rural area, we can revitalize local area and can improve technology level.

In addition, we can expect increased money income in the rural area and stabilization of sugar price.

5 Possibility of Project Spread

In the year 2000, the gasoline demand in India was 6,613,000t/year. Based on the past record and assuming the demand will grow by an average of 3.6% annually, the gasoline consumption in 2003 will be estimated as 7,353,000t (10,073,000kl).

In India, the target ethanol content of gasoline is 10%, and for achieving this, they need to produce more than 1,000,000kl of ethanol from 2003 onward.

By converting 30% of the molasses, of existing sugar factories origin, to an raw material for anhydrous ethanol production, we can obtain required amount of ethanol to produce the required amount of gasohol.

There are about 450 sugar factories in India, and it is very possible to diffuse and promote gasohol by the government aid such as tax deduction for ethanol price and making its production process more efficient for profitability,

6 Summary

This research is about the project conducted in the Warana Sugar Factory, located in Kolhapur, Maharashtra State, India. The project was to study the possibility of utilizing molasses (waste sugar juice) and bagasse (sugar cane trash), which were by-products from the factory, as the raw materials for producing anhydrous ethanol, and then use it for producing ethanol-blended gasoline (gasohol).

The Warana Factory, being research target, has problems to solve depressed sugar price and lack of job opportunities for cooperators of the Warana Cooperative Complex. Currently, therefore, the gasohol policy is of deep concern to the government. The Warana Sugar Factory has seriously examined about founding their own alcohol factory, but because of big financial strain and lack of information about efficient technologies for fermentation and dehydration, they haven't implemented it yet.

The result of this research shows that the ethanol production out of molasses is very feasible from the view of its technical advantage and profitability. In addition, the result shows that, although leaning on a future policy regarding ethanol price, we can expect the early spread of gasohol in India.