Digital Asia Discussion Paper Series

DP 07-004

An Introduction of Bio-Ethanol to Thai Economy (II)
– A Survey on Sugarcane and Cassava Processing Factories –

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March 2007

Academic Frontier Project
"Digital Asia Building: Regional Strategy Design Platform"
Digital Asia Regional Strategy Research Center

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Content

1. Introduction

After the cabinet resolved in 2003 to include bio-ethanol as renewable energy for Thailand's sustainable energy development strategy, ethanol has been highly promoted through both demand and supply sides.

A plant that would like to produce anhydrous alcohol for use as fuel must get permission from the National Ethanol Committee. So far there are 45 plants that have received the permission. Yet there are only 6 plants that have started operation as listed in Table 1.1.

Table 1.1 List of Fuel Ethanol Plants Currently on Operation in Thailand

Updated on 26 January 2007

Ethanol Plant Name	Province	Raw Material	Production Capacity (liter/day)	Commencing Date
1. Pornwilai International Group Trading Co., Ltd.	Ayuthaya	Molasses	25,000	October 2003
2. Thai Alcohol Pub., Ltd.	Nakhon Pathom	Molasses	200,000	August 2004
3. Thai Agro and Energy Co., Ltd.	Suphanburi	Molasses	150,000	January 2005
4. Thai Nguan Ethanol Co., Ltd.	Khon Kaen	Cassava	130,000	January 2006
5. Khon Kaen Alcohol Co., Ltd.	Khon Kaen	Cane/ Molasses	150,000	January 2006
6. Petrogreen Co., Ltd.	Chaiyaphum	Cane/ Molasses	200,000	December 2006

Source: Department of Alternative Energy Development and Efficiency (DEDE), Thailand

Among them there exists only one plant that uses fresh cassava roots as a raw material, Thai Nguan Ethanol in Khon Kaen. We planned to visit the plant but due to its technical and environmental problems we could not have a chance to visit or even interview. According to EPPO[1]'s fuel ethanol plant visit report, Thai Nguan Ethanol faced a problem of high temperature in the production system two months after starting operation, which caused the plant to stop operation temporarily. The plant uses ethanol production technology from China where cassava chips are used as a raw

[1] EPPO stands for the Energy Policy and Planning Office, Ministry of Energy, Thailand.

material. Thus, the technical problem occurring might be due to the use of fresh cassava instead of cassava chips. Besides, it also has improper waste treatment and raw material purchase problem. It sets a high purchasing price but with starch percentage at 32% despite the fact that chip factories' standard is between 25% and 30% (EPPO, interview). Farmers who find the condition of the chip factories better, they don't sell their roots to Thai Nguan. The plant thus has difficulties in raw material procurement.

The rest five plants consist of three plants that use molasses and the other two use both cane juice and molasses. The latter two plants are the plants that are expanded from sugar factory, Khon Kaen Alcohol and Petrogreen, where we visited.

"An Introduction of Bio-Ethanol to Thai Economy (II) – A Survey on Sugarcane and Cassava Processing Factories" is a second report following the first one "An Introduction of Bio-Ethanol to Thai Economy (I) – A Survey on Sugarcane and Cassava Fields". This report not only focuses on a survey on a bio-ethanol plant but also a sugar factory, which provides cane juice and molasses, current raw material for ethanol production, as well as, a cassava chip factory and a cassava starch factory, producing cassava products, which can be alternatively used as raw material for ethanol production as well.

2. Sugarcane-based sugar factory

2.1 Mitr Phol Cane Complex

Mitr Phu Khieo Sugar Mill we visited this time belongs to the Mitr Phol Sugar Group, the largest sugar company in Thailand. Mitr Phol Sugar Group has 5 sugar mills with the total production capacity of 1 million tons. Mitr Phu Khieo Sugar Mill and the factories that use by-products from sugar production, including recently constructed ethanol plant were built in the form of complex, called "Mitr Phol Park".

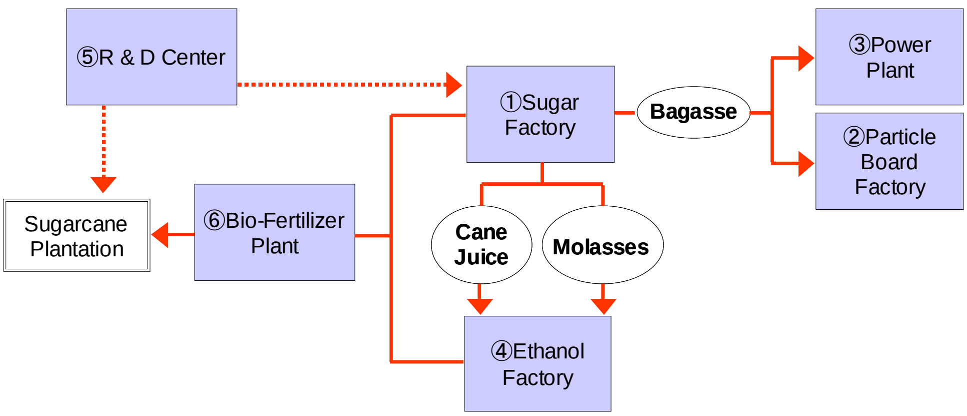


Diagram 2.1 Cane Complex Structure

The complex consists of the following factories.

1. Mitr Phu Khieo Sugar Factory
2. MP Particle Board (using bagasse as raw material)
3. Phu Khieo Bio Energy (using bagasse and cane leaves to generate electricity)
4. Petrogreen (ethanol plant)
5. MP Sugarcane R&D Center
6. Bio-fertilizer plant

The sugar factory is a center of the complex. Bagasse and cane leaves left from the sugar factory are raw materials for both the MP particle board factory and the bio-energy plant (electricity generation). Also, the ethanol plant uses cane juice and molasses from the sugar factory. Waste left from the sugar factory and ethanol plant is used to produce bio-fertilizer, which will be sold to sugarcane fields under the sugar factory's contract.

2.1.1 Mitr Phu Khieo Sugar Factory

Mitr Phu Khieo Sugar Factory has a large production scale with almost 3 million tons of sugarcane crushed each year. This year (2006/2007) cane crushing target is 2.7 million ton. On average Mitr Phu Khieo operates its sugar mill 300 days a year, in which 120 days are sugarcane crushing period (December to March). During the crushing period it produces raw sugar around 50% of the total production and the left 50 % is white and refined sugar. Then the remaining 180 days are re-melting period, the period that re-melts raw sugar produced in the crushing period to produce white or refined sugar for sale during the left time of the year.

Sugar products of Mitr Phu Khieo are super refined sugar, refined sugar, white sugar and raw sugar. Those sugar types differ in color (IU), moisture (%), polarization value (%) and size (mm). For example, super refined sugar has color number at most 20 IU, moisture at most 0.04% and polarization value at least 99.90%

On average 1 ton of sugarcane can produce 105 kg of sugar (no matter it is raw sugar or refined sugar). This year the target is 115 kg/ton-cane. 25,500 ton of crushed cane per day can produce 1,500 tons of refined sugar and 1,450 tons of raw sugar. The whole Mitr Phol Group's daily crushed cane amount is 113,000 ton-cane in which 5,100 ton of refined sugar and 7,550 ton of raw sugar are produced.

Picture 2.1 Mitr Phu Khieo Sugar Factory

98% of sugarcane planting farmers under Mitr Phu Khieo's contract use human labor in cane cutting, the left 2% using machine. Mitr Phu Khieo thinks that, rather than large-scale, small scale farming is more sustainable for Thai economy. Consequently, most of sugarcane fields under its contract are small-scale. Due to small-scale production, farmers don't have their own truck, but E-Taen, small 4-wheel truck. The company has therefore set a depot for farmers who are far from the mill to transport canes to the depot. Then the company will convey canes to the mill itself. 24% of total farmers use this service, whereas the left 76% transport their canes directly to the mill.

The company puts a lot of effort to communicate with farmers to avoid burning canes when harvesting. Mitr Phu Khieo's burnt cane percentage is low, around 15%, whereas that of Khon Kaen Sugar is more than 70% and that of central region is around 50 – 60%. But at the time we visited it was nearly the end of crushing period so farmers rushed to harvest plus a labor shortage problem in the region, resulting in a higher percentage of burnt cane, 29%, in daily based data (March 20).

As for employment aspect, Mitr Phu Khieo employs 300 regular workers and 450 day-basis workers. A minimum day wage rate is 150 baht.

Picture 2.2 Trucks Transporting Sugarcane to the Sugar Factory

Mitr Phu Khieo's sugar production process is as in Diagram 2.2. First, it is to cut sugarcane stems by cutters and make them smaller by shredders (1.Cutting and 2.Shredding). Then, it is to mill shredded cane by sprinkling water (to make it easy for juice extraction) on the shredded cane passing the milling machines. At this stage you will get mixed juice (3.Milling, Picture 2.3). Bagasse left from the milling machines is used as fuel to generate electricity. A next step is to add lime to the mixed juice in order to precipitate an undesired solid substance out (4.Clarification). Precipitated mud is put through the filter and what is left from the filter is called "filter cake". This filter cake will be used to produce compost for sugarcane fields. Clarified juice is then put in the evaporator to concentrate and get syrup (5.Evaporation). Syrup is then put in the crystallizer to form crystals (6.Crystallization). Apart from crystals, what is left in the crystallizer is called "molasses," uncompleted crystallized dark-color syrup. Lastly, sugar crystals will be put in the centrifuge to separate molasses from the crystals again in order to make the color lighter (7.Centrifugation). These sugar crystals are called "raw sugar" or Sugar A.

Sugar A will be used to produce refined sugar immediately or kept in the silo waiting for the refinement later. Molasses left from crystallization process will be used to produce Sugar B and Sugar C. The molasses left after producing Sugar C is called "final molasses". There are 2 – 2.5 million tons of molasses each year, normally sold to domestic market such as liquor, food, feed industries for 1 – 1.5 million tons and exported for 1 million tons. Recently, a part of final molasses is used to produce fuel ethanol.

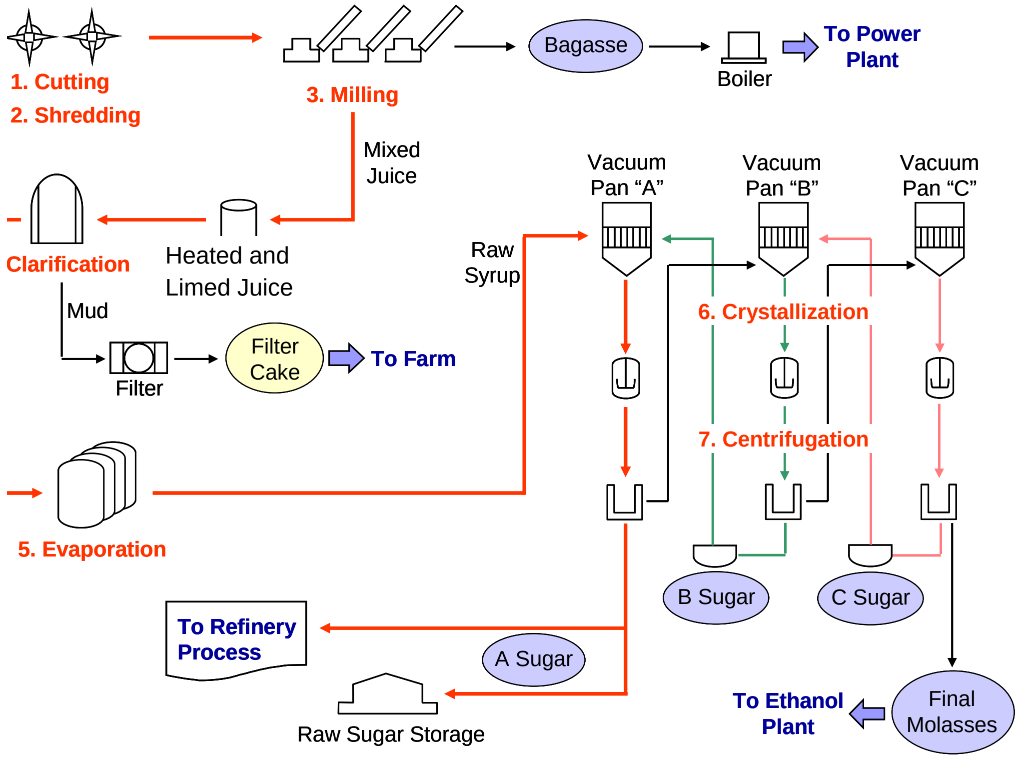


Diagram 2.2 Raw Sugar Production Process

Picture 2.3 Milling Machine

Picture 2.4 Sugar Silo

Raw sugar or sugar A is then used to produce refined sugar (Diagram 2.3). First is to melt raw sugar by hot water (1.Melting). Milk of lime and CO_2 are added to precipitate out an undesired substance (2.Carbonation), which will be then filtered to set aside the substance (3.Filtration). Next, with the ion exchange resin the syrup's color will become white (4.Decolorization). After this step, refined sugar production process is as same as that of raw sugar production process; that is evaporation crystallization and centrifugation (process 5 – 7). Then, sugar crystals will be dried up and cooled down prior to packaging and transportation.

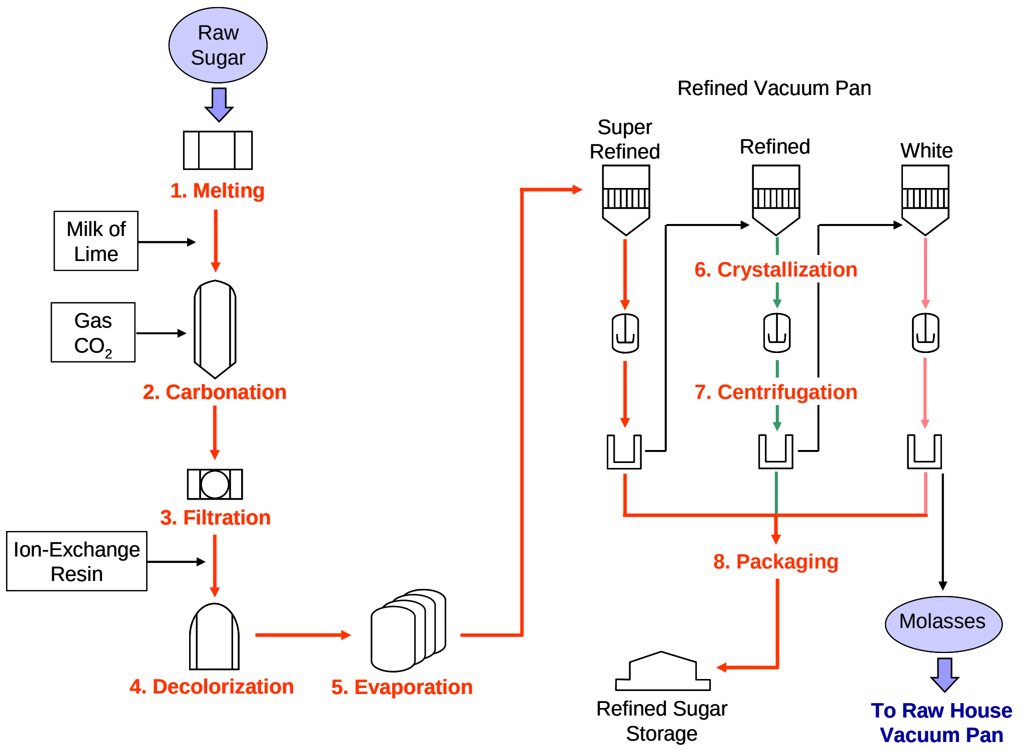


Diagram 2.3 Refined Sugar Production Process

Picture 2.5 Refined Sugar Packages

2.1.2 MP Particle Board Plant

MP Particle Board Plant uses bagasse from the sugar factory as a raw material. Mostly the particle board is used to produce furniture. MP Particle Board's production is about 100,000 m^3 yearly.

2.1.3 Phu Khieo Bio-Energy Plant

Apart from being used in the particle board factory, bagasse is also used to generate electricity to supply to the factory itself and sell the left to EGAT (Electricity Generation Authority of Thailand). The plant not only uses bagasse but also cane leaves, rice husk and corn stalk as raw materials to generate electricity. The total capacity is 41 MW, 6 MW used in the sugar mill, 2 MW used in the particle board factory, 4 MW used in the office and the rest of 29 MW sold to EGAT.

Picture 2.6 Bagasse Kept for Production in the MP Particle Board Factory

2.1.4 Bio-Ethanol Plant

Petrogreen, Mitr Phol Sugar Group's ethanol plant has production capacity of 200,000 liters a day. Its ethanol product is anhydrous ethanol with 99.8 – 99.9% alcohol, while standard ethanol for blending with gasoline is 99.5% alcohol. Petrogreen bought ethanol producing technology from Maguin, France. Less than 60 employees work in 3 shifts all day.

In terms of raw materials, during the crushing period, Petrogreen uses clarified cane juice[2] from Mitr Phu Khieo sugar mill. To produce 200,000 liters of ethanol, 2,500 ton of juice is needed. Over the re-melting period, molasses is used. For full capacity production 760 ton of molasses is required each day. Molasses is a by-product from sugar production and can be kept long for years. Thus, it has no

[2] Basically the 70:30 benefit allocations according the Cane and Sugar Act 1984 do not allow use of juice to produce products other than sugar and its by-product, molasses. Mitr Phol however succeeded in negotiation with its own farmers and can use juice to produce ethanol.

problems with the raw material procurement for the whole year. Petrogreen itself has raw material storage space as following, 4,000 m^3 molasses tank and 700 m^3 juice tank. Nevertheless, Mitr Phu Khieo in the same complex has 12 molasses tanks with total storage capacity of 100,000 ton. Therefore, Petrogreen does not need a large raw material storage space. This is one advantage for an ethanol plant built in the same complex with a sugar factory.

Picture 2.7 Petrogreen, Bio-Ethanol Plant

Picture 2.8 Cane Juice and Molasses Storage Space

Ethanol production process is as follows, yeast propagation, fermentation, distillation and dehydration processes.

1. Yeast propagation

Yeast propagation is the process to culture yeast and increase its number to the amount needed for the fermentation process. Petrogreen has two yeast culture tanks.

2. Fermentation

Fermentation is to add yeast to cane juice or molasses in order to change sugar to alcohol. Clarified juice has pH value of 6 – 7. It must be adjusted to 4.2 – 4.5 before fermentation. Molasses' pH value is just perfect but before fermentation it must be diluted with three times the amount of water. Then, it is to ferment juice or molasses with yeast for 16 hours in case of juice and for 30 hours in case of molasses by using continuous 6 fermenting tanks. The temperature that yeast works well is around 33 °c. During fermentation the temperature increases; therefore, soft water is used to cool down the system's temperature. The reason why not use water supply is that water supply might contain unpurified substance, which probably clogs the pipe.

There is a great deal of CO_2 released from the fermentation process. When the CO_2 release stops, it means the fermentation finishes. Actually CO_2 can be collected and sold to carbonated beverage industry, extinguisher liquid industry or other chemical industries. Petrogreen does not collect CO_2 released because the amount CO_2 is not yet as much as enough to pay back the facility installation. Besides CO2, another by-product is fusel oil. Fusel oil can be used as fuel by blending with kerosene and also used as an emulsifier in the perfume industry. Ethanol production in case of using molasses as a raw material generates 100 liter of fusel oil. In case of cane juice, a little bit more fusel oil is produced.

After mash is fully fermented, the fermented mash is now called "beer" and contains around 9 – 10% alcohol.

3. Distillation

Next, the beer will be pumped to the distillation system in which we will get 93 – 95% alcohol at this stage. After distillation, only 8% out of the fermented mash becomes ethanol, whereas the left 92% is waste water.

4. Dehydration

The last step is called dehydration in which the remaining water will be removed. Two dehydration columns are operated in rotation every 10 -15 minutes.

Alcohol after being dehydrated is called anhydrous ethanol with at least 99.5% alcohol. According to the talk with plant staff, he said this plant used a high dehydration technology in which an amount of ethanol after dehydration does not decrease compared to other plants' technology.

Petrogreen has two 250m³ and two 1,250m³ ethanol storage tanks accounting for the storage space of 3 million liters or equal to 15-day produced ethanol amount. Because ethanol can be consumed as liquor, the law requires that ethanol be denatured with a small amount of gasoline (0.5%) before leaving the plant. As for transport, gasoline companies such as PTT, Bangcak, Shell, Esso and Cartex will send their own Lorries to receive ethanol from the plant and pay ethanol price by subtracting transport cost from the previously set Bangkok ethanol price. The plant far from Bangkok is disadvantageous.

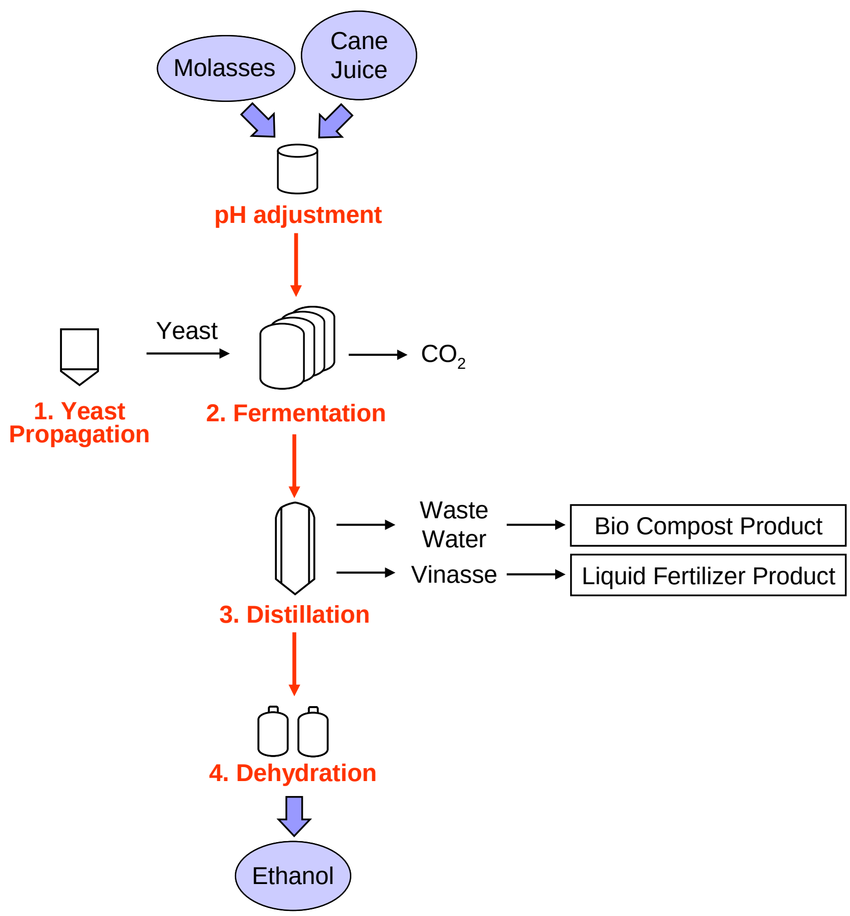


Diagram 2.4 Ethanol Production Process

Petrogreen's plant manager mentioned about three factors important to ethanol plant management.

1. Raw material procurement: good quality, cheap price and constant supply. This is essential because raw material cost is about 70 – 75% of the total cost.

2. Environmental problems: smell and water waste management

3. Power supply: If an ethanol plant is expanded from a sugar factory, electricity and steam left from use in the sugar factory can be used in the ethanol plant. This helps save much cost. There are some plants using coal to generate electricity. This causes acid rain, which affects people in the neighboring area. There was a case of demonstration against the plant operation.

2.1.5 MP Sugarcane R&D Center

The center has conducted researches on sugarcane cultivation such as proper fertilization and weeding method, productivity raising, cost reduction, disease prevention, and new breed development.

2.1.6 Bio-fertilizer plant

During the distillation process there are two types of waste water released. First is called "process condensate", contaminated stream after used to heat the distillation columns. If raw material is molasses, 960 m^3 of process condensate is released a day. If juice, 1,680 m^3 a day. Process condensate after treated in waste water treatment system will be sent to sugarcane farmers under its contract to water the cane. Actually, the plant has planed to mix process condensate with filter cake from the sugar production process to produce bio-compost in the near future.

The other one is called "vinasses", waste water left in the distillation columns. In case of molasses there is vinasses left 900ton/day, while that of cane juice is 250 ton/day. Actually the amount of vinasses first released from the distillation columns is three times as much as mentioned above or about 10 -15 times an amount of ethanol produced but it must be dehydrated to reduce the volume. Besides, it has high BOD and COD about 45,000 and 100,000 ml/liter, respectively (Sriroth, K. et al., 2006). Vinasses' pH value must be adjusted so that it has pH value of 4 before selling to sugarcane farmers at 800 baht/ton with free delivery service if within 20 – 30 meter distance. Until now about 200,000 ton of vinasses have been used in more than 300,000 rai of sugarcane fields.

2.2 Khon Kaen Sugar Cane Complex

2.2.1 Khon Kaen Sugar Factory

Khon Kaen Sugar Industry Public Co., Ltd. was founded in 1976 and became a public company in 2005, the first sugar company that became a public company. Khon Kaen Sugar is one of the four sugar mills of Kwang Soon Lee (KSL) Group with crushing capacity of 26,000 ton cane per day.

Like Mitr Phu Khieo, Khon Kaen Sugar's plant operation days are 300 days in which 120 days are the crushing period and 180 days are the re-melting period. During the crushing period, the total 9 "Sugar A" producing machines are fully run; whereas, in the re-melting period only 3 machines are used. Machines for producing Sugar B and C are fully operated over the year.

One-day cane crushing amount is 25,000 tons, which can produce 760 tons of raw sugar, 600 tons of Hi-Pol sugar, 800 tons of refined sugar and 700 tons of white sugar. Annual cane crushing amount is 2.7 million tons, which can produce 230,000 tons of sugar (no matter it is raw sugar or refined sugar). As for the whole KSL group, daily cane crushing amount is 67,000 tons in which 450,000 tons of sugar (raw sugar + refined sugar) is produced.

Picture 2.9 Khon Kaen Sugar Factory

Picture 2.10 Final Molasses

Picture 2.11 Sugarcane Put into the Crusher

Picture 2.12 Sugar Packages Being Prepared for Transportation

2.2.2 Biomass power plant

Approved as a CDM project recently this year (2007), Khon Kaen Sugar Power Plant Co., Ltd. uses bagasse as a main raw material to generate electricity with cooperation from Agrinergy Ltd., an English CDM project developer. Its electricity generation capacity is 30 MW in which 20 MW is sold to EGAT (Electricity Generating Authority of Thailand); while another 5 MW is self – consumed in the plant and the other 5 MW is sold to other factories in the same business group, KSL group.

20 MW x 300 days x 24 hrs equal to 144,000 MWh is an electricity amount sold to EGAT per year. This is basically what to be concerned as CDM activities. Nevertheless, according to its Project Design Document (PDD), only 116,768 MWh is counted. An amount of CO_2 reduced from this project is 62,529 t-CO_2 /year. Transport of raw material other than bagasse, however, causes CO_2 release of 1,080 t-CO_2. As a result, an amount of 61,499 t-CO_2 is accepted in Certified Emission Reduction Certificate (CER).

2.2.3 Bio-ethanol plant

Khon Kaen Alcohol started its operation in January 2006 with alcohol production capacity of 150,000 liter per day. Khon Kaen Alcohol uses anhydrous alcohol technology from Praj, India. More than 200 plants around the world use Praj Industires' technology. Praj's yield guarantee is 260 liters of anhydrous alcohol per ton molasses but the plant can produce alcohol up to 280 liters per ton molasses. Anhydrous alcohol produced contains 99.8% alcohol.

Raw material is molasses. Cane juice is currently not used in alcohol production in this plant because the sugar price is still high and use of cane juice to produce other products that are not stated in the benefit allocation in the Cane and Sugar Act 1984 must be accepted by farmers first. Nevertheless, the plant is thinking to use wet cake from cassava starch production process as a supplementary raw material in the future as well.

Picture 2.13 Khon Kaen Alcohol Plant

2.2.4 Bio-fertilizer plant

This plant uses filter cake left from juice purification stage in sugar production process, ash from power plant, and spent wash or vinasses from distillation process in the ethanol production to produce fertilizer. Annual production is 100,000 tons. The products are both for sale and for giving away to sugarcane farmers.

Picture 2.14 Waste Water and Bio-Fertilizer

3. Cassava processing factory

As mentioned before cassava roots are sold to three factories, a chip factory, a pellet factory and a starch factory. An ethanol factory will probably be a new market for cassava roots.

3.1 Cassava chip factory

Most of cassava chip factories are small – scale and located near by cassava fields. The factory is actually a concrete ground using very simple technology. It is only to chop cassava roots into small size and sundry them. Most of dry chips had been processed to pellets at the pellet factory before a sharp decline in pellet export. Recently dry chips are directly exported especially to China.

3.1.1 Cassava chip processing method

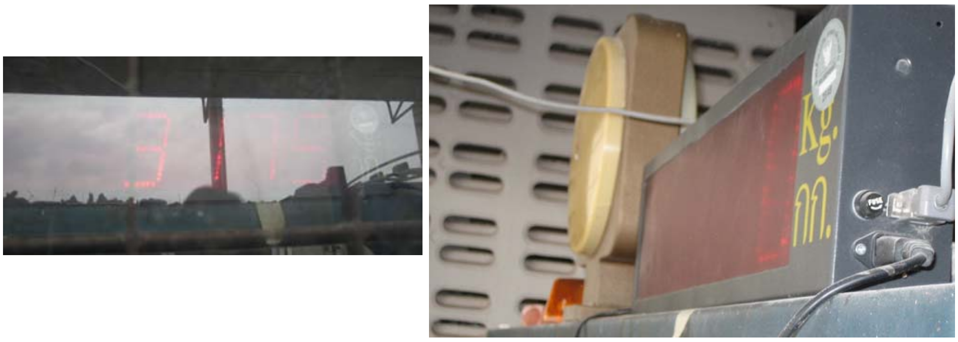
1. Weighing

Fresh cassava roots after being harvested will be immediately transported to the chip factory because starch part in the roots naturally reduces after harvest.

Picture 3.1 Cassava Roots Transported to the Chip Factory

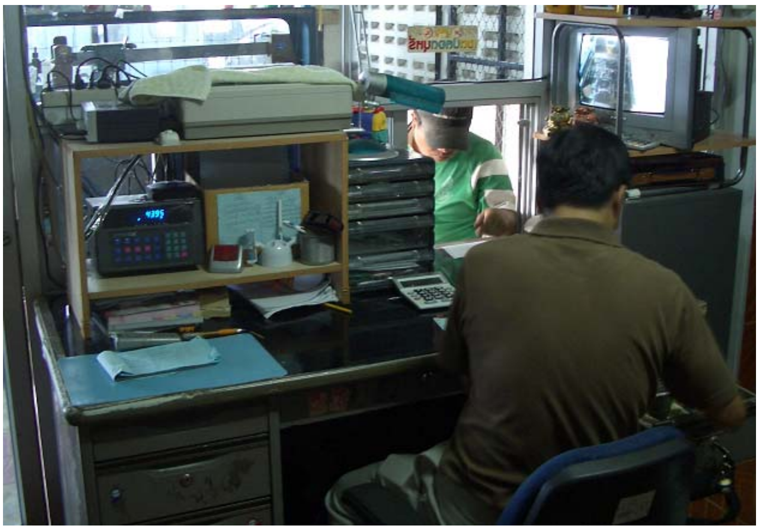
After transporting fresh cassava roots to the factory, a farmer will stop the truck on the steel plate in which a scale is set underground as in Picture 3.2. The weight of the truck with roots will be shown on the digital screen (Picture 3.3), which connects with the scale by the computerized system.

Picture 3.2 Underground-Set Scale.

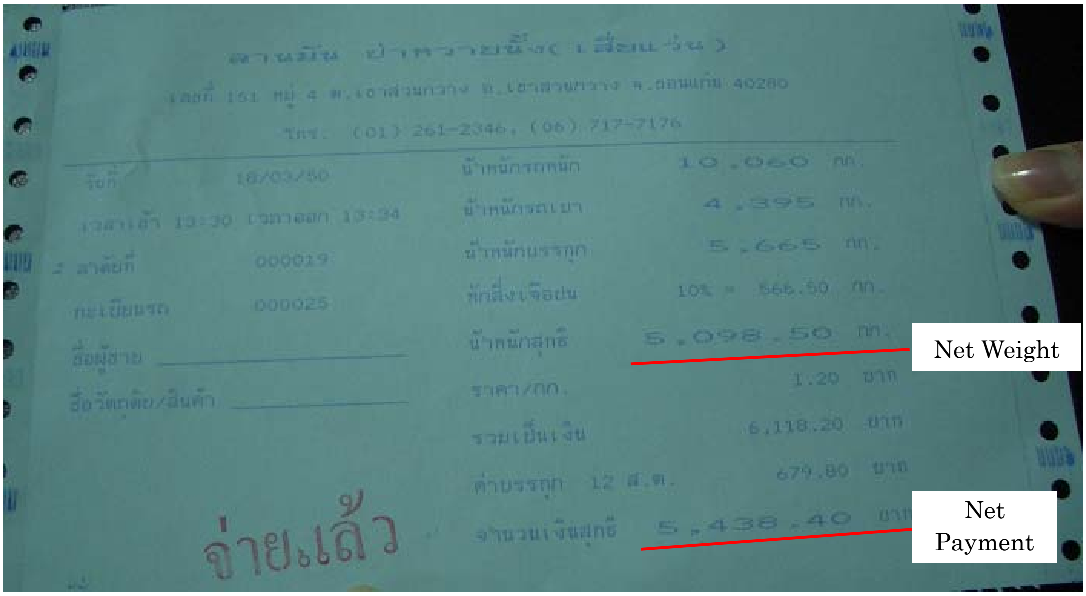


Picture 3.3 The weight is expressed in a digital system.

Then, the farmer will unload the roots from the truck and weigh only his truck to get the truck's weight. The truck's weight will be subtracted from the weight of the whole truck with roots to get the weight of roots only. The farmer will be paid in cash immediately (Picture 3.4) and gets a receipt (Picture 3.5).



Picture 3.4 when cassava roots' cost was paid
(At front is the chip factory's owner and behind is a cassava farmer.)



Picture 3.5 Receipt with Purchase Details

Details in the receipt are as follows. The left hand side displays a purchase date and time. The right hand side displays weight, a purchasing price and an amount of payment. As displayed in the receipt example, gross weight (trucks with roots) is 10,060 kg, then subtracted by the only truck's weight of 4,395 kg; the left is roots' weight of 5,665 kg. Noting that there has been a custom in the northeastern region that 10% of fresh cassava roots' weight will be deducted due to residues such as soil stuck to the roots, net roots' weight in this case is 5,098.5 kg.

With the purchasing price of 1.2 baht/kg, 6,118.20 baht will be paid to the farmer. Nevertheless, the farmer in this example bought diesel 679.80 baht, which is also sold at the factory, so the net amount that the farmer receives is 5,438.40 baht.

The scale was set 10 years ago. The scale cost 180,000 baht with construction cost of 120,000 baht, totally 300,000 baht. The computerized scale system was 50,000 baht.

2. Sand removal and chopping

After weighed, cassava roots will be pilled up on the ground (Picture 3.6). Next step is to put fresh roots in a sieve on the chopping machine (Picture 3.6) to set aside undesired residues without washing or peeling the skin. Then the roots will be automatically put to the chopping machine with rolling blades and the roots will be cut in 5 cm size. In summer when there is not much soil stuck with the roots, without sieving the roots will be directly loaded into the chopping machine. A new chopping machine with a sieve may cost around 120,000 – 150,000 baht.

Picture 3.6 Piled-Up Cassava

Picture 3.7 Chopping Machine with a Sieve on the Top

Picture 3.8 Chopping Machine's Blades

Picture 3.9 Chopped Cassavas

3. Sun drying

Chopped cassava will be placed on the ground by a feeding car (Picture 3.10) and left for sun dry for one day. There is no engine in the feeding car but only a feeder (Picture 3.11). The feeding car will be connected with and dragged by a bulldozer (Picture 3.12) when feeding chopped cassava on the ground.

Picture 3.10 Feeding Car

Picture 3.11 Feeder

Picture 3.12 Japan-Made Bulldozer

During the day chopped cassava will be turned around many times so that all surfaces of each cassava piece will face the sunshine. Then they will be moved to another ground. This will be repeated totally 3 times (3 grounds) a day. With strong sunshine the chips will be completely dry in one day.

Picture 3.13 Sun Drying the Chopped Cassava

After sun drying, dried cassava chips will be collected by the bulldozer with a long hand (Picture 3.14). The leftover after sun drying in form of dust, which can be mixed into dried cassava chips for sale, will be collected by a sucking machine (Picture 3.16).

Picture 3.14 Dry Chip Collecting Hand

Picture 3.15 Attaching a Dried Chip Collecting Hand to the Bulldozer

Picture 3.16 Cassava Dust Sucking Machine

On the day we visited, it was going to rain; workers therefore had to collect the chips, pile them up as a mountain, and cover the pile with vinyl cloth (Picture 3.17). Otherwise, the chips will get wet and starch part will be washed away.

Picture 3.17 Piling and covering dried chips with vinyl cloth to protect them from rain

4. Transport

Starch part in cassava roots easily reduces naturally after harvest. Within 3 days after sun-drying cassava chips must therefore be transported.

3.1.2 Cassava chip plant management

Fresh root purchase

In general Khon Kaen can produce cassava roots for the whole year. Therefore, an amount of roots sold to the chip factory is stabilized except for December when a harvest period of sugarcane peaks so almost workers are hired to harvest sugarcane, no enough labor left to harvest cassava roots. Thus, an amount of fresh roots sold to the factory in December is relatively small.

There are basically 3 methods a farmer carries fresh roots to the chip factory.

1. Use of his own truck
2. Truck rental
3. Letting someone to harvest, transport and sell roots and receiving a lump sum amount of money instead

Use of method 1 and 2 will make a farmer able to sell his roots at 6,000 baht a rai; whereas, use of method 3 will make only 2,000 – 3,000 baht a rai. Nevertheless, 70 – 80% of farmers use method 3 since they do not have a truck and it may end up at not much different revenue because using method 1 or 2 he has to pay for diesel or truck rent himself and of course labor cost for harvesting.

Cost and production

A fixed cost especially machines is as follows. A second-hand feeding car (excluding a bulldozer) is 40,000 baht. A hand for turning around the cassava is only 3,000 – 4,000 baht. A second-hand bulldozer costs around 70,000 – 80,000 baht. A second-hand sucking machine costs more or less 80,000 baht.

As for a variable cost, this factory employs one chief and five workers. A salary for the chief is 7,000 baht; where as that of workers is 4,000 – 6,000 baht. Diesel used to run all machines except for trucks for transport is consumed 5,000 – 7,000 liters a month.

Out of 100% of fresh roots normally 45 – 50% cassava chips can be produced in case of Kaset-breed. That of Rayong72-breed is around 30 – 42%. This factory produces 30 – 40 ton of cassava chips daily.

Sale

Cassava chips are directly exported or used to produce cassava pellets. This factory sells its chips to at least 4 export companies in Chonburi and Ayuthaya. Transport cost last year (2006) is 0.3 baht/kg but due to a rising fuel price this year's price (2007) is 0.4 baht/kg. If including transport cost, the selling price is at 3.5 baht/kg; while, without transport cost the selling price is around 2.9 – 3 baht/kg. A selling price actually depends on moisture and sand percentage in chips. A standard price is set at 20% moisture and sand (14-15% moisture and 5-6% sand). If moisture and sand percentage is more than that, the price a seller gets will be deducted according to the excess percentage. Nevertheless, a lower percentage of moisture and sand does not lead to a higher selling price. Thus, a cassava chip processor just simply produces chips with 20% moisture and sand.

At this time the cassava-based ethanol factory uses fresh roots as raw material. Thus there is no demand for cassava chips. But if there is demand for cassava chips for ethanol production in the future, he might consider selling his chips to the ethanol plant depending on the price.

3.2 Cassava starch factory

We visited Sanguan Wongse Industries Co., Ltd. (SWI), founded in 1974 and now a largest cassava starch producer in Thailand. With 650 employees and technology from Germany and Finland, the maximum production capacity since 2005 is 1,000 metric ton/day, becoming the largest producer in the Southeast Asia. Besides, SWI's roots purchasing price is set as a standard price for cassava roots in Thailand.

SWI's starch products are both native starch and modified starch. While native starch is made of pure cassava, modified starch is mixed with chemical substance and can be produced according to order or customer's need. Compound of each type of modified starch differs from one to another depending on the objective of use, for example, strongly adhesive super glue, less adhesive post-it, or non-absorbent ramen. 80% of its production is industry-use; whereas 20% is food grade. 80% of industry-use products go to paper industries. The rest is used in glue, biodegradable products, plywood, and textile industries. Food-grade starch is used to produce tapioca, monosodium glutamate (MSG), sweetener, jelly, and gum, for instance. Most of native starch is export products; whereas modified starch is mainly sold in domestic market.

3.2.1 Cassava starch processing method

1. Sampling

Fresh cassava roots a farmer carry to the factory will be weighed and sampled to check starch percentage. SWI's standard starch percentage is 30%. Then, roots' price will be calculated according to weight and starch percentage.

2. Tail cutting

Cassava roots bought from the farmers will be processed as soon as possible because the starch percentage immediately reduces after being harvested. First is to put the roots in the sand and soil removal machine as in Picture 3.18. The machine shakes to preliminarily remove sand, soil and some dried skin attached to the roots. This removed sand, soil and dried skin is sold to mushroom producers in which it is used to mix with the soil for mushroom cultivation.

Picture 3.18 Sand and Soil Removal Machine

Picture 3.19 Removed Sand, Soil and Dried Skin

Cassava roots' tail will be then cut by hand on the way the roots are sent to inside the factory (Picture 3.20). Cut tails will be sold to make charcoal.

Picture 3.20 Cassava tails are cut and roots are delivered to inside the factory.

Picture 3.21 Cassava Tails

3. Fine skin removal

Cassava's fine skin will be sieved by the machine as in Picture 3.22.

Picture 3.22 Fine Skin Removing Machine

Picture 3.23 Removed Fine Skin

4. Grating

After peeled the skin off and washed with water, cassava roots will be chopped and grated in small pieces.

Picture 3.24 Peeled-off Cassava Skin

Picture 3.25 Roots after Peeling Skin off and Washing

5. Extraction

Next step is to extract cassava pulp by using centrifugal. After extraction, starch and water is left as in Picture 3.26. Pulp is then sold in two forms, wet pulp and dry pulp (sun-dried pulp) to animal feed producers to mix up with other ingredients.

Picture 3.26 Starch with Water

Picture 3.27 Cassava Pulp

6. Centrifugation

Then, with the same centrifugal starch and water, wrapped with cloth that has holes bigger than water but smaller than starch, will be rolled in order to separate water from starch and then dewatered. What is left is called “wet cake” (Picture 3.28), containing of 35% water. Note that wet cake can not be kept more than 5 days.

To produce ethanol produced from cassava starch, cassava starch in form of wet cake is the most appropriate. Although ethanol can also be produced from starch with water (before separating water), because of minus ion in the water an enzyme used to change starch to sugar will not work properly. Use of wet cake to produce ethanol is considered as the most rational method.

Picture 3.28 Wet Cake

7. Drying

Wet cake will be dried in the dryer. Standard dried starch contains 12 – 13% water and could be kept for a year.

Picture 3.29 Dry Starch

8. Packaging

Dried starch will be packed in different-size bags according to order.

9. Transport

Starch sold in domestic market will be transported by trucks to the buyers. Transport cost is around 0.4 – 0.5 baht/km. As for starch for export, it will be carried to the train station, only 10 km from the factory, by Lorry with containers. After that it will be transported to the port by train.

3.2.2 Cassava starch plant management

Waste

As mentioned above, every cassava part removed from the starch production process can be sold leaving no waste. In SWI production process out of 100% of cassava roots, 22% is cassava pulp, 2% washed and peeled skin, 1% skin with sand and soil. Smell is another big problem of a starch factory. We though smell is worst in this factory compared to the rest factories we visited; however, according to SWI's staff, he said due to a high technology used in this factory the smell problem here is less than other starch factories.

Waste water is another main problem. SWI's waste water per day is 9,600 m^3. Because methane gas is naturally produced from the waste water, SWI solves the problem by collecting methane to produce biogas. This biogas can be substituted for bunker oil used in the dryer (600,000 liter/month). The remaining biogas will be used to generate electricity, 72 MWh/month. Actually SWI has Korat Waste to Energy Co., Ltd. located nearby produce biogas for it by giving away waste water for free but buying back biogas at a low price, 8 baht/liter, compared to bunker oil which is 12 baht/liter. Note that Korat Waste to Energy is one of the CDM projects supported the World Bank with cooperation from English consultant company, Eco Securities Group.

Waste water after extracting biogas will be treated in 7 ponds, covering the area of 600 rai. Good water after treatment from the last pond will be reused in the factory; while the rest of waste water, which values of BOD and COD decrease more or less 90%, will be sold to organic fertilizer producers.

SWI has also planed to build a cassava pulp based electricity generating factory, another way to make best use of waste.

Perspectives on cassava-based ethanol plant

SWI does not really think about ethanol production from wet cake because it has already had a firm starch market and the government's ethanol policy is not yet steady. Besides, to get a license of anhydrous ethanol production for blending in gasoline is not easy and needs political connection.

The only one cassava-based ethanol plant in Thailand at the present, Thai Nguan Ethanol Co.,Ltd. not only face an technical problem but also a problem of raw material procurement in which it cannot find farmers to sell cassava roots to its plant steadily. SWI does understand this problem well because it has put much effort on making a good relation with cassava farmers for years and it finally results in constant raw material supply to the factory. Thus, raw material procurement is obviously one of the most important factors to succeed in ethanol business.

4. Conclusion

An ethanol plant that is expanded from a sugar factory is basically advantageous in terms of raw material procurement, efficient use of energy and waste treatment. It has its own raw material, molasses and cane juice. Normally a sugar factory does not stand alone. It always belongs to a business group that has many sugar factories and other related products in the same group. For example, Mitr Phol Sugar Group has 5 sugar plants and a number of related business and product factories. Khon Kaen Sugar also belongs to KSL Group that has 4 sugar plants. Therefore, molasses and cane juice can easily be supplied by any factory in the same group.

Energy such as electricity and steam is also effectively used in both sugar factory and ethanol plant located in the same area. Bagasse left after crushing the cane is usually burned to generate electricity. Electricity left from its own use in the sugar factory can be sent to the ethanol plant. Waste treatment is one of the main problems that an ethanol plant must face. An ethanol plant connected to a sugar factory can solve this problem easily by giving or selling fertilizer made of treated waste to the farmers who have a contract with the sugar factory. This makes a big difference between an ethanol plant connected with a sugar factory and an ethanol plant standing alone.

During the past two or three years there are many companies interested in fuel ethanol business and applying for production permit. One of the main reasons is the government policy that by January 2007 MTBE use would be abolished and gasohol (currently E10) will be fully used instead of gasoline 95. However, on November 6, 2006 the National Energy Policy Committee announced the postponement of gasoline 95 sale abolition because of the following reasons.

On November 6, 2006 there were 5 plants with the total capacity of only 655,000 liters/day; while ethanol needed to blend in gasohol 95 is 800,000 liters/day. Ethanol price skyrocketed due to a rise in raw material price especially molasses' price and a limited number of producers.

The ethanol selling price is set by the government. At first under the fixed price system ethanol selling price was 12.75 baht/liter. When a raw material price went up, the government changed to use a cost – plus basis to solve the problem because raw material cost is about 60 – 70% of the total cost. During the cost – plus basis price calculation formula being prepared the government raised the price up to 15 baht/liter. After the formula was used, the price went up to 19, 21, 23, 25.30 baht/liter. This led to a larger gap between gasoline price and ethanol price, causing a higher gasohol cost. Nonetheless, at January 17, 2007 the government changed the ethanol price setting system again to use Brazil's ethanol price plus other costs such as freight and insurance. At the end of March 2007 the price went down to 19.33 baht/liter.

As for users, there are around 500,000 old model cars that car makers have not confirmed that the use of gasohol would not affect the car engine. These are reasons pressing the government to postpone the abolition of gasoline 95 sale.

Nevertheless, this reversed the situation in the supply side. Many producers have become reluctant in the government policy and slowed down the plant construction. That many government units have thought that ethanol is another market to help cassava farmers does not seem realistic anymore with this policy. Out of 45 companies that got production permit, 30 have planned to use only cassava or use cassava with other raw materials. And, only one plant out of 30 is actually operated. Will the rest 29 plants really operate and will the cassava farmers be helped? This is a question that the government and stake holders must think about.

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