CDM/JI PROJECT STUDY FY2003

Feasibility Study on Cogeneration Business in Thailand Utilizing the Bagasse and Rice Husk

Summary Report

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Contents

1 Purpose of the study

In the recent times, global warming has been growing into an issue requiring urgent attention, and promoting projects under the scheme of clean development mechanism (CDM) approved by the Kyoto Protocol is expected to be one of the most effective ways to address this issue.

The purpose of this project is to contribute to the anti-global warming efforts through biomass-fired power generation. In addition to dead leaves (trash) of sugar cane produced as a post-harvest waste from sugar cane cultivation, rice husk will be utilized as a biomass fuel.

The Rajburi Sugar Factory that produced 1,040,000 tons of cane (sugary stem of sugar cane) in the crop year 2002-2003 has been selected as a possible project site (harvest time: December 2002~April 2003). Trash collected from sugar cane farms that are under contract with the factory is used as biomass fuel for the project. Trash is planned to be used as the primary fuel during the sugar production period. Rice husk will be purchased to continue the biomass-fired power generation during the non-production period in order to sell electricity to the Electricity Generating Authority of Thailand (EGAT). Not all trash is available as fuel since it currently serves as fertilizer that is plowed into the soil. A realistic quantity that will be allocable for biomass fuel and also be within a range such that it will not have an adverse effect on the yield of sugar will be determined in order to set up a system of sustainable development of agriculture and energy.

Molasses or syrups produced during the refining of sugar as residual liquid which retain some sugar content can be resourced into the brewing process. The project also discusses cogeneration that enables the supply of part of the steam produced in the power generation into alcohol plants.

This feasibility study explores the potential of the above-mentioned system to satisfy the requirements of a CDM project introduced in Thailand.

2 Summary of findings

2.1 Basic information on Thailand

Thailand is a kingdom. Prime Minister Thaksin has established a strong political power base and displays aggressive leadership among the ASEAN countries. Although the country is relatively stable from the political, economical and religious points of view, the harsh reality of a sharp increase in murder, robbery, narcotics, crimes, and terrorism also exists.

Located in the Tropical Zone, Thailand is rich in agricultural resources and produces sugar cane (annual yield in 2003: 74,070,000 tons) and rice (annual yield in 2003: 27,000,000 tons).

Thailand is a developing country, and growth at a significant rate is expected not only in the economy but also in the demand for electricity. After the currency crisis in 1997, the country entered a recovery phase in 1999. Rapid economic growth is likely to continue in future (including an estimated rate, the average growth rate of real GDP from 1999 to 2003 is 4.6%). A high growth in electricity demand may reflect such a positive economic situation. According to the EGAT, the annual growth in electricity demand in Thailand is estimated to be around 6% from 2007 through 2016. While the government is yet to privatize power stations, it plans to further encourage the purchase of electric power from independent power producers (IPPs) and small power producers (SPPs) in order to facilitate the entry of private sector into the power industry.

At the same time, the country is also faced with growing concern regarding environmental issues of water and air pollution.

The government of Thailand ratified the UN Framework Convention on Climate Change (for prevention of global warming) in March 1995 and the Kyoto Protocol in August 2002. The government has adopted a liberal approach toward CDM and has shown willingness to approve any business if it can demonstrate its capability to serve the interests of the nation and contribute to the country’s sustainable social and economical development.

2.2 Outline of the project

To satisfy the requirements of a CDM project, the project plans to mainly utilize trash during the harvest period and rice husk during the non-harvest period as fuel for biomass-fired power generation. The mechanized collection of trash can reduce costs as well as labor. The process of mechanized harvesting of cane using a harvester involves collecting trash in a container mounted on the rear part of the harvester. It is difficult to secure trash in the necessary quantities for power generation throughout the year. Therefore, in addition to trash, rice husk will be purchased from rice mills for use during the period when trash is not sufficient to maintain electricity sales. To utilize steam more efficiently, part of the steam used at the power station is to be supplied to an alcohol plant constructed on an adjoining site, provided that the operation of the alcohol plant is outside the scope of this project.

2.3 Project site

In the proposal stage of this feasibility study, the following decisions were made regarding the project based on the information that the Rajburi Sugar Co., Ltd. had plans to improve the facility in the future. This was revealed by a fact-finding survey at the possible project site:

- Existing boiler, turbine, and generator will be improved to generate high-pressure power and high-temperature steam. Since excess bagasse is used as fuel for biomass-fired power generation, the project can be deemed as one aimed at preventing global warming. In order to export electricity throughout the year, rice husk is purchased to maintain biomass-fired power generation.
- Measures to control methane gas that might be generated from the bagasse in open stock area have been included in the discussion.
- Excess steam is utilized for cogeneration.

Recognizing that a part of the generating facility has become obsolete and the need for urgent modification, Rajburi decided to construct a new power generation facility with a capacity of 10 MW in May 2003. On completion of the new facility in December 2003, the plan was reviewed and amended as follows:

- Biomass fuel used in the project is replaced with trash since excess bagasse is used as fuel in the new 10-MW facility constructed by Rajburi.
- The discussion on controlling methane gas emission is called off since the bagasse is consumed by the Rajburi Sugar Factory.

Despite the project being subjected to a slight change, the Rajburi Sugar Co., Ltd. has continued to be interested in the new biomass power generation business. As shown in Figure 1, Rajburi is located in Ban Pong in the Ratchaburi Province. The company produced 1,043,477 tons of sugar cane in the 2002-2003-harvest season from 108,250 Rai of planted area (1 Rai = 1,600 square meters). The overall sugar cane production in Thailand in the 2001-2002 season was 59,490,000 tons, while the company’s performance during the same harvest year was 860,000 tons. In other words, the company’s domestic share in sugar cane production was 1.4%.

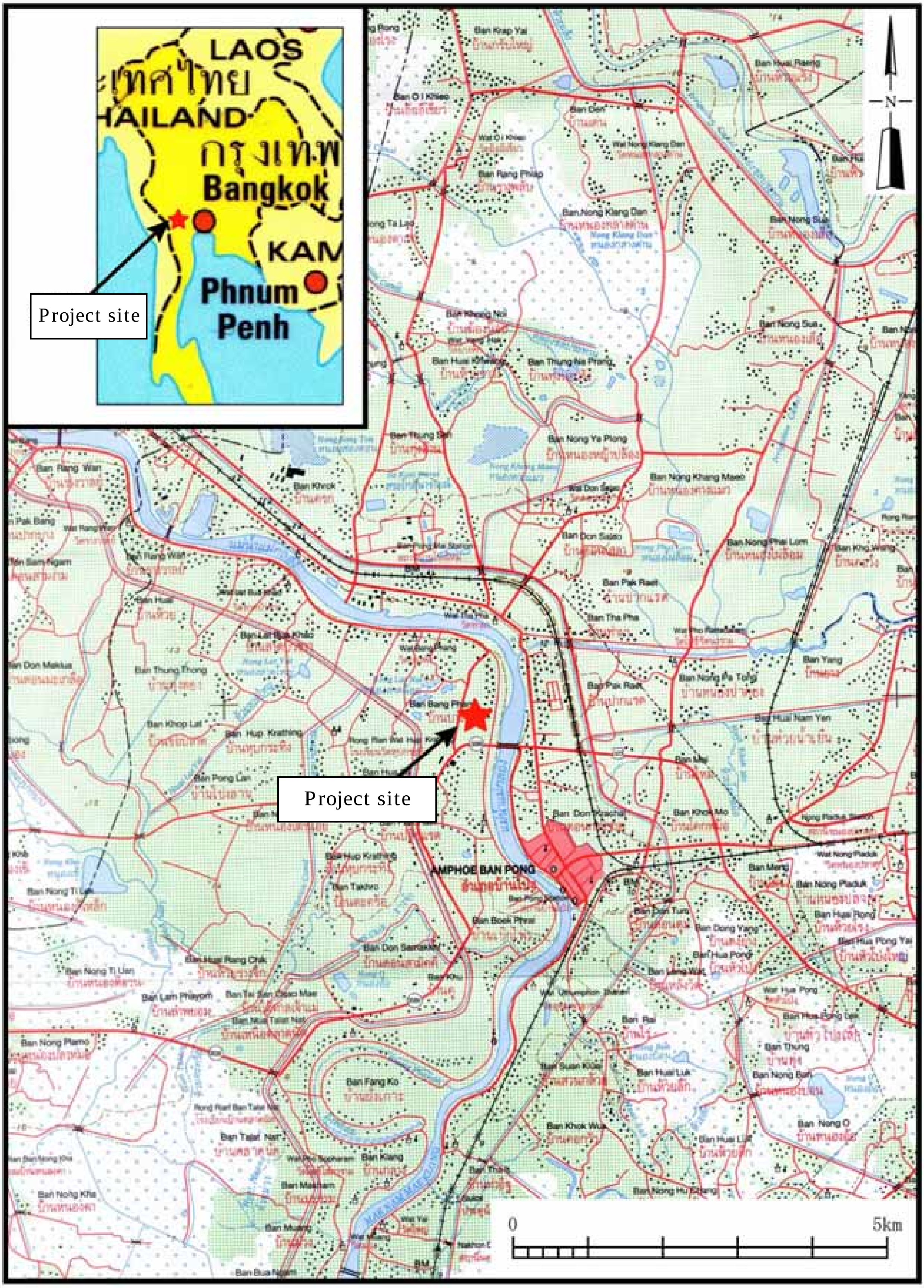

Figure 1 Project site (Rajburi sugar factory)

Rajburi Sugar Co., Ltd. was established in December 1985 with a capital of 200 million Bahts (average exchange rate from November 2003 through January 2004 is JPY2.81 = B1). The company engages in the following activities related to sugar production:

- In order to support and assist sugar cane cultivation by improving harvesting efficiency and reducing costs, the company employs a harvester, cane picker, tractor, and other agricultural machineries.
- The company launched a new irrigation system called the Norng Punchan Project. This project was financed by the Asian Development Bank with an investment of 96 million Bahts. The irrigation system covers more than 630 acres of land and 147 farmers.
- Under the Financially Secured Cane Farmers Project and in cooperation with research institutions, the company initiated an educational program for the farmers that involved harvest planning, technical improvements, laborsaving by mechanization, and shifting from chemical to organic fertilizers for improving the soil quality and preventing damage to the environment.
- The company was certified by ISO 9002 and ISO 14001 in March 1999 and April 2001, respectively and pays considerable attention to quality and environment control.
- The company has supplied electricity to the EGAT since 1994.

2.4 Outline of the use of biomass as fuel

Trash, which is potential fuel for the project, is currently treated in either of the following ways by the contract farmers of Rajburi:

- Trash is burned prior to harvesting by 25% of the contract farmers. This pre-harvest burning is mainly in order to assist in the harvesting operation and is employed by farmers in places where sugar cane is harvested manually. Approximately 5% of the burning is accidentally caused by flames from cigarette butts and husk burning.
- Trash is plowed back into the soil by 75% of the contract farmers. This trash can contribute to enhancing the quality of soil by increasing its content of organic matter, air permeability, water-holding property, cation exchange capacity and so on.

Organic consumption of the soil is estimated to be 595 kg/ha based on data such as humus content of the Rajburi contract farms, which is 2.38% (result of our field study), annual decomposition rate of soil organic carbon—1% (reviewed literature), and trash organic content—40% (reviewed literature). Half the volume of biomass applied to the soil is considered to be decomposed into organic matter. Therefore, at least 1,190 kg/ha should be returned to the field in this case.

In the meantime, the volume of trash can be estimated as follows, given that the cane yield per unit area is 62.5 t/ha (result of our field study) and based on the yield-to-weight ratio of trash on a dry basis:

$62.5 \text{ t/ha} \times 29.5\% \div 69.5\% \times 22.2\% = 5.9 \text{ t/ha}$,

where 29.5%: percentage by dry weight of cane (i.e., 70.5% moisture content) – reviewed literature

69.5%: yield-to-weight ratio of cane (dry basis) to sugarcane – reviewed literature

22.2%: yield-to-weight ratio of trash (dry basis) to sugarcane – reviewed literature

Therefore, the resulting difference of 4,710 kg/ha between 5,900 kg/ha of trash and the minimum requirement of 1,190 kg/ha to be left in the field would be the maximum amount of trash available for the project from the field. This percentage was determined to be 80%. Moreover, taking soil fertility into consideration, the quantity of trash that should be left in the field is 2,380 kg/ha , which is twice the minimum requirement of 1,190 kg/ha. In the latter case, the quantity available for the project would be reduced to 60%. However, if the returning of the ash of trash to the field is taken into account, it would still be safe to collect 70%, i.e., median value, of trash. With regard to the ash of trash, Dr. Ampon of The Environment Department of Thailand concedes that the ash of biomass such as trash is an outstanding soil fertilizer.

2.5 Facility design

The following prerequisites are taken into account in designing the project:

- The sugar cane yield is 863,200 t-c/year (t-c indicates deadweight tonnage of cane, rounded off to the hundreds place) in the 5-year average at Rajburi contract farms (minimum and maximum yields are 755,400 t-c/year and 1,043,400 t-c/year, respectively).
- The Rajburi Sugar Factory can treat 9,880 t-c/day of sugar cane. Thus, the harvest period is calculated as follows:

  863,200 t-c/year ÷ 9,880 t-c/day = 87 days.
- A new 10-MW power station fueled with biomass is constructed on a plot adjoining Rajburi.
- Considering the fact that water in the Rajburi area is hard water, the pressure and temperature conditions of the steam used for the boiler are set at 33 barG and 425ºC.
- Electricity sales to EGAT is 8 MW during the daytime and 6 MW (75% of the daytime capacity) during the nighttime (actual connection to the grid line is done by the Provincial Electricity Authority – PEA). On Sundays and holidays, the amount to be sold is 6 MW.
- The major fuel for biomass power generation during the harvest period is trash, while purchased rice husk is used during the non-harvest period.
- The collectable quantity of trash from the field should not exceed 70% of the total yield in order to prevent the deterioration of soil fertility of the sugar cane fields. Ash of trash burned in the new power station is to be returned to the fields for use as fertilizer.
- As shown in Image 1 and Figure 2, trash is collected using harvesters during the process of mechanical harvesting of sugarcane and is packed in bags to be carried to the new power station.

- A local special purpose company (SPC) established to implement the project will purchase 19 new harvesters and rent them to contract farmers. The capacity of the new harvesters would be 240 t-c/day. On an average, the present capacity is 120 t-c/day since the harvesters currently owned by Rajburi are secondhand. Mechanical harvesting planned for the project will be done using a total of 35 harvesters, including the 16 existing harvesters.
- A mechanization rate of 65% will be achieved with 35 harvesters. According to Rajburi, the current ratio of sugar cane fields available for mechanization is about 40%. However, once soil amendment by removal of the gravel is accomplished in order to introduce the use of harvesters, and the farmers recognize the benefits of cost reduction through mechanization, it will be possible to increase this ratio to 65%.

Image 1. Cane harvesting with a current harvester.

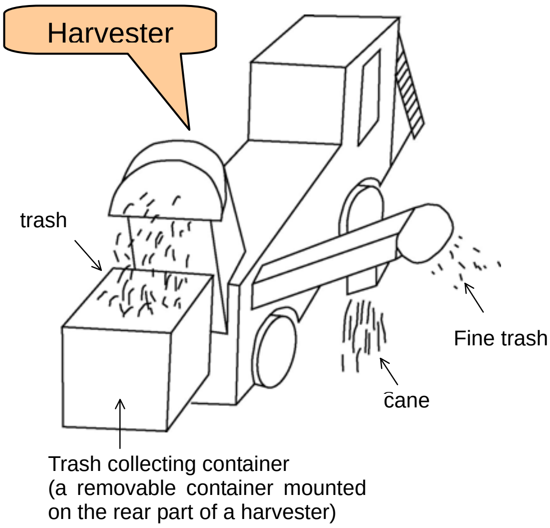

Figure 2. Means of trash collection for the project.

- Water is obtained from a single other source in addition to the current ground water source for Rajburi Sugar Factory. Effluent is to be discharged into the current drainage path of the factory.
- Improving of equipment in Rajburi Sugar Factory is not planned.
- For effective utilization of heat, steam is partially supplied to an alcohol plant (the alcohol plant is not included in the scope of the project).
- The alcohol plant produces ethyl alcohol from the molasses supplied by the Rajburi Sugar Factory. Molasses produced at Rajburi constitute 4.3%~4.8% of cane (data from the fact-finding survey). The annual yield of molasses should be 863,200 t-c/year × 4.3% = 37,100 t-m/year (t-m indicates deadweight tonnage of molasses). The volume of steam supplied to the alcohol plant should be 7 t-s/h (t-s indicates deadweight tonnage of steam) corresponding to the manufacturer’s designed capacity.

As shown in Table 1, the capacity of biomass power generation and the quantitative effect of the abatement of climate change are estimated based on the above-mentioned design conditions. Figure 3 shows the schematic diagram of the project system.

Table 1. Equipment and the quantitative reduction effect of GHG emission of the project.

Item	Result of trial calculation	Remarks
1. Equipment		
(1) Boiler	60 t/h	Volume supplied to an alcohol plant: 7 t/h
(2) Generator	9.64 MW	Power to be sold: 8 MW (daytime), 6 MW (nighttime)
2. Fuel		
(1) Trash	73,200 t/year	Moisture content: 49% Calorific value: 1,800 kcal/kg
(2) Rice husk	64,300 t/year	Calorific value: 3,440 kcal/kg
3. Power generation and the quantitative effect of GHG emission reduction		
(1) Power to be sold to the PEA	54,810 MWh/year	
(2) Power to be sold to an alcohol plant	2,341 MWh/year	
(3) Quantitative effect of GHG emission reduction	35,188 t-CO_2/year	

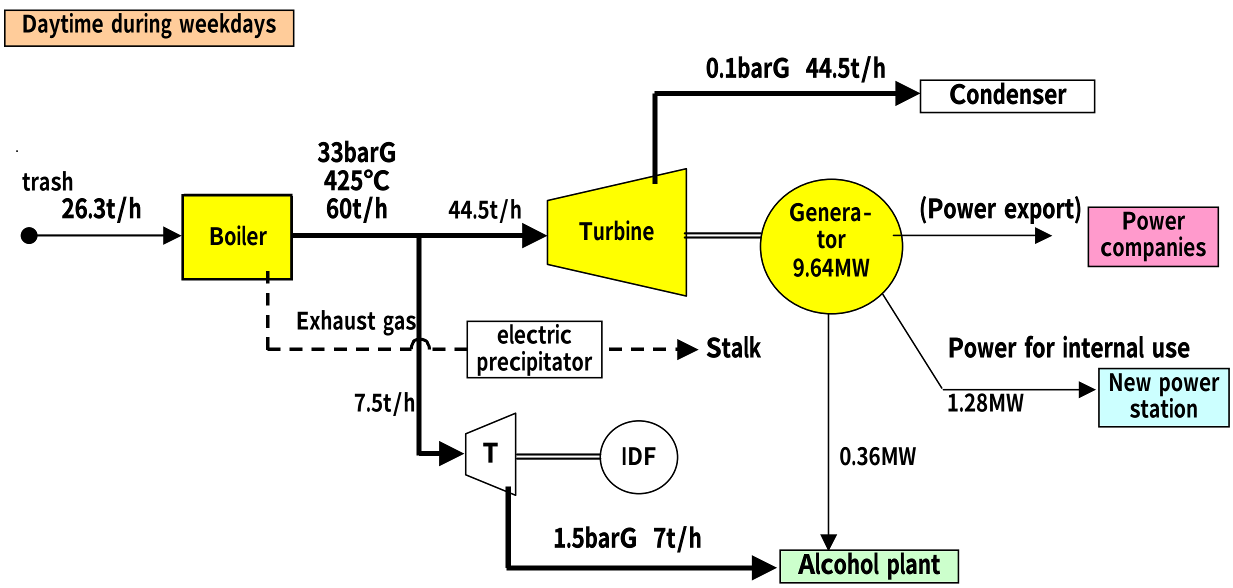

Figure 3. Schematic diagram of the system.

2.6 Income and expenses of the project

Income and expenses of the project are tabulated in Table 2.

Trial calculations are based on the following conditions:

- The cost estimated for the equipment is sufficient to cover the minimum necessities. A 30% discount on the manufacturer's quotations is taken into account.
- Currently, the purchase price of rice husk is soaring due to excessive demand. For the purpose of the trial calculations, the price is set at 400 Baht/t, which is considered to be a reasonable price corresponding to a calorific value fixed in future. (Currently, the market price of rice husk is 800–900 Baht/t. The views of the Association of Rice Mills in Thailand were also taken into account while setting the price for the computation.)
- It is reported that rice husk ash can be traded at a high price as it acts as a raw material for semiconductors due to the silica contained in it. Since making an accurate forecast of the price is not possible under the circumstances, transaction of rice husk ash shall be excluded from the budget consideration.

Table 2. Outline of income and expenses of the project.

(Unit: million yen)

Item	Amount	Remarks
1. Income	**470**	
(1) Power sales	349	Calculated based on the terms and conditions of a sales contract with EGAT
(2) Income from an alcohol plant	79	Power: yen 15 million, steam: yen 64 million
(3) Harvester rental	42	Rental of 19 harvesters
2. Operating expenses	**160**	
(1) Fuel	89	Trash: yen 12 million, rice husk: yen 72 million etc.
(2) Others	71	Including personnel, maintenance, consumables, land lease, SPC management, and monitoring expenses
3. Initial investment (facility)	**2,064**	Including an assumed 30% discount on manufacturer's quotations
(1) Boiler, turbine, generator	910	
(2) Peripheral equipment	350	Conveyer, water supply/drainage system, shovel loader, and truck scale
(3) Harvester	475	19 units
(4) Construction work	329	Including electric and piping work, transmission line work, and transportation expenses
4. Others	20	SPC organization expenses

2.7 Implementation of the project

Shown below are the scope (Figure 4), implementation structure (Figure 5), implementation schedule (Table 3), and financing plan (Figure 6) of the project.

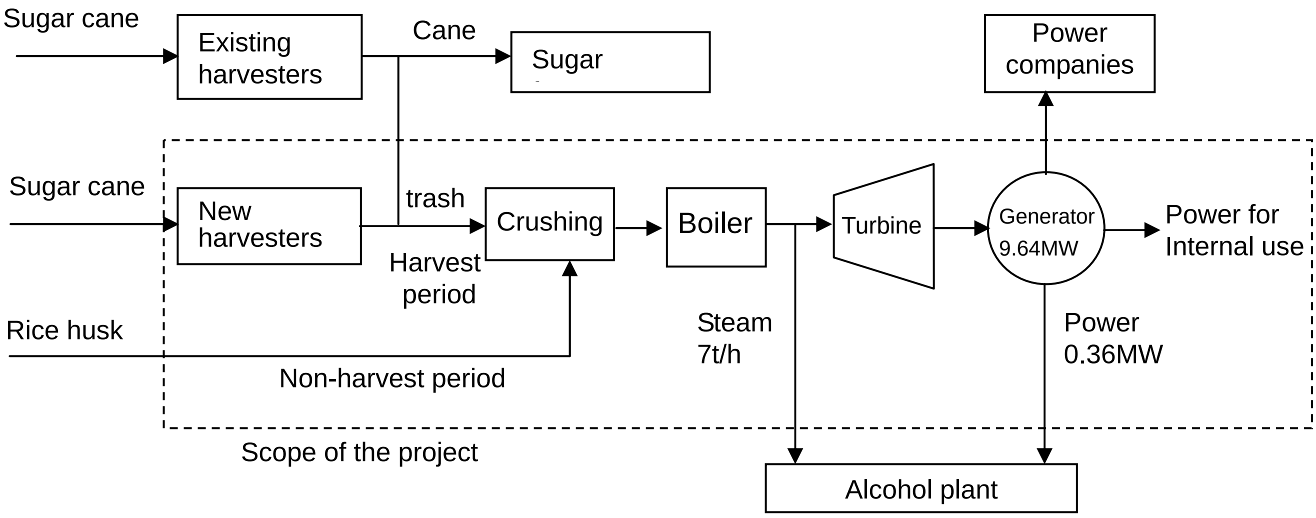

Figure 4. Scope of the project.

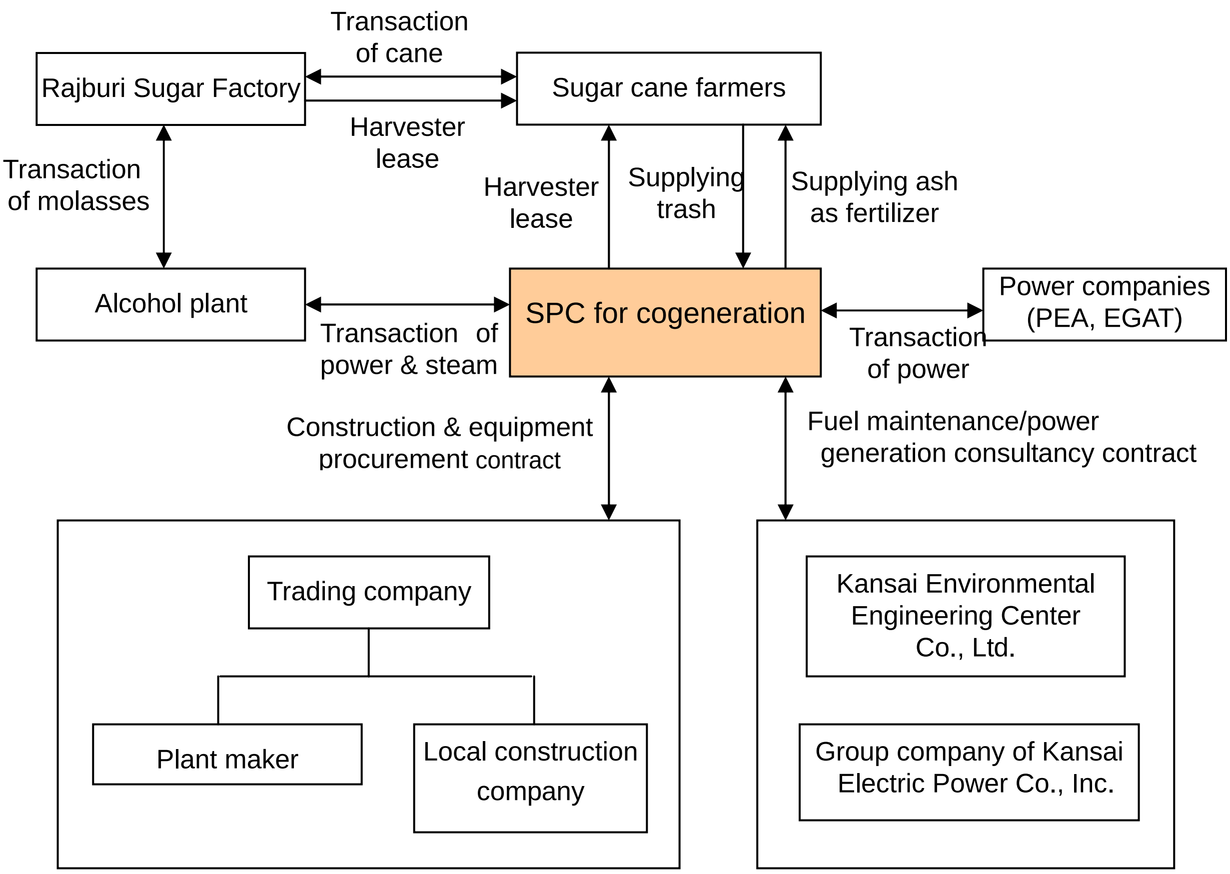

Figure 5. Implementation structure of the project (draft).

Table 3. Implementation schedule (plan).

Item	FY2004	FY2005	FY2006	FY2007
a) Detailed study, assessment				
b) Acquiring investors and financing companies				
c) Approval of PDD (Project Design Document)				
d) Designing				
e) Fabrication of equipment/machineries				
f) Construction, transportation, installation				
g) Performance tests, trial run				
h) Kick off				
i) Monitoring				

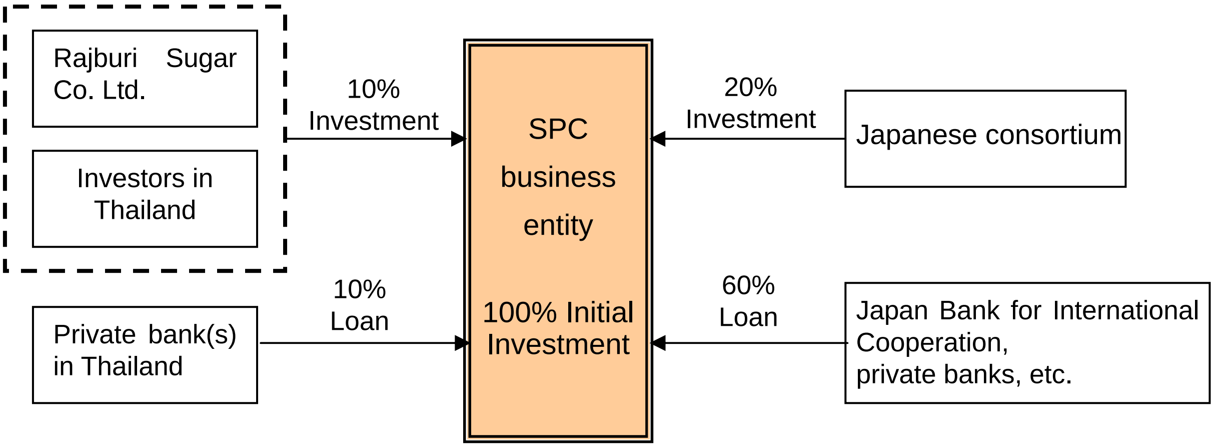

Figure 6. Financing plan for the project (plan).

2.8 Evaluation of the project

In evaluating the project, the following points have been focused upon:

a. Methodology of the CDM project

Given that 1 kg/h of steam equals approximately 0.7 KW, 60 t/h of the rated output of the primary boiler is converted into approximately 42 MW (< 45 MW) of electricity. In view of its capacity for cogeneration, the project has been judged to conform to the requirements of the small-scale CDM.

b. Selecting a baseline

From the applicable simplified baselines in Type I.D for small-scale CDM projects, the "weighted average emission of the current power generation mix" is selected as baseline for this CDM project. In other words, the baseline should be "the weighted average emission from the power generation mix" (a value obtained by multiplying the power to be sold under the project with the weighted average emission factor of a grid power source) in 2007, when the operation is schedule to begin.

c. Discussion on carbon leakage

The Project activity's renewable energy is produced by new equipment installed for the first time. Therefore, no leakage calculation is required, per item 30 Appendix B of simplified M&P for this small-scale CDM project activity.

For reference, regarding GHG emission caused by the implementation of this CDM project, there was no knowledge of trash being used as a substitute for fossil fuel other than in this project. On the other hand, rice husk has already been partly used as biomass fuel for power generation in the host country. Since the estimated volume of rice husk to be used in the project is 64,300 t/year, i.e., about 1.3% of the total rice husk produced in Thailand, the implementation of the project can hardly hinder the rice husk supply and is unlikely to lead to an additional consumption of fossil fuel outside of the scope of the project. The ash from trash that is used as fuel for the project is to be returned to the sugar cane fields as it is used as fertilizer. After collecting trash, a follow-up application of the chemical fertilizer is no longer necessary in these fields. Therefore, at this stage, it can be concluded that there can be no carbon leakage or generation of nitrogen monoxide (N_2O) from such a follow-up application.

d. Technical basis for producing the reduction effect of GHG emission

The emission factor of the grid is not zero since the power source mix at the EGAT contains thermal power utilizing fossil foil such as natural gas, petroleum, and coal, while the emission factor of biomass fuel used in the project is zero (carbon neutral). Thus, the difference between these two is the reduction of GHG emission.

e. The quantitative effect of GHG emission reduction

The estimated average CO_2 emission factor of the EGAT in 2002 is computed to be 0.642 t-CO_2/MWh, and electricity sold to the EGAT under the project will be 54,810 MWh annually. By multiplying these values, the annual baseline emission is determined to be 35,188 t-CO_2. Regarding the sources of GHG emissions due to the Project Activity within the boundary, the IPCC Guidelines stipulate that biomass combustion is assumed to equal its regrowth, and Appendix B of the simplified M&P does not require monitoring of GHG emissions from ancillary activities. Therefore, neither CO_2 emission from biomass combustion nor annual CO_2 emission of 3,804 t-CO_2 from the transportation of biomass fuel and trash ash are computed in relation to the major activities under the Project. Finally, the reduction of CO_2 emission realized by the project is estimated at 35,188 t- CO_2 annually.

f. Profitability study

From the study, it is deduced that the internal rate of return (IRR) over a 10-year credit period is 4.98%, which will increase by 1.15 percent to 6.13% when the carbon credit price is set at US$ 5.00/t-CO_2e.

The project will be able to recover the accumulated loss and go into black nine years after its start.

If profit from the sales of rice husk ash is included, the potential of the project as a business can be drastically improved because rice husk ash is likely to be sold at a high price.   At the same time, rice husk introduces an element of uncertainty since an excess of demand generates a substantial increase in the purchase price.

3. Others

The significance of the project lies in the fact that this is a new attempt to realize biomass power generation through the sustainable development of sugar cane cultivation by securing biomass fuel and utilizing and returning trash ash to sugar cane fields for use as fertilizer. In addition, the project can be of help in promoting mechanization that will be employed to address the issue of harvesting costs, which are likely to increase following the future increase in labor costs in Thailand as its economy grows.

Considering the environmental impact of exhaust gas, effluents, noise, and vibration caused by the new power station on the surrounding area, necessary countermeasures are to be devised.   Since no residential areas exist around the Rajburi Sugar Factory, the power station may not encounter major problems.