CHAPTER 2

CONCEPT, THEORY, DOCUMENT AND RELATED LITERATURE

In order to study the model for promoting a way of farming to reduce corn biomass in Mae Chaem District, Chiang Mai Province, the author gathered some concepts, theories, and related literature as follow:

2.1 Concepts and theories

The use of corn biomass for animal feed was conceptually a proper way to dispose of the biomass without causing any pollution. It was thought to be a waste to spend large amounts of money for the disposal of millions of tons of biomass. Thus, a proper method to eliminate the corn biomass by transforming it to produce revenue would be worth the management expense. There would be benefit for the operators as well. This would be a possible and reasonable way in real practice. However, how could we make it happen? How could we apply previous knowledge? According to the previously mentioned issues, we gathered the concepts and related theories that could be adapted as follows;

2.1.1 Price theory and price mechanism

Pricing the biomass, which is the agricultural waste product, would be based on economic basics. The price would depend on supply and demand. In the free market, when the supply meets the demand, the price of the goods is stable but, when the demand is higher than the supply, the price of the goods increases while on the other hand, when the supply is higher than the demand, the price of goods decreases. In a capitalistic economic system, or market economy, the operation and economical decisions are key tools for resource management for everyone in the economic system. In this kind of market, the price is a signal to the suppliers and sellers that goods and services in the market are either sufficient or insufficient. Thus, the price is a key factor that drives the market. The role of price is called price mechanism, which is the tool that reflects the possessive competition between the buyers and the sellers .If the biomass was utilized, value would be added and the process of exchange or trade of biomass would follow.

In order for a new market system to be created, the goods would need to be valuable enough. They would need to give a fair benefit in return. The goods would also need to be desirable enough to initiate trading and then the regular market cycle would begin. When the biomass market would take place, the farmers who plant corn would collect the biomass and sell it or utilize it themselves. By collecting the biomass, the farmers could utilize it directly or sell it at the purchasing outlets. The farmers would gain revenue from selling the biomass and they would not need to dispose of the biomass by burning it anymore.

2.1.2 Motivation Theory

Psychologists develop theories in order to explain human motivations, to find answers to the questions for why people do this and that, and their reasoning behind it. There is no theory that can completely explain motivation. The Incentive Theory, which was often mentioned in research, is a theory in connection with the external factors while other theories merely focus on the internal factors. The Incentive Theory explains that external factors, or environmental influences, attract people. According to this theory, people are motivated to act when incentives are positive and avoid action if the outcome or effect would be negative. These decisions to act or not act vary from person to person or from situation to situation. These depend on the different incentives, the person's personal values or how each person values the incentives. If a person considers an action worthy or meeting their expectation, then they will have the motivation to act. The value of the incentive comes from both biological factors and thought. For example, a starving person will have more motivation for food than a person who is full. Likewise, in order to convince the farmers to collect the biomass for utilization instead of burning it, the farmers would need to have a great incentive that would motivate such an action. The motivation for the farmers could be a proper profit. This would be seen as an attractive incentive for the farmers to collect the biomass for utilization instead of burning it. Another motivation could be social pressure that would make the farmers aware of the pollution from the biomass burning.

If the farmers could have a choice with a fair benefit mentioned above, it would strengthen the farmers' motivation to take part in promoting the utilization of biomass instead of burning it.

2.1.3 Innovation Adoption Process Theory of Everett Roger (1971)

According to Roger, adoption is a process which mentally takes place inside a person, starting from learning the innovation and then, adopting it. This process is similar to the decision making process and can be divided into five stages as follows:

2.1.3.1 The First Stage: Awareness Stage

This stage is the first step that leads to the adoption of or the refusal of the new innovation. This is the stage when a person learns about new things (innovation) in connection with their career or activities, but they don't fully acquire all the details. This learning usually happens accidentally and it may encourage a person to learn more because they may need that innovation for solving their problems.

2.1.3.2 The Second Stage: Interest Stage

This stage is when a person is interested in searching for further details of the innovation. This behavior is intentional and full of thought. The person acquires some knowledge about the innovation. Personality, personal values, norms or experiences in part have an effect on the person's perception. The person may give their full attention to the details of the new information.

2.1.3.3 The Third Stage: Evaluation Stage

In this stage, a person considers adopting the innovation by comparing the advantages and disadvantages. If the person sees more advantages than disadvantages to their activities or situation, then the person adopts it. This stage is different from the other stages because the person actually makes the decision to try the new idea. Normally, people think that trying new things is risky. Thus, this stage needs reinforcement. The person needs suggestions and other news to ensure their decision.

2.1.3.4 The Fourth Stage: Trial Stage

The trial stage is when the person adapts the innovation to their own situation, but just some parts of it to see the result. In this stage, the person looks for specific news related to the innovation for further information.

2.1.3.5 The Fifth Stage: Adoption Stage

This is the stage that the person fully adopts the innovation after the trial is successful.

However, according to Wittaya (1986:39), recently many flaws are found in Roger's Innovation Adoption Process Theory as follows:

a) The process usually ends with the person's adoption. Actually, when the person makes it to the evaluation process, they sometimes refuse the innovation.

b) The stages in this theory may not respectively happen. The person may skip some stages or reach only some stages of the whole process, especially the trail stage and evaluation stage.

c) The process usually ends with the person's adoption. However, if the person has a chance to search for further information, the person may reconsider if they should adopt the innovation based on the information they find to support or ensure their decision. Thus, the adoption process has been improved and a model called the Innovation Decision Process is presented below, which consists of four stages as follows:

Knowledge Stage: the person learns about the innovation and understands some of its roles.

Interest Stage: the person likes or dislikes the innovation because of their attitude towards the innovation.

Decision Stage: the person takes part in activities which lead to making a decision to adopt or refuse the innovation

Confirmation Stage: in this stage, the person looks for the reinforcement to adopt the innovation. However, the person may reconsider their decision if they have found information that seems to oppose the innovation later 11

Acceptance is mental process in humans, which differs with each person whether he or she chooses to agree with something or not. For this matter, it needed to be decided how to motivate farmers to accept and apply this new innovation as expected. After thoroughly considering, it was certain that not only officials' techniques and the art of motivation, but also the new concepts or methods along with other factors that would influence the farmers' decisions. Direk (1982:57-52) had stated factors relevant to humans' acceptance to new concepts as follows:

a) **Conditional or Situational Factors**

The following are conditional or situational factors.

b) **Economic Conditions** Farmers who possessed larger amounts of production inputs were more likely to accept changes easier and faster than farmers who had less production inputs.

c) **Social and Cultural Conditions** Inhabitants of reserved and more conservative societies with more solid class structures, social values and beliefs which conflicted with changes would result in a slower rate of change and less changes.

d) **Geographical Conditions** Areas with easy access to other areas, remarkably higher technological advances, or areas with natural resources more related to production inputs would result in faster changes.

Efficiency of Related Institutions with institutions such as the Agricultural Credit Institution, the Agricultural Research and Extension Institution and marketing-related institutions etc. that work effectively for the benefit of people, changes will occur much faster and easier.

Direct Factors

Below are direct factors as followed;

a) **Target Persons** Farmers who accept change. Farmers' backgrounds vital for accepting changes are:

b) **Society** Females tend to agree on changes easier than males. People with higher education and experience, having been in contact more frequently with agricultural extension officials, are more likely to accept change. Moreover, adolescents are the fastest to accept change and acceptance of change becomes slower as we age.

c) **Economics** Farmers who possess more land, work with larger amounts of land and contain more essential production resources agree on changes much faster and easier.

d) **Communication** Farmers who could read, communicate and write accept change more readily.

e) **Others Farmers** with a motivation for achievement, mental readiness and a positive attitude toward agricultural extension officials and technology are more likely to accept change faster and easier.

Innovation or technology vital for change are:

Cost and Profit Technology with the least amount of investment but gain the most benefit obtain higher and faster acceptance.

a) **Similar and Fit** Keeping with local traditions and beliefs and being suitable with physical qualities in each community.

b) **Practical and Understood** Not too complicated or having a too complex set of regulations

c) **Visibility** Having seen visible proof regarding the benefits, people would apply or accept the matter much easier and faster.

d) **Divisibility**

e) **Time-saving**

f) **Group Decision** With these characteristics, the more they have, the easier farmers would accept new technology or innovation.

2.1.4 Diffusion Theory

Everett Roger (1995) is the originator of the Diffusion of Innovation Theory. This theory emphasized the social and cultural changes that occurred from the diffusion of new things from one society to another once the society accepted and adapted to new things that were considered innovation, including new knowledge, techniques and technology. His Diffusion of Innovation Theory consists of four main elements which are (1) Innovation, (2) Media, (3) Appropriate Time and (4) Social Characteristics

2.1.4.1 Innovation or novelties, diffused to a new society which would later be accepted by the community. Generally, diffused innovation should consist of two major sections; ideas and materials. Whether the innovation would be accepted depends not only on the recipient's social system and communication, but also the innovation itself. Acceptable innovation should meet the following five criteria: (1) Relative Advantage, (2) Compatibility (3) Complexity, (4) Trial ability and (5) Observability.

The biomass digester innovated by the researcher was developed to the point that it digested corn cobs more effectively, granted higher yields, and cost less per kg than digesters previously accepted and supported by the government.

Therefore, the new innovation was more suitable and less complicated for farmers. These biomass digesters used a similar process as the previously known digesters but were much more effective and could be used further to produce fertilizer or mushroom producing materials. Farmers would invest less but gain better competitive capabilities and better chances to be widely recognized for the innovation which would magnify the biomass management in maize growing areas.

2.1.5 Mae Chaem District, Chiang Mai Province

Mae Chaem District is located in the northeastern part of Chiang Mai Province covering approximately 3,361 square kilometers or 2,100,625 rai. The overall agricultural area is 126,685 rai with 106,059.25 rai consisting of mono-cropping areas and the rest in the woodlands. During 1994 – 1995, many private companies encouraged farmers to grow maize using their contracted farming system, which resulted in the growing number of maize, eventually becoming Mae Chaem's number one agricultural crop. According to Mae Chaem Agricultural Extension Office, approximately 80% of Mae Chame's farmers were growing maize and producing corn seeds.

Table 2.1 Six Important Agricultural Crops in Mae Chaem District

Number	Economical Crops	Cultivated Areas (rai)	Percentage (%)
1	Maize	82,904	78.16
2	Red Onion	19,937	18.80
3	Lychee	1,586	1.50
4	Longan	1,391.75	1.31
5	Garlic	198.50	0.20
6	Tangerine	420	0.03
Total		**106,059.25**	**100**

Source: Agricultural Extension Office

Therefore, we can assume that from 1995 onward, since private companies encouraged Mae Chaem's farmers to grow maize, the production process has significantly changed. Farmers intensely made use of lands and huge amount of chemicals were used and deserted lands were transformed into maize growing areas. According to Mae Chaem Agricultural Office (2005-2006), the overall amount of maize growing areas was 81,344 rai with average product at 1,168 kilograms and total number of 95,070,900 kilograms in overall products. The district production information can be categorized as below:

Table 2.2 Maize Information Per Sub-districts of Mae Chaem District

No.	Sub-Districts	Cultivated Areas (rai)	Products (Kilograms)
1	Mae Na Chon	14,135	16,300,800
2	Tha Pha	13,608	16,135,800
3	Chang Koeng	13,350	15,564,000
4	Mae Suek	12,100	13,866,000
5	Pang Hin Fon	11,550	13,844,400
6	Ban Thap	8,465	9,933,900
7	Kong Khaek	8,136	9,426,000
Total Cultivated areas of the 7 Districts		**81,344**	95,070,900

Source: Agricultural Extension Office

As a result of the intensive use of the land and the increased motivation, the average land price rose from 4,606 baht in 2004-2005 to 6,500 baht. Due to the financial support and support for the raw materials from private companies, farmers didn't only change what they grew but also invaded forests, leading to deforestation.

Deforestation to grow maize became serious during 2000 – 2001. People began to deforest very rapidly and were very much likely going to continue expanding in Mae Na Chon Sub-District, where the largest maize cultivation and deforestation was being conducted.

Mr. Pracha Chantorsaeng, Sedosa, the village chief, Mae Na Chon Sub-District, Mae Chaem District, claimed the Mae Chaem woodland has significantly decreased since maize was introduced by private companies and was very likely going to get much more serious in the near future if no solution would be carried out. Therefore, government sectors needed to enforce policies regarding this issue immediately in order to suppress deforestation. In his own Sedosa village, lived Pgakoenyau tribes whose cultivation traditions were still being practiced. He expressed his concern for villagers who still practiced traditional cultivation and struggled with capitalism since it was surely difficult for locals to withstand the system. In case capitalism would overthrow traditional cultivation, direct impact would fall on the villagers themselves. He also believed Mae Chaem's maize cultivation areas would face an extreme soil nutrition deficiency and they would no longer be suitable for cultivation. There would be too many residues and soil would be unable to grow any crops. Once this happens, private companies would surely withdraw to new cultivation areas while villagers would have to endure the results left in Mae Chaem District.

Due to the growing demand of maize for domestic use and international export and the remarkably increasing energy demand, farmers were encouraged to produce ethanol for vehicles from maize materials and maize prices noticeably increased. This resulted in increased areas of deforestation in nine upper Northern provinces to twice the size of those in 2002. Previously, Mae Chaem District had less than 30,000 rai of maize cultivation area while the number has risen to more than 100,000 rai recently. Deforestation and maize waste burning at a similar time has caused serious air pollution in summer from January to May every year.

Since 2006, petitions have been filed to the government regarding dust and thick fog in Chiang Mai Province from the station near Yupparaj Wittayalai School since it had exceeded PM10 of 120 microgram per square meter within 24 hours.

Table 2.3 Analysis on Atmosphere Particulate Matter (PM10) in the Upper Northern Provinces in 2006 – 2011(Continued)

Investigated Areas (province)	Date/Month/Year	Total Days with Exceeding PM10 Standard	PM10	
			Highest (µg/m3)	Lowest (µg/m3)
Chiang Mai	14 Mar 2006	35 Day	382.7	21.2
	24 Mar 2007	8 Day	206.3	9.5
	14 Mar 2008	21Day	235.3	15.8
	17 Mar 2009	22 Day	279.9	12.3
	8 Mar 2010	0 Day	109.9	5.8
	19 Mar 2011	17 Day	215.9	20.9
Lamphun	14 Mar 2006	18 Day	236.7	12.2
	17 Mar 2007	40 Day	350.3	23.8
	26 Mar 2008	0 Day	114.1	5.9
	26 Mar 2009	22 Day	274.8	37.7
Chiang Rai	16 Mar 2006	16 Day	201.4	29.5
	23 Mar 2007	4 Day	174.3	19.2
	13 Mar 2008	27 Day	288.0	16.4
	26 Mar 2009	43 Day	291.9	28.4
	6 Apr 2010	2 Day	142.3	11.0
	21 Mar 2011	30 Day	470.8	35.6

Table 2.3 Analysis on Atmosphere Particulate Matter (PM10) in the Upper Northern Provinces in 2006 – 2011(Continued)

Mae Hong Son	20 Mar 2006	28 Day	339.6	43.9
	25 Mar 2007	4 Day	134.0	14.6
	12 Mar 2008	33 Day	254.3	14.6
	18 Mar 2009	37 Day	518.5	25.9
	6 Apr 2010	2 Day	158.4	7.9
	19 Mar 2011	22 Day	367.6	19.4

Source: THAIPLUBLICA

2.1.5 Health Effects

Polluted air could cause people, whose activities were mainly outdoors, to have sore eyes, sore throats, tire easily and constriction. A risk study on out-patients that had respiratory allergies, cardiopathy and asthma at Maharaj Nakhon Chiang Mai Province Hospital, Faculty of Medicine in 2006, found the respirable dust level higher than 50 micrograms per square meter raised triple the number of patients at risk for asthma and emphysema. In the meantime, normal people were likely at risk for mortal conditions at a 0.26% higher rate when respirable dust exceeded 10 micrograms. Chiang Mai University conducted a study on the relationship between respirable dust and morbidity and fatality rates in Chiang Mai Province and Lamphun; they found a daily average rate of 2.5 micron respiable dust in Chiang Mai Province is 3-6 times higher than the U.S. standard. Chiang Mai Province has had an increasing number of patients suffering from respiratory diseases annually. The respirable dust caused ischemic heart disease, which was related to the rising fatality ratio as found in Saraphee Hospital located in the densest respirable dust area in Chiang Mai Province. (Chiang Mai University Research Center under the leadership of Ass.Dr. Mongkol Rayanakhon)

The Bureau of Occupational and Environmental Diseases reported dust or less than 10 micron dust from fire caused respiratory diseases and eye inflections. Moreover, Cardiopathy would be likely to increase due to dust collected in lungs causing the white corpuscles to clean the contaminants and vein inflammation occurred thereafter, leading to pneumonia. In some cases, patients could hardly breathe and fell into a crisis state or suffered from coronary artery diseases from inhaling densely polluted air in the North. These symptoms are similar to those caused by polluted air from vehicles' exhaust pipes in Bangkok. They also found that if dust reaches every 10 micrograms per square meter, the fatality ratio increased to 4.5% from respiratory diseases, to 9.8% from cardiopathy and coronary diseases, to 3.9% from elders aged over 65 years old and to 5.4% remarkably those suffering from relevant respiratory diseases such as allergies, asthma, emphysema and cardiopathy. (Dr. Somkiat Sirirattanapruek, 2009) "Once the body absorbs toxin and dust, it will gradually result in the failure of cardiac muscles and ischemic stroke. Some suffer from paralysis since the block of blood flow to the brain and is hugely affected. In pregnant women, the study clearly stated that babies, whose mothers were pregnant during the densely polluted air, were born with subnormal weight and at mortal risk with other diseases. Also they are more likely to suffer emphysema. The worst is that carcinogens are included in the polluted air they inhale, causing people to be at risk for cancer". The Northern region ranks the top for lung cancer patients; Lampang ranks the first, Lamphun and Chiang Mai Province rank second and third respectively. Some locals, that had never smoked, suffered and passed away from lung cancer caused by inhaling polluted air.

World Climate Effects

World climate effects, such as, global warming, greenhouse effect, air pollution from wild fire destroyed people's respiratory systems which directly affected locals' children and elders. Also these circumstances gradually decayed the natural beauty of the community.

Water Effects

There were also effects on the water, such as, changes in water balance, floods, droughts and polluted water. Sediment-polluted water flowed from waterways to rivers, which gradually heaped up resulting in shallow rivers. Floods occurred easily causing agricultural disasters. During dry season, soil was full of sand and soil was firm from wild fires, which made it unable to absorb water during rainy season. Drought was caused by these factors and communities suffered as well as the agricultural areas.

Soil, Nature and Forestry Effects

Deforestation resulted in decreased ability to absorb water by the woodland soil, less soil nutrients and damaged top soil. Erosion then occurred after heavy rains, which happen very often in the Northern provinces and this directly affected the locals.

Traffic and Tourism Effects

Polluted air and wild fires have immensely affected both tourism and service industry businesses since many airlines cancelled flights for the safety of their passengers. They also affected traffic on interprovincial highways and tourists either delayed or cancelled their plans due to the news regarding these matters. Kasikorn Research Center foretold if the

2.1.6 Solution Methods for Maize and Other Agricultural Waste Burning

Cultivating maize on highlands and mountainous regions comes with logistical difficulties. However, maize and corn were worth the price. Hence, maize was transported from agricultural areas to mills then transferred to the animal feed markets. Stalks and leaves were left at the planting areas to be burned in the dry season. Huge piles of corn cobs and silk were collected at mills since local farmers tend to transport their products to the same local mills. These were kept and were burnt in dry season due to the suitable dryness of the biomass at that time, yet we could develop a logistical system of collecting the waste instead of the existing process of burning it by determining the appropriate distance for each mill to stock the waste, providing for easy transportation to and from each mill and installing a fire protection system. By stocking the waste, would create possibilities to reproduce biomass for beneficial uses such as replacing sawdust in mushroom production materials, briquette fuel and fermented food for cattle. To produce fertilizer, a mill would need a sieve no bigger than 6 millimeters. These uses would truly add value to the biomass. Each mill should consist of at least 5 rai for waste stocking and have a large area for fertilizer production. By doing so, farmers could form in a small group to reduce economical costs called, economics of scale. For coal, waste could be used without milling and for fertilizer, primary milling would reduce time it needed to break down yet to cut the costs, the waste could be fertilized without prior milling.

2.1.7 Biomass Digester

According to studies and research about the usage of agricultural waste from maize, maize biomass should undergo digestion and size reduction processes in order to store and transport it cost-effectively before it can be efficiently utilized. This is an upstream process which prepares the raw material for its efficient usage.

There are many size reduction methods involving mechanical force, e.g. shear force, pressure, impact, compression, and explosion, depending on property, type, and desired fineness of the material. When dry, maize waste is light-weight and flexible and has tough fiber that makes size reduction difficult. The combination of a shear shredder and hammer mill methods would efficiently digest maize biomass. Chavarit Rungittivong et al. from the Institute of Technological Development for Industry, King Mongkut's University of Technology North Bangkok (KMUTNB) developed the pellet mill and a machine that recycles agricultural waste into biomass pellets. The machine consists of a chopper, a grinder, a pneumatic conveyer, a cyclone, a rotary valve, a power engine, and a trailer.

Driven by a 90-hp diesel tractor, with the pounder, pneumatic conveyer, and pellet machine mounted on the trailer, the machine can be used to produce pellets in fields, on farms, or in other areas without electricity. Main factors that determine the efficiency of the machine are shown below:

a) Biomass sources - Distribution of agricultural waste could be divided in two ways, gathered in one area (millhouse, sugar factory, tapioca starch factory, palm oil factory, and rubber wood factory) or distributed in agricultural areas (corn stalks and leaves, sugarcane leaves and tops, rice stubbles, twigs in forest and on countryside footpaths), which was the target of this machine.

b) Size of biomass waste - The machine was suitable for small-sized residue, e.g. small twigs and leaves. Big-sized residue, e.g. twigs, tops, and slabs of rubber trees, were not suitable for this machine.

c) Moisture – The moisture level of the residue used as fuel should not exceed 30%. Residues that were too moist, e.g. tapioca residue and yeast with 80-90% moisture levels, were not suitable for this machine.

d) Objects mixed-Objects mixed with the residue, e.g. soil, pebbles, gravels, and palm oil spill, could reduce the efficiency of this machine.

This biomass pellet machine could reduce the size up to 25 mm in diameter of biomass waste with a moisture level below 20% (e.g. sugarcane tops and leaves) and to a diameter of 8.0 mm and a length of 25-50 mm with bulk density of over 600 kg/sq. m. at the capacity of 100-150 kg/hour. This machine could reduce the cost of transportation of biomass residue and expand its durability. The biomass pellets could replace fuel oil and gas as energy sources. Since the pellets were produced from domestic agricultural residue, they could help in the reduction of imported fossil fuels, improve international trade balances, create job opportunities, and help farmers and other people increase their revenue.

Ekkachai Krongyut and Boonyarit Sirisom (2010) from the Department of Industrial Engineering, Faculty of Engineering, Khon Kaen University conducted a study on the effects of speed and sieve hole size of hammer mills for the size reduction of corn cobs. The study was conducted on a digester with 10-hp belt-driven power engine at the speeds of 800, 1,000, 1,200, and 1,400 rpms, the sieve hole sizes were 6, 8, and 10 mm, and the feed rate was 300 kg of corn per hour, tested on both non-fermented corn cobs and fermented corn cobs. Ultimately, the size reduction of the fermented corn cobs granted higher yields than non-fermented corn cobs, the speed of 1400 rpm resulted in the best yields, and the blade thickness of 9 mm granted the highest yields. (New Researcher Development Project, Department of Industrial Engineering, Faculty of Engineering)

According to the study, the most suitable biomass digester for corn cob consisted of two blades: a shredder and a pounder. Biomass corn cobs were fed into the digestion tank consisting of a hammer mill blade. After the size was reduced to 5 mm, the residue went from the digestion tank through the sieve. A 50-hp diesel engine was used to drive the digester. The machine could digest biomass residue at the capacity of 1,000 kg/hour with a fuel consumption rate of 10 liters/hour. At diesel oil prices of Bt32/liter, this digester would cost Bt320 per ton. Then, the digested corn cob was packaged, ready for transportation, sale, and storage. It could then be used for silage fermentation, mushroom planting, or used as fuel pellets. However, the price of digested corn biomass needed to be in accordance with the cost of operations, packaging, transportation, maintenance, and SG&A.

Under the assumption that each rai of corn produces 500 kg of agricultural residue (300 kg of corn stalks and leaves are left at the field and 200 kg of husks and cobs are separated from kernel at the millhouse), a 10,000-rai corn field in Mae Chaem would result in at least 50,000 tons of agricultural waste. If the price of corn biomass is Bt600/ton, the total value of the corn biomass would be at least Bt30 million, given that farmers could use their free time after the harvest to clear the farm. Farmers could sell or use digested corn biomass. This would create new jobs and would generate additional income for farmers. Corn biomass purchasers would have to have adequate space and have convenient access for both purchasing and selling.

2.2 Documents and Related Literature

Corn biomass could be used to produce economical animal feed:

2.2.1 Economical TMR Feed

According to the Department of Animal and Aquatic Science, Faculty of Agriculture, Chiang Mai Province University, total mixed ration (TMR) animal feed could be made with this recipe:

a) Cover the floor with a plastic sheet and put wood at the edges to prevent the urea fertilizer from leaking.

b) Mix 5 kg of molasses and 2 kg of urea fertilizer with 30 liters of water. Dissolve urea fertilizer and stir well. Sprinkle the solution on 43 kg of corn husks and cobs.

c) Mix 20 kg of ground corn, 800 g of salt, 100 g of sulphur, 100 g of dicalcium. Sprinkle the mixture on the corn husks and cobs mixed with the molasses and urea fertilizer. Mix all ingredients together.

d) Put the mixture into a plastic back, and then a fertilizer sack. Leave it in a dry place for 21 days. Finally, the TRM feed is ready to be used to feed animals or saved for use in drought.

Advantage of TMR Feed

The TMR feed consisted of nutritionally balanced rations of silage, roughage, and mineral and vitamin supplements. TMR feed was easy to control and saved time and labor. Cows received sufficient and balanced nutrition as well as the following benefits:

a. Suitable pH levels for microbes living in rumen.
b. Improved nutrition synchronization in rumen.
c. Helped improve digestion in rumen.
d. Improved nutrition absorption.
e. Prevented gastroenterologic acidity problems.

f. Helped keep cattle at full productivity.

2.2.2 Fermenting Corn Stalks with Ethanol to Produce Economical Silage for Cattle

Panom Sriwattanasombat (2005) from the Department of Zoology, Rajamangala University of Technology Lanna Phitsanulok, came up with the idea of fermenting corn stalks (common waste from corn farming) in ethanol to replace hay and grass as livestock feed during drought. Chopped corn stalks were mixed with an ethanol solution (ethanol at 6% of water weight) at a ratio of 1:1 then stored in vacuum black plastic bags, and kept indoors for at least one month. The silage should be fed to cattle at up to 3% of the cow's weight or 20 kg/day for each cow and is suitable for both young and mature cows. In addition to putting the waste to good use, this silage also reduces the use of expensive molasses by ten times.

2.2.3 Silage from Maize Residue for Cow Marbling

According to Khanchai Danmek (January 27, 2014) from the School of Agriculture and Natural Resources, University of Phayao, the University of Phayao, the Northern National Science and Technology Development Agency (NSTDA), and Phayao Livestock Research Station cooperated and initiated an academic project "developing silage from maize waste for cow marbling" to inform farmers. Since Phayao's major economic crop is maize, having over 325,060 rai of land dedicated to maize farming in 2012 (B.E.2555/2556), the Northern region has abundant waste from maize, especially husks and cobs, which are mostly disposed of by burning. Phayao is also a major producer of high-quality marbled beef. However, it tends to face animal feed shortage problems during drought. Thus, the School of Agriculture and Natural Resources, University of Phayao conducted a study to recycle maize waste (husks and cobs) into silage for beef cattle. Initially, silage made of maize waste met the Department of Livestock Development's standards and the percentage of protein increased from below 2.0% up to 4-10%. The study was initiated at the cattle farm of Manit Intasarn, the president of the Dok Khamtai Marbled Cattle Grower Group (Phayao's largest marbled cattle grower group) and at the Phayao Livestock Research Station, which is Thailand's largest White Lamphun beef cattle grower. The study at both farms showed excellent results. Phayao Livestock Research Station increased its silage production to 10-30 tons per round and fed more than 500 cattle and published the information on its official website. The station's feed mill raw material costs also decreased by over 40%. In addition, this gave the maize farmers additional income from husks and cobs.

Previously burned as waste, maize farmers sold husks and cobs at Bt10-15/sheaf (16-18 kg) in early 2014, which was a reasonable price for both maize farmers and the marbled and beef cattle growers. In line with Phayao's strategy and promoting the province's title as the producer of high-quality marbled beef under the name "Kho Khun Dok Khamtai" (Dok Khamtai Marbled Beef) since 2014, sales were projected at Bt40 million per year. This maize silage could replace the high-cost of brewer grain and other feed from the Central region, and its value would likely increase. Consequently, it would decrease the maize waste incineration and solve the smog problem in the Northern region in the long run.

Ingredients for Fermented Plant Juice Leavener for Maize Husk Fermentation

300 g of fermentation flour or yeast, 500 g of molasses, 100 g of urea fertilizer, and 10 liter of water

Recipe:

Dissolve the urea fertilizer in water and stir well. Add molasses and stir well. Add fine fermentation flour, stir well, and leave the solution for one hour. Finally, the concentrated fermented plant juice leavener for dried maize husk fermentation is ready.

Instruction:

Mix 1 liter of the concentrated leavener with 10 liters of water, leave the solution for two days, and use it to ferment the maize husks. After leaving the leavener for two days, mix 1 liter of the leavener with the ingredients leaving out 300 gram of the fermentation flour for further use.

2.2.4. Ethanol from Corn Stalks

Asst. Prof. Pramuk Parasukulsatid from the Department of Biotechnology, Faculty of Agro-Industry, Kasetsart University conducted a study on the optimal pretreatment of biomass from wood from eucalyptus, acacia mangium, and oil palm stems and leaves. Pentose content in the biomass was reduced by steam explosion, and the lignin was separated out by alkali to increase the percentage of cellulose and boost the enzyme activity to improve the production of ethanol.

Removing hemicellulose by steam explosion, the optimal pretreatment of the four kinds of wood was logR0 3.84 (210'c, 4 minutes), which decreased the hemicellulose by 81.38%, 56.24%, 86.35%, and 78.71%, respectively. Eliminating lignin in these four kinds of wood by sodium hydroxide solution after steam explosion and hot water extraction, the optimal pretreatment was at a 25% concentration, 70'c, and 90 minutes for eucalyptus wood and acacia mangium wood and at a 15% concentration, 90'c, and 60 minutes for palm stem and leaves. After simultaneous saccharification and fermentation (SSF) by the optimal pretreatment for the four kinds of wood (10% dry weight, 40'c), palm stems produced the largest amount of ethanol of 44.25 g/liter, followed by palm leaves, eucalyptus, and acacia mangium of 33.16, 30.60, and 23.16 g/liter, respectively. Ultimately, wood from palm stems was the most suitable wood for SSF. After finding the optimal pretreatment, Woraluk Kongjindamunee (Prince of Songkla University) studied ethanol production from corn stalks under two processes; comparing digestion by chemicals versus enzymes, and comparing fermentation by baker's yeast versus saccharomyces cerevisiae (YSC2).

Corn stalks digested by enzymes and fermented by YSC2 produced 520 liter/ton of ethanol at the lowest cost of Bt15.32/liter, while corn stalks digested by chemical and fermented by baker's yeast produced the largest amount of ethanol of 549.31 liter/ton at the cost of Bt37.45/liter. According to Chatchanun Niwaswong and Chalerm Ruangviriyachai from Biofuel Energy Reserch Group, the National University of Research, Khon Kaen University, ethanol was produced by separating hemicellulose and lignin out from the biomass for pure cellulose, and then using enzymes to break down the polysaccharides into monosaccharides (e.g. glucose) to feed microbes, e.g. saccharomyces cerevisie, escherichia coli, and zymomonas mobilis, which would process the sugar into bioethanol.

George W. Bush, former U.S. president, solved the continuous petroleum prices hike problem by producing ethanol from corn kernels. Corn kernels could generate 5 billion gallons/year of automotive fuel, substituting 30% of gasoline usage. Corn kernel ethanol production was targeted at 7.5 billion gallons/year in 2012 and 35 billion gallons/year in 2017. However, this caused corn pricess to surge from Bt5,280/ton in 2007 to Bt8,280/ton in 2008. Therefore, corn residue with a content of 40% cellulose was used to substitute corn kernels for ethanol production. To relieve excessive demand for corn problem, ethanol production from cellulose (cellulosic ethanol) was researched to replace ethanol production from corn kernels. Ethanol production from corn kernels is less complicated since only amylase is used to break down corn starch into monosaccharides (glucose), and then microbes are used to process glucose into ethanol. For cellulosic ethanol, hemicellulose (xylose and five-carbon sugars) and lignin (binding two polymer sugars) are separated out from the biomass (grass, hay, corn cobs, leaves, and stalks) for cellulose, then two polymer sugars are broken down into monosaccharides, which would be processed by microbes into ethanol. Yeast normally does not process xylose and five-carbon sugars into ethanol. E.coli was used and resulted in acetic and lactic acids, producing 6.4%

ethanol; this is patented by Celunol, Louisiana, to produce 1.4 billion gallons/year of cellulosic ethanol. Then, other researchers used other kinds of bacteria; zymomonas mobilis produced 10% ethanol and is currently under improvement for commercial production. Researchers were also genetically modifying yeasts to improve their ability to produce higher cellulosic ethanols. Nancy Ho from Purdue University, West Lafayette, Indiana, was the first to successfully genetically modify yeast for cellulosic ethanol production in 1993. Cellulosic ethanol production did not depend only on the process and the microbes. The production took two days, which was very long compared with corn kernel ethanol production which took only a few hours. Researchers sought to minimize the amount of time taken for ethanol production by using weak acid or steam or using ammonia at low temperature; the latter reduces cost of production by USD 0.40/gallon. Producing ethanol from high-lignin wood scraps was not effective enough, so researchers genetically modified plants to increase their cellulose content. Vincent Chiang from North Carolina State University could genetically modify poplar, decreasing lignin content by 50% and increasing cellulose content, resulting in higher ethanol production. There is also research about cellulose crystallinity and improving monosaccharide breakdown (glucose) to minimize the amount of enzymes used and to reduce costs. Researchers have also genetically modified switch grass and miscanthus to lower their lignin content.

Most research aimed at reducing the cellulosic ethanol production cost which was USD3-4 /gallon. In 2009, when the first cellulosic ethanol commercial production plant was established, the production cost was supposed to decrease to USD 2/gallon. However, the U.S. Department of Energy’s goal was to reduce the production cost to USD 1.07/ gallon which would be competitive with the production cost of corn ethanol. However, the production cost of corn ethanol gradually decreased due to more research and development of the starch-dissolving enzymes. Nowadays, some automobile manufacturers in the United States have started to expand their production line of E85 cars which use 85% ethanol and 15% gasoline. The Zhong Liang Sheng Hua Neng Yuan Zhao Dong Co.,Ltd, located in Zhaodong City, Heilongjiang Province, manufactures ethanol from corn biomass. Corn is a grain widely planted around the world. People consume the corn grain or make different kinds of processed foods from it. The parts of the corn left in the field after harvesting are tons of its leaves, husks and stalks which are needed to disposed of. There are many methods used to dispose of this waste. These disposal methods have all caused pollution to the environment. It is a waste to just dispose of the corn biomass. Thus, some methods of utilizing this waste have been created. One method is making alternative energy from the corn biomass by a method called biomass gasification. This alternative energy can be used as a thermal energy for cooking, for electricity and other uses. Recently, ethanol could be made of the corn kernels which we consume. This ethanol could replace the oil fuel, bensin up to 85% because its efficiency has been improved by the enhancement of a recently found substance.

The process of making the ethanol involved grinding the leaves and stalks of dried corn to a fine powder then steaming it. After that, it was digested with an enzyme until it became brown and left to ferment until it changed into ethanol then distilled until it became a pure solution. In order to be used, it needed to be mixed at a ratio of 3 portions of the enhanced substance to 12 portions of bensin oil (together adding up to 15 portions) and ethanol 85 portions. Then, this EURO-3- standard alternative energy is ready to use.
From the above vision, the The Zhong Liang Sheng Hua Neng Yuan Zhao Dong Co.,Ltd, located in Zhaodong City, Heilongjiang Province did some research to produce the ethanol from corn. They succeeded in the production process by adding less of the 12% enhanced substance they found during their research to the 85% ethanol, Brazil used 25%. The Zhong

Liang Sheng Hua Neng Yuan Zhao Dong Co, Ltd did thousands of tests and made hundreds of inspections over seven years until they could produce the standardized products. We could say that they killed three birds with one stone; first, they utilized the waste from cultivation, second, they indirectly preserved the environment and third, they increased the revenue for farmers who planted corn around the country.

2.2.5 Cellulosic Ethanol

Cellulosic ethanol is an alternative way of producing ethanol for the future. Ethanol is the alternative energy that received full attention all over the world because the price of the oil, which has been the major source of energy of the world for many years, steadily increased to USD 147 per barrel on September 11, 2008. These days, every country that imports oil realizes the risk of depending on oil alone. These countries began to search for an alternative energy to reduce the amount of oil imported. In addition, the ethanol was attractive because it was a clean energy. The ethanol could fulfill what was needed to resolve the global warming problem caused by greenhouse gases. Nowadays, ethanol production requires two main materials: plants that produce sugars, such as sugar cane and molasses, and plants that produce starches, such as cassava, rice and corn. However, there is a concern that the materials would not be sufficient for producing the ethanol in the future. Some countries such as United States and China used these food plants and corn, to produce ethanol, which caused the crop production in their countries to increase. Thus, many countries focused on using other material, such as cellulose which is a waste from cultivation, to develop ethanol production technology.

Cellulosic ethanol, or ethanol made of cellulose, is an ethanol made of rice straw, bagasse, corncob and bark. These materials consist of lignocellulose materials which are organic compounds. The core part of the plant's cells is carbohydrate. The carbohydrate consists of long linear chains of glucose or glucose polymer. Ethanol made of glucose has the same chemical property and chemical characteristics as ethanol made of sugars and starch.

Today, in many countries such as China and Canada, the cellulosic ethanol production is still in the trail stages. However, commercial production may happen soon because some of the cellulosic ethanol production technology and development companies are preparing the plans to establish plants in United States and Canada.

Cellulosic Ethanol Production Process

There are two main processes:

Cellulolysis is a method where cellulose is digested to glucose then fermented with yeast until it becomes alcohol. After distillation and water splitting, the alcohol becomes ethanol. Gasification is a method where the carbon compounds in the cellulose are broken down to carbon monoxide, carbon dioxide and hydrogen are then fermented with microorganisms until it becomes alcohol. After distillation and water splitting, the alcohol becomes ethanol.

Benefits of Cellulosic Ethanol Production

a) Cellulose is a part of many kinds of plants, so it is easily obtainable. The wastes from cultivation such as rice straw, bagasse and corncobs could be materials for producing cellulosic ethanol. The production and utilization the cellulosic ethanol produces 85% less greenhouse gas compared to the production and utilization of bensin oil, while ethanol from starch produces only 18-29% less green house in the same comparison.

b) Cellulose is a part of the plant that the human body is unable to digest. There would be no concern of wasting a food plant in order to produce the cellulosic ethanol because the material is not a food plant.

c) The materials for producing ethanol vary because ethanol could be produced from many parts of plant. Sugar cane juice is commonly used in the production of ethanol and the cellulose is a material that could be used for cellulosic ethanol.

However, the major obstacle in cellulosic ethanol production is the high production cost compared to the production cost of the ethanol from sugar and starch. In 2006, the cellulosic ethanol production cost in United States was around USD 0.59 per liter (compared with the recent selling price of ethanol in United States at USD 0.40). Nevertheless, United States set a goal to reduce the production cost to USD 0.28 by 2012.

2.2.6 Biochar production, the Biomass Briquettes Produced from the Waste from Cultivation, Corn Cobs, an Alternative Environmental Solution.

Dr. Pimsiri Tiyayon, from the School of Agriculture Resources, Chulalongkorn University conducted some research of applying biochar to cultivation areas in Nan. He said biochar, the bio-briquettes produced from biomass such as a waste from cultivation, have different properties than common briquettes. It was not used as a fuel, but as a soil amendment. The biochar was spongy and well ventilated. It helped retain water and absorb the necessary nutrients for growth. Moreover, the biochar reduced the soils acidity and was a habitat for useful microorganisms. According to records, the corn planting rate in Nan dramatically increased. After deforestation, in order to expand the corn planting area, farmers applied herbicides and chemical fertilizers, which caused soil degradation and soil acidity and tons of waste from cultivation such as corn stalks and corncobs. Most farmers burnt this waste to prepare the land for new planting which led to haze pollution and global warming. Thus, the concept of producing biochar from the waste in order to transform it to a soil amendment was adopted and this lowered the fertilizer cost for the farmers as well. The knowledge was acquired by the students and professors from the School of Agriculture Resources when they took a trip to the northeast of Thailand to study biochar. They designed a simple and low-cost stove and produced biochar from a process called pyrolysis. The principle was to use heat conduction without oxygen or with lowered oxygen which could be done in two ways, fast or slow break down. The average temperature is around 500-700 degrees Celsius. The product was 30% bio-briquette. The output of biochar was similar to a common briquette, but lighter in weight, a little shiny and remained in its input material form. The biochar incineration reserved the carbon and emitted less smoke which would transform it to bio-oil and synthetic gas. This would reduce global warming, Dr. Pimsiri said. To use the biochar, we would need to ferment the biochar with the manure. The biochar would absorb the smell and nutrients from the manure. It would be able to retain the nutrients for a long time unlike most chemical fertilizers which nutrients are easily washed out not leaving much for the plant.

The biochar would gradually release the nutrients to the plants. The rate of use for biochar was 1 ton per rai, depending on the soil condition. The soil sample would need to be analyzed for pH and nutrients in order to calculate a proper amount of biochar needed. After studying, the School of Agriculture Resources, Chulalongkorn University, shared this knowledge with the farmers in many districts of Nan. They demonstrated and gave the farmers primary instruction on how to incinerate biochar with the stove they designed. They gave suggestions to the farmers to form a group for producing the biochar which got positive feedback from the farmers because they wanted to reduce chemical fertilizer production costs and also improve the fertilizer efficiency. In the beginning, biochar was used to amend the soil quality and increase corn products as a trial so that the deforestation would decrease. In addition, a comparison between the chemical fertilizer and biochar mixed with manure was made and tested in different soil conditions. The improvement of soil could take years before seeing any result, however the results would be long term. According to Ms.Woralak Chindamunee, Prince of Sonhkla University, her research was about producing ethanol from corn cobs and was divided into two processes; one was to recondition the corn cob digestion, comparing chemicals and enzymes, and the second was to ferment them with baker's yeast and saccharomyces cerevision. From the recondition and digestion with enzymes and saccharomyces cerevision, an output of 520 liters was produced. The lowest production cost was 15.32 baht per liter. Recondition by chemicals and fermentation with baker's yeast produced the most output at around 549.31 liters per 10 tons of material and the production cost was 37.45 baht per liter.

2.2.7 Corn Cob Charcoal

Mr. Ekachai Chaiyasarn, 1996-1998, a villager from Dok Khamtai District, Phayao, produced charcoal from corn biomass to sell. The charcoal he produced was better than the common charcoal. It burnt longer and maintained a steady temperature for a long period of time and it was good for grilling. Mr.Ekachai Chaiyasarn and Mr.Ekapong Chaiyasarn started the invention in 1998 with instruction from Professor Natthawut Boonreab from National Research Institute and succeeded in creating the corn cob charcoal. Previously, the farmers threw away all the corn cobs, but later they sold the corn cobs to Mr.Ekachai at 5-6 baht. He puts the corn cobs in the simple stove built with bricks with chimneys that was able to open and close. If the corn cobs were dry, it would take only 3 days to burn them to charcoal while the wet corn cobs would take 7 days. When the corn cobs were burnt, he would close all the chimneys so that the corn cob did not become ash, leaving the corn cobs in the stove until they cooled down. After 3-4 days, he would take out the corn cob charcoal. Some corn cob charcoal was in small pieces and some was powdered. The charcoal was not ready to be used because most of it was powdered, which was not good to light. He separated the corn cob charcoal from the ashes, removed any nails or steel scraps, and put the corn cobs in the charcoal grinder. He ground it into a coarse powder, mixed 100 grams of corn cob charcoal powder with 2 kilograms tapioca starch and a proper portion of water. He blended all the ingredients together. This process required a skillful person otherwise the charcoal may not have been able to hold its form during the molding process. The tapioca starch helped the charcoal stick together. When all ingredients were well blended, he scooped it and put it in the crushing machine then cut it into 5 inch lengths, leaving a hole in the middle of the charcoal for a better burning.

After the corn cob charcoal was cut, he put it in the oven for 8 hours at 60 – 80 degrees Celsius. When the charcoal was perfectly dry, it was ready to use. He sold the charcoal 8 baht per kilogram. The cost is 5-6 baht while wood charcoal was sold at 10 baht. Today, Ekachai has 5 stoves, 1 grinder, 1 mixer, 1 crusher and 1 oven. The production capacity is 10-12 tons per month. For those who wanted to produce the corn cob charcoal to sell, they needed to be where they could get corn cobs nearby or they could try to use other materials in their area. Another thing that they needed was at least 300,000 baht in funds because there was a lot of high priced equipment to purchase. It would be an advantage if they themselves were the technician. Nowadays, Ekachai is part of the community enterprise in the agricultural field. He received support funds from the Bank for Agriculture and Agricultural Co-operatives (BAAC), Dok khamtai branch.

The use of corn cobs There are many corn fields in Uttaradit. Each season, tons of corn cobs were thrown away and many people cut down trees to make charcoal. Promoting corn cob charcoal was not only a way to get revenue from the waste, but also reduced air pollution problems and deforestation. Corn cob charcoal provides high temperature of 6,300 calorie per gram and takes 1.30 hours to burn to ash while the wood charcoal provides a temperature of 4,300 calorie per gram and takes only 1 hour to burn to ash. The interesting thing is that the corn cob charcoal rarely emitted smoke. The Social Development Center supported the farmers in producing corn cob charcoal by giving some funds for purchasing machines. The farmers could invest with partners in order to strengthen the production efficiency.

Farmers were interested in producing charcoal because it was a way to create jobs in the community and earn more revenue. Corn cob charcoal is a briquette used for cooking in the household and could be a material for growing flowering and ornamental plants such as Flamingo Flowers and orchids. In addition, black water, which was the carbon evaporating during the charcoal burning process, could kill the grass within 15 minutes, so it could be used as an herbicide. However, further research was needed to support and confirm this issue before sharing the accurate knowledge with the public. The corn cob charcoal provided high temperatures for a long period of time without smoke, so it was favorable in the community in such places as noodle shops, grilled chicken shops and other restaurants. However, due to the low production rate, many people could not use the corn cob charcoal. If there was a group of operators who could produce the corn cob charcoal, they should be supported. The corn cob charcoal was a non-renewable briquette, so if there were manufacturers in each area, they would still get the market share.

Regarding the marketing promotion, charcoal producing cooperatives could be established. In case there were many producers, establishing producing cooperatives would strengthen the group. Meanwhile, the farmers in the area could earn extra revenue from selling corn cobs they collected to the producers. Corn cob marketing cooperatives could be established so that the villagers in the community would have an outlet to sell the corn cobs at a standard price. They could use corn cobs or the corn core to produce corn cob charcoal. The husks and stalks are used to feed animals or used in the industry. Even though the husks and the stalks could be a material for producing charcoal, the quality is not as good as the cobs. To make a corn cob charcoal, the corn cob would need to be burnt by first, getting three pieces, 2 inches in diameter each, and vertically line them up on the side of a 200 liter oil drum, not too close to the top or bottom of the drum, then, rotating the opening of the drum to the same direction of the wind before lighting some pieces of wood inside. When the fire is stable, put 1 portion of corn cobs in the drum (there will be 3 portions of corn cob). Once the flame grows around the drum without smoke, the corn cob is burnt and more corn cobs are needed to fill the tank. If the corn cobs cover the holes, seal those holes and close the opening of the drum. After that, turn the drum upside down on the ground or sand and leave it there overnight. On the next morning, when the drum has cooled down, cautiously get the charcoal out of the drum as it is still burning. From 100 kilograms of corn cobs, the resulting charcoal would be around 30-40 kilograms which would now be ready for crushing. The important point the producers should be aware of is that the whole corn cob must be completely burnt otherwise the final charcoal product would emit the smoke because the fibers left in the corn cob would cause the smoke when it is burnt.

This makes the corn cob charcoal less effective. Another point is that, when taking the corn cob charcoal from the stove, the producers should sift the charcoal finely in order to get a better charcoal quality. The innovation "Corn cob for a Better Life and Environment" initiated by the Social Development Center unit 72, Uttaradit, brought great advantages to the community. The corn biomass was an easily obtainable material in PaKhaLuang Sub-district, Ban Luang District, Nan which could be used to produce corn biomass charcoal. There was too much biomass to dispose of and it took a long time to bury it. Thus, there would be tons of corn cobs everywhere in Ban Luang District. Thus, the PaKhaLuang Sub-district Administrative Organization selected a representative in PaKhaLuang Sub-district to attend the seminar at Alternative Energy Resource, Naresuan University to learn about some ideas of corn cob disposal and transforming it into energy. The community received over 100,000 baht in funds from the Thai Khem Kaeng Project, so three machines, a corn cob grinding machine, a material mixer machine and a crushing machine were purchased for the uncomplicated process of producing the charcoal.

Corn cob charcoal production process

Firstly, the cobs need to be burnt to a charcoal. For this process the producers would stack the corn cobs up in a pile and burn them or burn them in the 200 liter drum with a long chimney above the drum which would reduce the smoke. However, burning corn cobs in a drum produces less charcoal so there was a study about the adaptation of 4 in 1 truck for burning the corn cobs so that the pollution from burning would be reduced. Second, grind the burnt corn cobs finely then mix the corn cob powders with tapioca flour and water. The portion is 100 grams corn cobs (burnt) : 10 kilogram tapioca flour : 2.5 liter water. After that, put it in the crushing machine, working like a common animal food extrusion, the machine will crush the material with the mold and push it out. Lastly, dry the charcoal which would normally only take 1 day before it is ready to use. This project of the community was worth the investment because there were many advantages from producing the corn cob charcoal. The advantages were that, people could utilize the waste in their community, reducing the deforestation and reducing the costs in their households. However, the community needed to discuss where to sell these products, and how much they should sell for, which was an important issue. If there was no market to support their products, the group of producers would not be stable. If they were going to only be using the charcoal in their households, then there was no need to invest so much. We hoped that the farmers could make extra revenue after cultivating the corn and we needed to find a market for the farmers.

2.2.8 Production of Windrow Composting without Turning.

Asst. Prof.Teerapong Sawangpanyangkura, Faculty of Engineering and Agro-industry, Maejo University, has acquired a proper knowledge for alternative management of the waste from cultivation.

The knowledge was an innovation that could produce a lot of organic fertilizer at one time by placing the materials into piles, 100-200 meters per pile. The point was that these piles did not need to be turned. The heart of this innovation was to keep the humidity in the pile stable. This method was called the Maejo 1 Engineering Method. With this method, those who were interested in producing high-priced organic fertilizer needed to put 4 portions of dung and 1 portion of crop residue into triangle-shaped piles.

There is no further action required after this, but keeping the humidity both inside and outside stable was very important. The producers may need to ask the Sub-district Administrative Organization for watering assistance. This method took only two months. One 4 meter pile will produce 1 ton of organic fertilizer which could be sold at 4,000-7,000 baht per ton and the cost for the dung was only 750 baht per ton. The farmers who produced organic fertilizer from their crop residue with the Non-Turning Method could make extra revenue from selling the organic fertilizer and also improve their soil conditions, and then the cost of chemical fertilizers would reduce. Some farmers could even operate an Organic Agriculture without chemical fertilizers. The farmers and local administrative organizations could consider this as an opportunity for their people to earn revenue, improving their lives and reducing the haze pollution problem. Maejo University used this method together with the National Research Council of Thailand to study the organic fertilizer production from seven groups of farmers in five provinces in the Northern of Thailand in order to prevent biomass burning.

2.2.9 The farmers always left the cornstalks and leaves in the planting area

Dr. Bruce E. Logan**,** professor of environmental engineering of the University of Pennsylvania**,** says that the farmers always left the cornstalks and leaves in the planting area. The 250 million tons of cornstalk and leaf biomass came from maize planting. This is the number three production crop that produces solid wastes from fields in United States. There is 90% biomass left in the fields every season. 70% of this biomass is cellulose or hemicellulose which is a group of complex carbohydrates bonding in a long chain. Using vapor pressure to break the bond would release organic sugar substances and other compounds from the corn biomass. At the moment, a researcher at the University of Pennsylvania is thinking about producing ethanol from the corn biomass. They also studied the sugar released from exploding the biomass with vapor pressure to feed microbes for producing electricity.

Using the sugar from biomass digestion with vapor pressure at the temperature of 180-200 degrees Celsius to produce electricity, Dr. Bruce E. Logan talked about how people paid attention to the study of using cellulose to produce sugar for microbial feeding. To produce the electricity, microbes would change the organic substance into a hydrogen gas. Then, it uses the hydrogen in the fuel cell and it turns it into an electrical current. Electrical currents come from movement of the electrons of hydrogen. Atoms, from the anode move to the cathode and is turned into electrical current. Hydrogen, that already released its electron, will combine with oxygen and is turned into water in the fuel cell and is released from the fuel cell. The process of turning the organic substance into an electrical current would not maintain enough organic substance to cause a pollution problem after getting rid of the liquid waste from the system.

Dr. Logan mentions this production method would give 1 watt of electricity per 1 square meter at 0.5 volts. The common light is a 60-watt light, so in order to increase the wattage, the fuel cell's surface area must be increased. To increase voltage, the fuel cells must be connected by series of connections.

2.2.10 Electricity Production from Corn Cobs with Gasification System

Mr. Aniwat Haphokee, engineer of an electricity plant, explains the electricity production process. It began with the Supreme Renewable Energy Co.,Ltd in 2006. The Supreme Renewable Energy Co.,Ltd surveyed the area in Lai-ngao Sub-district, Weangkaen District, Chaing Rai Province and established a biomass electricity plant which produced electricity using corn cobs. The company held public hearings in the community to share the knowledge with the people over a long period of time until the people accepted the idea in 2006, and then they successfully established the community's 100kw electricity plant in 2008.

This electricity plant was considered the first electricity plant in Thailand that supplied electricity from corn biomass to the Provincial Electricity Authority. Between 9:00am – 10:00 pm is the period of time when people consume the most electricity. It is called the 'peak time' and the price is higher during peak times than in off-peak times.

Producing electricity started by loading around 60 kilograms of corn cobs into the stove per hour. In an airless condition, the main products were carbon monoxide and hydrogen with a little methane. These gases are flammable and could be used as engine fuel and a dynamo generator. It gave benefit to the community because the farmers could sell the biomass to the electricity plant instead of burning it. This was a way to make extra income and reduced the pollution problem. Burning biomass in an airless condition also produced charcoal powder which was a material for producing charcoal bars. In the production process, they would use water to wash and clean off the gas and dust that came with the gas and cooled down the gas temperature. The water also came with the pyroligneous acid which could be used for agricultural activities. When considering the analysis of the economical investment of the electricity plant which used corn cobs as a material, over a 20 year operating time, with a rate of 6.5% interest with 100kW production capacity, the gross profit would be 1,640,000 baht per year. The IRR is 12.33% and payback period is 7.31 years.

2.2.11 Guidelines for Utilizing Corn Biomass from Studying the Maize Village, Less Haze Project.

Associate Professor, Ph.D. Suchon Tangtaweewipat, Department of Animal and Aquatic Science, Faculty of Agriculture, Chiang Mai Province University, along with her team were supported by the Ministry of Science and Technology, monitored by the director, Dr. Kanit Thirakhun, to use the agricultural scientific knowledge to instruct the farmers in order to reduce corn biomass burning at Baan Bonna, Moo 14, Chang Kerng Sub-district, Mae Chaem District, Chiang Mai Province. To reduce the corn biomass, the farmers used the biomass for growing mushrooms or beans, paved inside the stables or made fermented food for cattle from the husks and cobs. The corn cobs could be used as a fuel in the household or as dry fuel for agricultural products. It could also be used as a material for making charcoal. The husks could be a material for making paper. The promotion of those activities took 3 years (2011-2013), but it was not successful. Biomass burning still existed and the haze pollution problem continued until 2014. From the models of promoting utilization of corn biomass which were not successful, the author selected three potential models that could be improved upon which were using the corn biomass for growing mushroom, making a fermented food for cattle and making compost. The author spotted some flaws in the processes and methods of use in these three models, so the author fixed it so that these models worked practically and the farmers could make extra income. The reason that the author selected these three models was because they were ways to use up the biomass and the farmers themselves could avoid the burning that caused the haze pollution. If these three models were effectively operated, there would be no biomass left, and there would not be burning or air pollution. The benefit would also be decent enough for the operators to continue.

2.3 Principle for Problem Solving

The method that was suitable and had a potential in real practice for solving the air pollution and deforestation caused by the maize planting and biomass from the production was to collect all the biomass and use it for commercial purposes. The method could be used in in real practice, was not complicated and the farmers themselves could operate the production or they could collect biomass then sell it to the organizations that needed to use the biomass for things such as making a fermented food for cattle during the summer, mixing it with manure to produce organic fertilizer to replace the chemical fertilizers, reducing production costs and improving soil conditions. Some could use the biomass to grow the mushrooms instead of using sawdust from rubber wood which has very expensive due to the transportation costs. The transportation management was another issue to be discussed. Since there was biomass in many areas, collecting and moving it properly were tasks to complete. The corn miller would need to be placed in the center zone so that people could move the collected biomass to the zone easily. The biomass grinder would need to reduce the biomass size to 5 millimeter with an economical price. The machine would need to be able to be moved to the area which biomass was gathered. This led to the study of biomass' primary transformation so that the biomass could be well collected, moved and stored economically. The biomass would need to be ready to use or competitive with other materials without further transformation. The area of study was Mae Na Chon Sub-district, Tha Pha Sub-district and Chang Kerng Sub-district, Mae Chaem District, Chiang Mai Province because the maize planting was a regular job in every household. In addition, according to an aerial photograph of Mae Chaem District, this area had many hotspots every year where it was a source of polluted air from the biomass burning.