SUMMARY REPORT ON FEASIBILITY STUDY FOR CDM/JI YEAR 2008

Feasibility study on Programmatic CDM for Ethanol production using cassava pulp in Thailand

Feb 2009, Mayekawa Mfg. Co., Ltd.

1. Outline of the project

(1) Host country, area: Feasibility study on Programmatic CDM for cassava starch plants in all areas of Thailand

(2) Outline of the project

This is a feasibility study on Programmatic CDM for ethanol production using cassava pulp in which bio ethanol is produced from cassava pulp that is the byproduct (waste) of starch production process of cassava starch plants in The Kingdom of Thailand (hereinafter called “Thailand”) .

In this project, an ethanol plant adjacent to existing starch plant will be built where cassava pulp (in which, 50~60% of starch is included in dry weight)is used as raw material and around 50 to 75% of medium grade ethanol is distilled which will contribute to mitigate the generation of methane gas caused by fermentation of stored waste in an open field otherwise. In designing the production process, care should be taken to reduce the consumption of fossil fuel as much as possible by using waste biomass such as cassava skins or rice husks as much as possible as far as the energy consumed for ethanol production such as steam is concerned.

Medium grade ethanol produced by the project will be further distilled up to over 99.5% to be used as automobile fuel by the ethanol plants dedicated to the production of automobile fuel so that this business will not compete against existing fuel ethanol plants.

This plan is to establish a “Programs of activities” (PoA) and build multiple ethanol plants using cassava pulp as raw material in various places in Thailand.

CER derived from each project will not be so big, so that the expenses required for the procedures of CDM project is too high for each project. For this reason, we propose to turn this project as PoA and negotiate with “Thai Tapioca Starch Association” (TTSA) to become the coordinating entity of PoA.

As a candidate for the first project of SSC-CPA (small scale CDM – CDM Program Activity), we selected “A Starch Company”(ASC) which is located in Nakhon Ratchasima province about 250kms northeast of Bangkok and made business plan.

Representative model of CPA

As a result of the study, estimated CER at ASC will be 4,649t-CO2/y available from the avoidance of methane production from cassava pulp when 500tons of ethanol is produced from 1200tons/day of cassava pulp waste. As product, 32.5kL/day equivalent to dehydrated ethanol (Net 43.3kL/day as shipped at 75% concentration) can be produced. Additional CER for about 24,000t-CO2/y can be expected if the effect of being alternative to gasoline can be counted as CER. However, there is no approved Methodology at the tome of this feasibility study and it is required to develop a new Methodology for gasoline alternative effect of ethanol.

Contribution to sustainable development in Thailand

According to the Thai policy for developing automobile fuel ethanol, there are three objectives such as reduction of consumption of fossil fuel, increase of self supply ratio of energy and development of new market in the agricultural sector. This proposed project matches such three objectives of ethanol development policy.

1) Stable business for starch factories, stable revenue in agricultural sector
The utilization of cassava pulp from byproduct (waste) of cassava starch factory contributes to the stable business for cassava starch factories.

2) Ethanol production for automobile fuel from the raw materials not competing against foodstuff.
The conventional approach is to produce ethanol using fresh cassava when there is not enough molasses available. However, this is conflicting against foodstuff production and some experts raise question on such approach. In this proposal, cassava pulp which is the byproduct of starch factory is used and the production of automobile fuel ethanol is possible without conflicting foodstuff.

3) Securing ethanol raw material available throughout the year
Molasses is mostly used as ethanol raw material. The harvesting season of sugar cane is from November through April (dry season in Thailand). Molasses is produced during sugar factories are in operation. During the remaining period of May through October, ethanol production is maintained using the stock of stored molasses in the sugar plants. The shortage of available molasses may occur before the next sugar production season starts when the supply and demand are out of balance or export of molasses is increased.
Cassava materials are basically available for 12 months. As the seasonal feature of Starch factories, cassava growers may slightly reduce harvesting during rainy season (September to October) but not all of 70 starch factories in Thailand stop operation at the same time. Therefore, cassava pulp is available stably through out the year as ethanol raw material.

4) Coexistence by using refining process of existing ethanol plants.
In Thailand, 45 factories have licenses for automobile fuel ethanol plants and currently 12 plants have started operation. In Nakonrachasima province, for example, where the production of cassava is highest in Thailand, one factory is already in operation and two other relatively large factories (TPK Ethanol, Buenok) are scheduled to start operation by the end of 2009. Therefore, if cassava starch factory starts production of 99.5% ethanol on site, a severe competition may be expected against existing ethanol factories. In this proposal, due to such reasons, ethanol production from cassava pulp is limited up to 75% ethanol to maintain coexistence in the same business. (Note: some starch factories have already obtained license to produce 99.5% ethanol. For such factories, it may be possible to produce 99.5% ethanol from cassava pulp.)

5) New employment of skilled engineers
Many processes of ethanol production from cassava pulp requires dedicated skills. By implementing proposed projects, it will lead to create new employment of skilledengineers.

2. Contents of the study

2.1 Objectives of the study

At the time of conducting this CDM feasibility study (hereinafter called “this study”), few reports prior to this report have been issued.

Firstly, there is no example of implementation in Thailand in spite of high potential of ethanol production from cassava pulp.

Factories have big problems in treating cassava pulp particularly during the wet season. Because they can not sell it as feedstuff unless it is dried under the sun, it is stored in the empty land within the property of the factory until it is dried under the sun and sold. Sometimes it is sold at extremely low price due to the low demand.

Based on these facts, this study is focused on following subjects:

(1) The trend of automobile fuel ethanol industry in Thailand and the expectation for cassava materials
(2) The trend of starch industry and outline of starch factories
(3) Study on business model of ethanol plant using cassava pulp at cassava factories
(4) Collection of technical information for the production of ethanol using cassava pulp and various experiments.
(5) Study on ethanol plant system
(6) Study on GHG reduction in the standard model plant
(7) Study on Programmatic CDM to develop this project
(8) Trend of CDM projects by various countries in Thailand

2.2 Participants for executing the study

<subcontractors in Thailand>

Kassesart University Agricultural products Institute (KAPI): collecting information for cassava starch factories, coordination during the research work on site, analysis for setting up baseline

<Japanese subcontractors>

Climate Experts Ltd.: Assisting work to develop PoA-DD PoA Specific CPA-DD Completed CPA-DD of small scale CDM

National Institute of Advanced Industrial Science and Technology: Preliminary experiments of pretreatment conditions for cassava pulp by water heating method which is required to design the system for the project

2.3 Contents of the study

(1) The trend of automobile fuel ethanol industry in Thailand and the expectation for cassava materials

In Thailand, automobile fuel ethanol has been introduced practically since 2003. 12 plants are in operation in February 2009. Mostly molasses (waste liquid sugar) is used as raw material but cassava will be used as raw material in more factories when consumption of ethanol is increased. Since molasses is the byproduct of sugar plant, itis supplied preferably to the ethanol plants which are subsidiaries of sugar company. If other companies enter into ethanol business, they may select cassava material. Cassava is expected to be an alternative ethanol raw material following molasses.

(2) Trend of cassava industry in Thailand and outline of starch factory

Cassava is an important agricultural product in Thailand equivalent to rice, sugar cane and palm oil. Thailand is the No.1 country of exporting cassava products. There are 70 cassava factories. They spread in major cassava producing area such as Nakhonrachasima province in Northeast and Kamphaeng Phet province in North.

Factories with cassava receiving capacity of 800 to 3,000tons/day are grouped in medium to large scale factory.

Among several factories interviewed during the research, it was found that “A Starch Company (ASC)” in Nakhonrachasima province showed great interest in the project. It is a large scale factory with longer operation period in the year and has a biggest problem in treating massive quantity of cassava pulp among all. For this reason, it has been selected as a CPA site for the business development study.

(3) Business model study for the ethanol plant using cassava pulp at the starch factory

After summarizing information obtained from several starch factories, it has been decided that the capacity of the ethanol plant should be 32.5kL/day equivalent to dehydrated ethanol using 500ton-wet/day (equivalent to 1250t/day of fresh cassava processed in the starch factory).

In the project, the distillation process is designed up to 75vol% ethanol due to actual efficiency. This is a kind of business model that it is possible to reduce investment cost considerably by reducing the cost of distillation process and eliminating dehydration process in order to improve profitability as well as to avoid competition against existing ethanol plants and look for coexistence.

(4) Collection of technical information for the production of ethanol using cassava pulp and various experiments.

Ethanol production process using starch (hydrocarbon) is divided into pretreatment process of raw material, liquefaction-saccharification process, fermentation, distillation process and dehydration process if it is to produce dehydrated ethanol.

There is no reference of producing ethanol from cassava pulp in Thailand. In Japan, there was a reference using dry cassava pulp pellets in the industrial ethanol plant for 2 years from 1985.

In this project, ethanol is produced on site at the starch factory to use highly wet cassava pulp. When highly wet cassava pulp after simple dewatering treatment is used as raw material in order to reduce excessive procedures and energy, mechanical trouble may be expected due to high fiber contents unique to cassava pulp and preliminary experiments were conducted in this regards.

As a result, a system configuration including introduction of pretreatment system which requires a little bit of further development (pilot operation research) and elimination of fiber after liquefaction-saccharification process, was selected as an improved conventional ethanol production method using cassava material

(5) Study on ethanol plant system

Design of ethanol production plant based on the result of (4) was conducted.

(6) Study on GHG reduction in the standard model plant

The study on the preconditions to calculate GHG reduction based on operating conditions through the year for ASC was conducted. In the case of ASC, it is supposed that methane gas production from cassava pulp occurs from the waste between April to October. According to AMS III.E. methodology, baseline emission is calculated as around 6,400t-Co2/y. CER is to be around 4,600t-CO2/y after deducting project emissions.

Although there is no approved methodology at the moment, GHG reduction for around 24,000t-CO2/y can be expected by ethanol as an alternative to gasoline.

(7) Study on Programmatic CDM to develop this project

The study of Programmatic CDM project nominating Thai Tapioca Starch Association (TTSA) as coordinator was conducted in order to develop this project as CDM in Thailand. Most of starch factories in Thailand join TTSA industrial association. Many of participants in the regular meeting of TTSA showed interests after hearing the presentation of the business scheme of this project.

(8) Trend of CDM projects by various countries in Thailand

13 CDM projects in Thailand have been approved by CDM Executive Board as of February 2009. About 90 projects have been uploaded for public comments. As for investors (credit buyer), 23 from Japan, 17 from Denmark, 14 from United Kingdom, as well as Switzerland and Germany have entered in business. After 2008, unilateral projects without indicating investor country increase its share and 19 projects have been uploaded for public comments.

As for CDM project types, majority is shared by biomass and biogas projects.

3. Business development of the project

(1) Project boundary and baseline

This is a Programmatic CDM project with the boundary of all areas of Thailand for cassava starch factories (about 70). Following is the explanation of specific CPA for “A Starch Company”. (hereinafter “ASC”), located in Nakhornratchasima province.

In this CPA. Ethanol is produced from cassava starch discharged from starch production process in ASC and methane gas production from cassava pulp during storage is mitigated. The boundary of CPA is the ethanol plant built within the facility of cassava starch factory and GHG emissions from the transporter trucks entering the premises.

GHG emission of baseline scenario is methane gas production from cassava pulp and emissions related to the transporting of cassava to the users before the project is implemented.

As far as emission related to transporting from ASC is concerned, it is not added to CER because project emission is far less than baseline emission from the conservative point of view although it was calculated.

For the methane gas production from cassava pulp which is the major objectives of GHG emission reduction, baseline emission is calculated for cassava pulp used for ethanol production for 5 months during wet season (April to October). Although methane gas production from cassava pulp is detected during the dry season, it is dried under the sun within 24 hours with only a slight methane generation.

Applicable methodology is AMS III.E. Avoidance of methane production from decay of biomass through controlled combustion, gasification or mechanical/thermal treatment / The latest version

(AMS III.E. avoidance of methane production from biomass fermentation by controlled incineration, gasification or mechanical processing, heat-treatment)

(2) Monitoring plan

*Baseline emission

It is the volume of methane emitted by fermentation of degradable organic carbons from cassava pulp and calculated as below:

$$BE_y = BE_{CH4,SS,y} – MD_{reg,y} * GWP_{CH4} \quad \text{(formula 1)}$$

Table1 Data parameters to calculate baseline emission

parameter	unit	explanation	remarks
BE_y	tCO_2e	Baseline emission of year y	Calculated by methodology
$BE_{CH4,SS,y}$	tCO_2e	Baseline emission due to fermentation of cassava pulp	Calculated by methodology
$MD_{reg,y}$	tCH_4	Methane destroyed or eliminated due to safety or other rules	Calculated by methodology
GWP_{CH4}	tCO_2e/tCH_4	Global warming factor of methane	21 IPCC default value

In Thailand, there is no regulation to force recovery of methane in the waste disposal facility. Therefore, there is no “Methane destroyed or eliminated due to safety or other rules”.

$$MD_{reg,y} = 0 \quad \text{(formula 2)}$$

Therefore baseline emission is calculated as below

$$BE_y = BE_{CH4,SS,y} \quad \text{(formula 3)}$$

$BE_{CH4,SS,y}$ methane production potential calculated by “Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site (Version 04)”

$$BE_{CH4,SS,y} = \varphi*(1-f)*GWP_{CH4}*(1-OX)*16/12*F*DOC_f*MCF*\Sigma W_x*DOC*e^{-k(y-x)}*(1-e^{-k}) \quad \text{(formula 4)}$$

Table 2 GHG calculation parameters for methane gas production from cassava pulp

parameter	unit	Explanation	remarks /specific value of project SWI
$BE_{CH4,SS,y}$	tCO_2e	Baseline emissions from the decay of cassava pulp	Calculated: 6,386
φ	−	Model correction factor to account for model uncertainties	0.9: Default value in the applied methodology
f	tCH_4	Fraction of methane captured at the disposal site and flared, combusted or used in another manner	0: Default value in the applied methodology
GWP_{CH4}	tCO_2e/ tCH_4	Global Warming Potential (GWP) of methane, valid for the relevant commitment period	21: Default value in the applied methodology
OX	−	Oxidation factor	0: Default value in the applied methodology
F	−	Fraction of methane in the disposal site gas (volume fraction)	0.5: Default value in the applied methodology
DOC_f	−	Fraction of degradable organic carbon (DOC) that can decompose	0.5: Default value in the applied methodology
MCF	−	Methane correction factor	0.28: Default value for stockpile
W_x	t/yr	Amount of cassava pulp prevented from disposal in the disposal site in the month x, dry basis	21,000 tons/year, 3,000 tons/month
DOC	−	Fraction of degradable organic carbon (by weight, dry basis) in cassava pulp	0.44: Pulp, paper and cardboard (other than sludge), Boreal and Temperate, Dry)) in the applied methodology)
k	−	Decay rate for cassava pulp	0.06: Default value for stockpile (Pulp, paper and cardboard (other than sludge), Boreal and Temperate, Dry)) in the applied methodology)
x		Month during a year: x runs from the first month of a year	x = 1) to the month y for which avoided emissions are calculated (x = y)

y		Month for which methane emissions are calculated	

●Project emission

$$PE_y = PE_{y,comb} + PE_{y,transp} + PE_{y,power} \qquad \text{(formula 5)}$$

Table 3 GHG calculation parameters for project emission

parameter	unit	explanation	remarks
PE_y	tCO_2e	Project activity direct emissions in the year y	Calculated : 1,737
$PE_{y,comb}$	tCO_2e	Emissions through combustion of non-biomass carbon of ethanol in the year y	0
$PE_{y,transp}$	tCO_2e	Emissions from incremental transportation in the year y	0
$PE_{y,power}$	tCO_2e	Emissions from electricity and diesel consumption in the year y	Calculated : 1,737

(3) GHG reductions

Table 4 shows estimated GHG emissions according to AMS III.E.

Table 4 Estimated emission reductions (during credit period)

Year	Estimated baseline emission (t-CO2e)	Estimated project emission (t-CO2e)	Estimated leakage (t-CO2e)	Estimated reductions (t-CO2e)
2012	6,386	1,737	0	4,649
2013	6,386	1,737	0	4,649
2014	6,386	1,737	0	4,649
2015	6,386	1,737	0	4,649
2016	6,386	1,737	0	4,649
2017	6,386	1,737	0	4,649
2018	6,386	1,737	0	4,649
2019	6,386	1,737	0	4,649
2020	6,386	1,737	0	4,649

2021	6,386	1,737	0	4,649
Total	63,860	17,370	0	46,490

(4) Project period, credit period

Credit starting date: 10 years from January 2012

Credit period: 30 years

(5) Environmental impacts, other indirect impacts

In this project, Environmental Impact Assessment (EIA) is not required as an ethanol plant is built in the existing starch factory.

Thai DNA – TGO requires IEE (Initial Environmental Evaluation) and SDC (Sustainable Development Criteria). There is no negative impact to environment because methane gas and odor are mitigated by the effective use of cassava pilp in this project.

(6) Stakeholders comments

Interview with the buyer of cassava pulp

Many of feedstuff factories in Thailand produce pellet type feedstuff made from cassava tips and cassava pulp. Although cassava pulp is cheap, it is used as supplement to cassava tips and no influence is expected if less cassava pulp is available.

Interview with 2 existing ethanol plants

They showed great interests in the distillation business of 75% ethanol in this project and expressed anticipations for early start of the project.

(7) Project implementation scheme

Figure 1 shows project implementation scheme

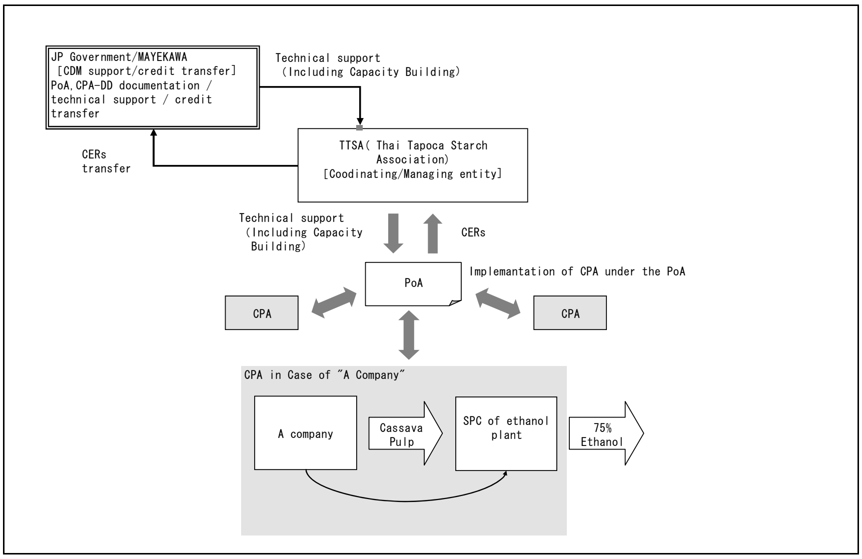

Figure 1　Project implementation scheme

(8) Financial scheme

This project requires initial investment cost for 833,000,000 Yen. As for financing, 50% from own capital and 50% from bank loans.

(9) Economical analysis

・Investment amount

Table 5 Initial Investments

Ietm	Qty	Amount (millionYen))
1.Pretreatment process	1 lot	260
2.Liquefaction, Saccharification	1lot	111
3.Fermentation	1lot	82
4.Distillation	1lot	48
5.Civil, utilities	1lot	256
6.Miscellaneous expenses	1lot	76
Total		833

・ IRR analysis

Table 6 show Internal Rate of Revenue (IRR) with assumptions for various factors.

Table 6 Project IRR

	CER=0Yen	CER=1000Yen	CER=2000Yen
IRR	14.07%	14.79%	15.49%

(10) Justification of Additionality

*Investment barriers

Ethanol plant requires large amount of investment. Ethanol production from cassava pulp will be considerably smaller at around 30kL/day than general ethanol plants in Thailand (150kL/day). Due to the small scale, return from the business is extremely low. On the other hand, the baseline scenario requires no investment or running cost because cassava pulp is stored in the field during the wet season.

Thus, this CPA project will not be realized without the revenue from CER.

*Technology barrier

There is not reference of producing ethanol from cassava pulp in Thailand. In other countries, cassava chips are

used as supplemental material for ethanol production in China but no reference of ethanol production using cassava pulp. Cassava pulp contains more fiber than cassava chips or fresh cassava (roots) and more difficult to produce ethanol. Therefore, there is a high technology barrier.
However, in Japan, there is a reference for commercial operation of producing ethanol from cassava pulp materials and technologies to overcome such problems related to the raw material has been developed. The CPA requires technical assistance from Japan. CDM will help CPA to acquire technical assistance to overcome barriers.

(11) Business development and issues
Based on the feasibility study from August 2008 to February 2009, the discussion will be continued with Thai Tapioca Starch Association (TTSA) and cassava starch companies to develop Programmatic CDM by solving issues related to realization of CDM project.
The discussion will be continued with Thai stakeholders for the future development.

Acquisition of CER: <A is a faster track> A. Avoidance of methane gas only according to the existing methodology AMS III.E. （CER per 1 factory, 1 CPA: less than 10,000t-CO2/y） B. Apply a new methodology for fuel alternative effect of bio ethanol （CER Per 1 factory: 20,000 to 40,000 ｔ－CO2/ｙ. Approval of new methodology may take one and half year）
PoA or individual CDM for the first ethanol production A. First project as individual CDM, PoA after 2nd project. B. PoA for all projects including the first project.（due to no preceding PoA project and it may take more time to obtain project approval before coordinating each companies and DNAy who have limited knowledge）
Limited to cassava pulp or not A. Limited to cassava pulp B. Include cassava chips or fresh cassava roots as adjacent material depending on the market trend

The stakeholders in Thailand and Japanese companies interested in ethanol business and CDM project showed great interests in the project of “ethanol production from agricultural waste and CDM” in this research. It is our intention to develop CDM projects as early as possible based on the information obtained through this research.

4. Realization of Co-benefit in the host country
(1) Evaluation of environmental protection in the host country
By implementing this project, odor caused by cassava pulp will be mitigated. A benchmark should be developed to measure and evaluate. Odor is difficult to make benchmark and continuous measurement is also difficult. Therefore, at the moment, it is recommended to check number of complains in a year from local residents.

(2) Proposal for establishing benchmark of co-benefit (provided result of research in this regard is

available)
After implementing this project, methane gas production and odor from cassava pulp during storage will be mitigated. The amount of avoidance of methane gas production is calculated in a conservative way according to AMS.III.E. However, it is possible to calculate amount of avoidance of production of other gasses based on the “baseline emissions”.

Fig.2 Location of Nakhon Ratchasima province


Pic.1 Cassava field


Pic.2 Collection of cassava roots


Pic.3 Cassava pulp (80％ water)

Pic.4 Storage area for cassava pulp
（methane gas production detected）

Pic.5 Unloading cassava pulp

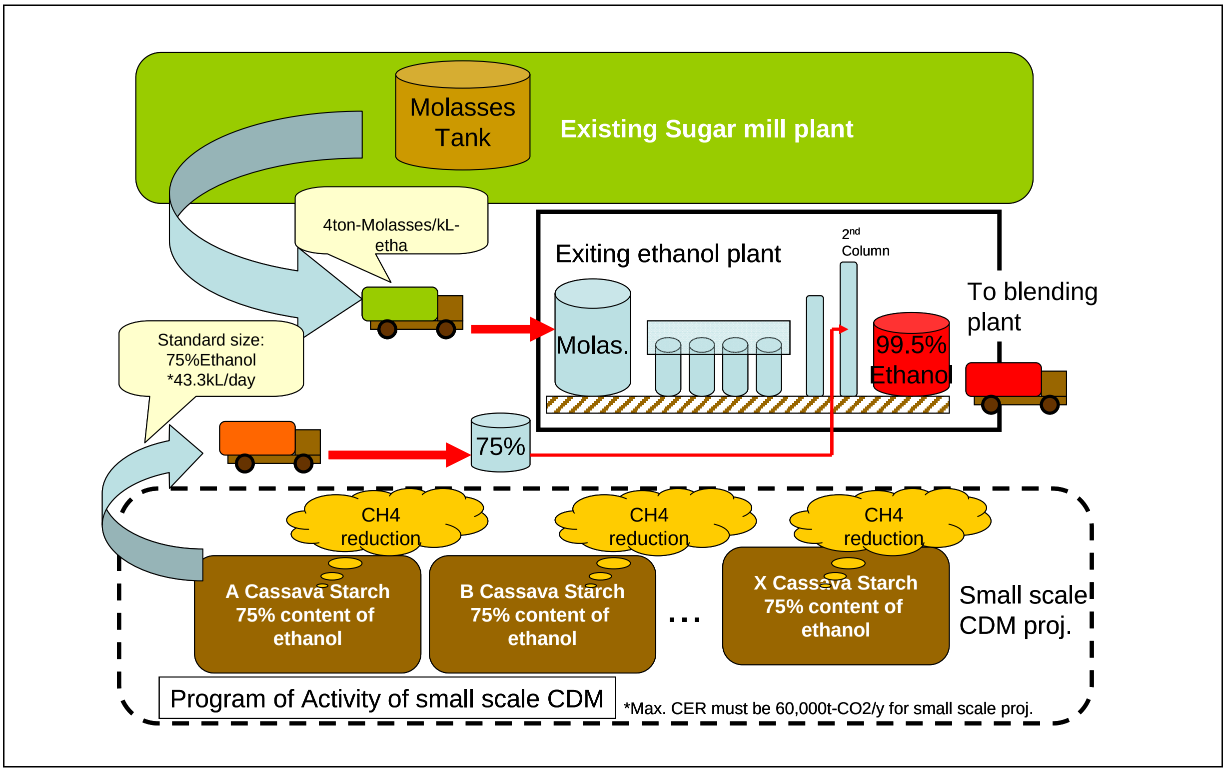

Fig.3 Images of entire project scheme

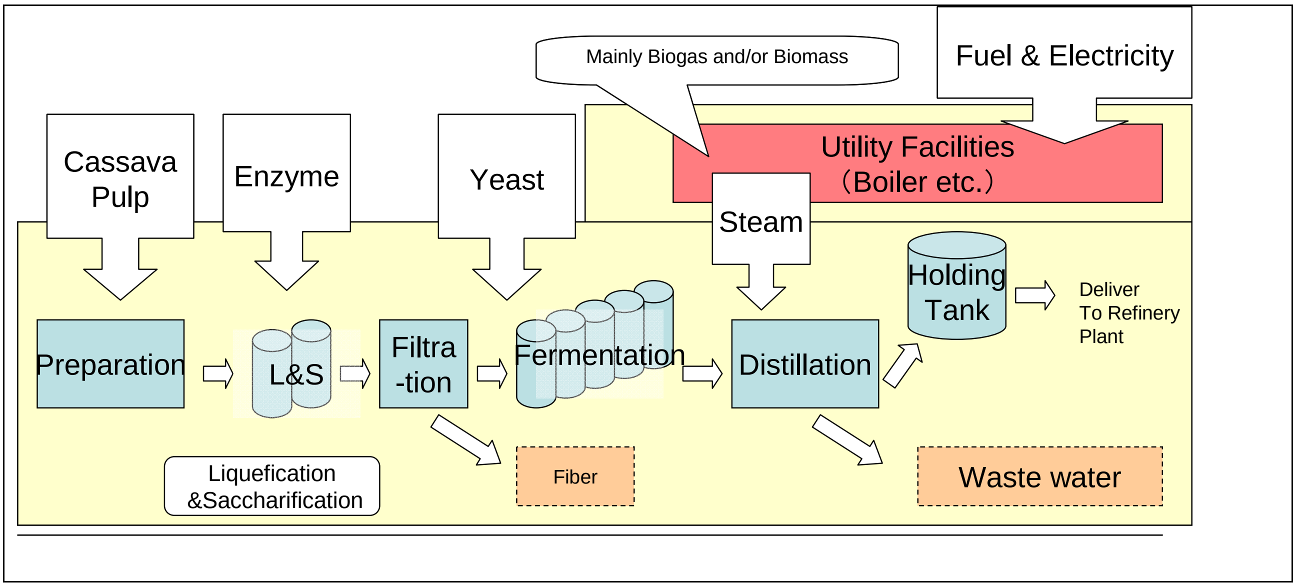

Fig.4 Outline of ethanol production plant

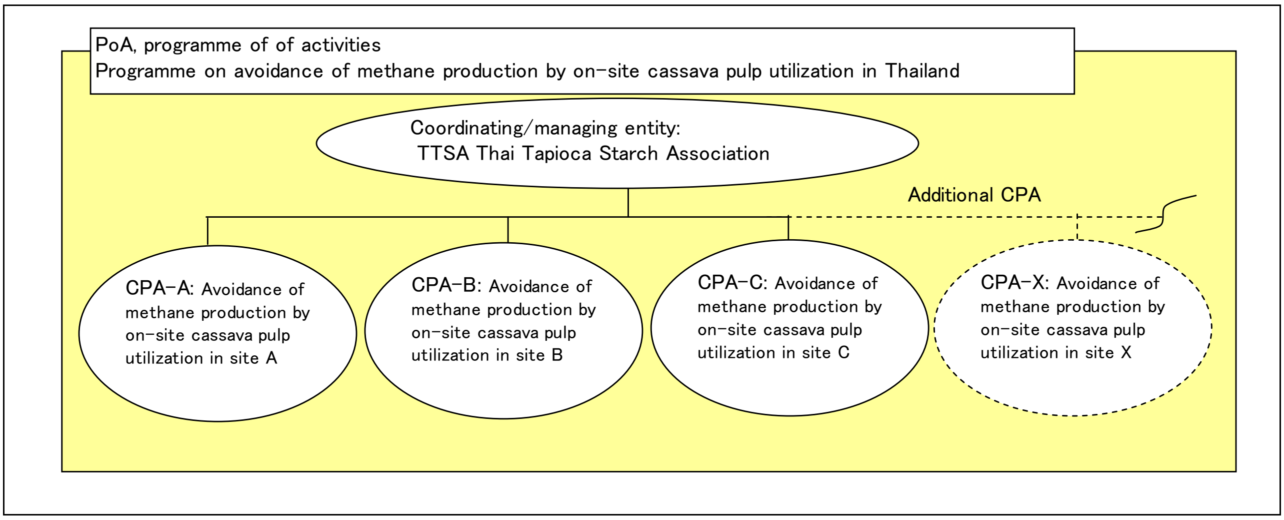

Fig.5 Image of PoA scheme