An Opportunity on New Biomass Materials Application for Renewable Energy in Thailand: Perspective of Pineapple Farmers

Kttinun Boonrod and Pichet Ninduangdee

***Abstract*—** This study was based on a survey research design aimed at examining the feasibility of using biomass materials from pineapple plantations for energy production based on the viewpoints of pineapple farmers as the main source of raw materials under the topics of interest in gathering each type of raw material, incentive and obstacles to gathering the raw materials, including guidelines for gathering raw materials in the future. This research employed the Cochran Method to set the sample size with a confidence level of 95 percent. The research went into the field to conduct the survey with questionnaires in 200 pineapple farmers in Phetchaburi Province and Prachuap Khiri Khan Province where 0.036 million hectare of pineapples are grown, or 48.00 percent of all pineapple plantations in Thailand. According to the main findings, raw materials in the form of leftover pineapple biomass are composed of crown leaves, leaves, ground sucker, root stalk and stubble. Crown leaves are raw materials that have attracted the greatest interest in gathering as raw materials and stubble has attracted the least interest. As for approaches to gathering raw materials, the findings revealed that agricultural associations/groups/clubs are the people best suited for compiling and buying raw materials. In terms of obstacles to gathering, labor and factoring involving convenience were found to be significant obstacles in gather raw materials. Both of these factors were in the highest zone.

***Keywords*—**Pineapple, Residues, Biomass, Renewable Energy

I. Introduction

Pineapples are another economic crop in Thailand, which is the number-one in ten pineapple producers worldwide. Furthermore, according to a report from the Office of Agricultural Economics in 2016, the western region has a total pineapple plantation area covering the following four provinces: Prachuap Khiri Khan, Phetchaburi, Ratchaburi and Kanchanaburi for a total plantation area of 0.044 million hectare, or approximately 58.67 percent of the plantation area nationwide (0.075 million hectare). The present study targeted the provinces of Prachuap Khiri Khan and Phetchaburi as the main study area. In 2016, both provinces had a total pineapple plantation area of 0.036 million hectare, or 81.81 of the western pineapple plantation area, with total production as high as 0.87 million tons, or 79.09 percent of production nationwide [1].

Another policy movement in Thailand is found to be supporting the biomass application for decreasing the need to import energy from abroad and help solve the energy crisis in the country. This energy scheme is proposed as part of the national Renewable and Alternative Energy Development Plan for 25 Percent in 10 Years (AEDP 2015-2036) for Thailand. According to this plan, the target energy production from renewable energy from Biomass (Thermal Energy) in the year 2036 is set at 22,100 kiloton of oil equivalent (ktoe) where the baseline production in 2014 is at 5,144 ktoe. [2]

When the date from the Department of Alternative Energy Development and Efficiency is considered in terms of the chemical properties of scrap materials from pineapple on use for energy, the findings indicated that stubble biomass from pineapples has a heat value of 15.76 MJ/kg, which is a higher heat value than rice husks (14.40 MJ per kilogram). Furthermore, based on reports on the energy capacity of pineapple in 2013, pineapple stubble was found to have solid biomass energy capacity for the entire country at a 484.61-thousand-ton equivalent to crude oil [3]. Moreover, the findings of a study by Braga and et al. [4] on the heat value of pineapple crown leaves, which have a heat value of 18.93 MJ/kg. The above data indicates the capacity of the aforementioned in using leftover pineapple biomass to use as fuel in the production of alternative energy. At the same time, however, no use of raw materials from pineapple fields in the production of any energy either in the public or private sectors. For this reason, the conceptual framework for the present research has been devised with the goal of studying the feasibility of using biomass from pineapple fields in producing energy based on the viewpoints of pineapple farmers as the main source of raw materials under the topics of interest in gathering each raw material, factors on incentive and obstacles to gathering the biomass as well as approaches to gathering the biomass in the future. The research findings will serve as key baseline data in planning for the development of using pineapple biomass as fuel or in other capacities in the future.

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II. METHODOLOGY

A. Scope of Study

The scope of the study was set in two provinces in Thailand, namely, Phetchaburi and Prachuap Khiri Khan where the plantation area is approximately 60 percent and the collective production capacity is approximately 80 percent of all pineapple plantations in Thailand (Fig.1). The sample size was set by the Cochran Method [5] by setting the confidence level at 95 percent. The researcher went out into the field to conduct a questionnaire survey with 200 pineapple farmers covering both provinces and data was collected from January to June 2017.

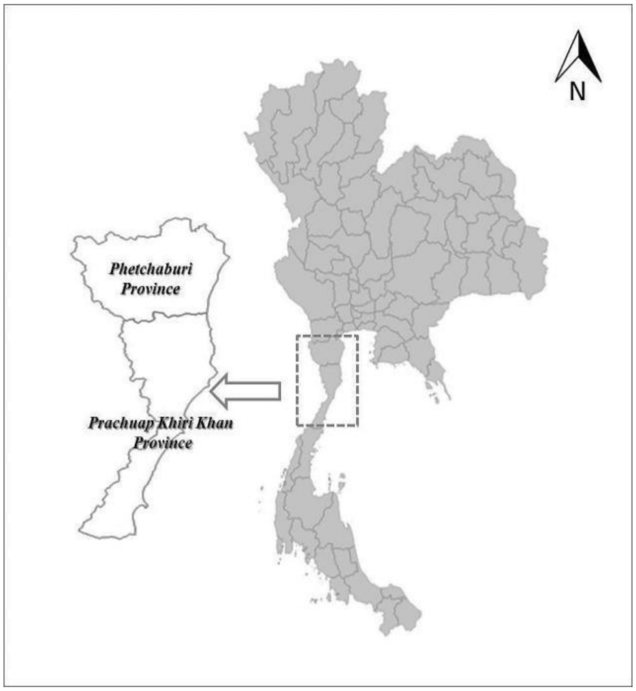

Fig. 1 Target study area

B. Research Tool

In the present study, the researcher went into the study field to interview pineapple farmers there. The instrument used was a questionnaire with open- and close-ended questions. The questionnaire was submitted to the process of examination for accuracy by experts and tested for instrument reliability before conducting the real survey. The reliability analysis by using Cronbach´s Alpha Coefficient resulted in a reality score of 0.78. The present study was aimed at examining the characteristics of biomass generation and the opinions of pineapple farmers about using leftover biomass to produce energy. The study of opinions was composed of 6 topics with 27 questions (Fig. 2) as follows: 1. Degree of willingness to gather the raw materials (WILLIN); 2. Approaches to gathering the leftover materials (APPROCH); 3. Direct incentive for gathering (INCENT); 4. Indirect incentive for gathering (IN_INCENT); 5. Perception on opportunity and participation (OPPOR) and 6. Obstacles to gathering (OBSTAC). The scoring system applied is the 5 levels Likert Scale where each of the range are marked as <1.80 being lowest, 1.81 – 2.60 low, 2.61 – 3.40 moderate, 3.41 – 4.20 high and 4.21 – 5.00 highest.

Topics	Question
Willingness to gather the raw materials (WILLIN)	- You are willing to gather crowns for use in energy production. (CRW) - You are willing to gather ground suckers for use in energy production. (SCK) - You are willing to gather leave for use in energy production. (LEA) - You are willing to gather stalk for use in energy production. (STK) - You are willing to gather stubble for use in energy production. (STB)
Approaches to gathering the leftover materials (APPROCH)	- You are willing to become a middleman/entrepreneur in gathering and purchasing materials. (ENTP) - Processing Factories are the most suitable parties for gathering and purchasing biomass. (FACT) - Produce purchase yard owners are the most suitable parties for gathering and purchasing biomass. (MARK) - Agricultural Equipment/ Supply Stores are the most suitable parties for gathering and purchasing biomass. (SUPL) - Agricultural associations/groups/clubs are the most suitable parties for gathering and purchasing biomass. (CLUB) - Municipality or government agencies are the most suitable parties for gathering and purchasing biomass. (GOVE)
Direct incentive for gathering (INCENT)	- Cost effectiveness and profit influence your decision to gather materials (IC 1) - Incentives in the categories of prizes, discounts, special privileges, etc. Influence your decision to gather materials. (IC 2) - You are willing to gather any type of material as long as you consider doing so to be economically viable and investment-worthy. (IC 3)
Indirect incentive for gathering (IN_INCENT)	- Non-monetary incentives such as social benefits, environmental benefits, etc. Influence your decision to gather materials. (IN_IC 1) - You are willing to gather any type of materials if you deem that doing so will create activities that benefit the community and society, even if they are not cost effective. (IN_IC 2) - You are willing to gather any type of materials if you deem that doing so will create environmentally-friendly activities, even if they are not cost effective. (IN_IC 3)
Perception on opportunity and participation (OPPOR)	- You think that leftover materials from pineapple plantations can be used as raw materials in alternative energy production in the future. (OP1) - If leftover materials from pineapple plantations are utilized and processed into other products beyond those that are currently available, the market value of these materials will increase. (OP2) - If in the future the use of leftover materials from pineapple plantations in alternative energy production is promoted, revenue will be generated for farmers and you, too. (OP3) - You will be able to generate income for yourself if the use of alternative energy from biomass is promoted in the future. (OP4) - This is your first step toward making use of biomass and paying attention to the environment and alternative energy and will lead to additional studies for information. (OP5)
Obstacles to gathering (OBSTAC)	- Labor is a major obstacle to your gathering of materials. (LABO) - Your free time is a major obstacle to your gathering of materials. (TIME) - Terrain inconveniences are major obstacle to your gathering of materials. (INCO) - Storage facilities are major obstacle to your gathering of materials. (STOR) - Uncertainties in the purchase price of materials are a major obstacle to your gathering of materials. (PRIC)

Fig. 2 List of Questions

C. Data Analysis

The data obtained was analyzed by using descriptive analysis with the following statistical values: percentage, mean and standard deviation. The data was then analyzed with inferential statistics by using Pearson Product Moment Correlation Coefficient in order to find the correlations between the two variables. Testing the opinions on various issues led to planning by telling the degree or extent of the correlations by using the R value. In cases where the R value approached -1 or 1, a high degree of correlation was indicated. If, however, the value was near 0, a low degree of correlation or no correlation at all was indicated. A negative R value indicated a correlation in the opposite direction, while a positive R value indicated a correlation in the same direction.

Generally speaking, consideration of the R value relies on the following criteria for interpreting the findings:

0.90 to1.00 and -0.90 to-1.00 as a highest correlation
0.70 to 0.89 and -0.70 to-0.89 as a high correlation
0.50 to 0.69 and -0.50 to-0.69 as a moderate correlation
0.30 to 0.49 and -0.30 to-0.49 as a low correlation
0.00 to 0.29 and 0.00 to-0.29 as a lowest correlation

III. Result and Discussion

A. Characteristics of the generation and use of biomass materials

In Thailand, pineapples are predominantly grown in two areas. Nearly all of these areas are located in the western region, followed by the eastern region in the provinces of Chonburi, Rayong and Trad [1]. According to the findings, the pineapple farmers' cultivation and harvesting behaviors in the western region mean that farmers harvest approximately three sets of pineapples per planting, which is different from the eastern region where farmers harvest only once. Thus, the following five types of biomass are produced by pineapple plantations:

- Crown Leaves (CRW) are biomass that is found at the tops of pineapple fruits. Once the pineapples have matured sufficiently to harvest, the farmers cut the crown leaves and leave them in the fields, sending only the fruits to food processing factories. The factories buy only the pineapple fruits, which is different from pineapples that are consumed fresh and sold in the marketplace where they keep their crown leaves to maintain the freshness of the produce. The crown leaves can be used to cultivate the next crop, but this practice is only popular in the eastern region.

- Leaves (LEA) have been found to be a biomass material made up of the leaves cut off in the furrows of the fields. Pineapple farmers usually cut off the pineapple leaves to facilitate work. The part of the plants cut off and discarded is only the part adjacent to the path. Farmers who do not do this work themselves hire field laborers to cut off the leaves. The scrap leaves that have been cut off are not used for anything. Rather, they are only discarded to cover the top soil where they biodegrade to fertilize the pineapples.

- Ground Suckers (SCK): According to the survey findings, all of the farmers in the western region use the ground suckers as material for further cultivation in planting the next crop. The leftover ground suckers are sold to other farmers. Thus, the ground suckers are considered a material that is in demand and valued in the current marketplace.

- Root Stalk (STK) is the part that is underground. Current findings reveal that this part is beginning to be sold for use as a raw material in the production of Bromelain Enzyme, a ingredient used in mixing animal feed. However, this practice is only encountered in the eastern zone, because the eastern zone commonly harvests only one crop per year. Therefore, there is a large amount of rootstock each year, which is different from the plantations in the western region where farmers plant three crops per year. The sales are conducted in the form of lump sum purchases per rat, depending on the plant size.

- Stubble (STB) is a material that is generated when farmers clear their fields to plant new crops. In this practice, the farmers plow up and over through the stubble to use it as fertilizer in preparing the soil for the next crop. The stubble components are made up of stalk, rootstock and some parts of leaves leftover from slashing before harvesting the fruits.

Fig. 3 (a) Cut Crown Leaves after Harvest, (b) Leaves Discarded along Pathways, (c) Ground Suckers Bundled for Subsequent Sale and Reproduction, (d) Dead and Dried Stubble after Last Harvest

B. Opinions about the Use of Biomass Materials for Energy

The study on the farmers' willingness to gather materials found the farmers to be moderately satisfied about gathering materials with a mean value of 3.18 (TABLE I). Crown leaves were the materials that produced the highest level of willingness with a mean of 4.36, while stubble ranked last with a mean value of 1.89 (Fig.4 (a)).

The study on the approaches used to gather leftover materials found that farmers' associations/groups/clubs (CLUB) were the most suitable people for gathering and buying materials with a mean value of 4.11, followed by the SAO municipality or government agencies (GOVE) with a mean value of 3.86, which is also in the high zone (Fig.4 (a)).

At the same time, the study on the direct incentive for gathering found monetary incentives and investment cost effectiveness to be required by farmers for biomass gathering to occur with a mean value of 4.61, which is in the highest zone. On the other hand, indirect incentives or non-monetary incentives such as social and environmental benefits were in the high zone with a mean value of 3.50 (TABLE I).

As for the study on perceived opportunity and participation (OPPOR) in activities, the farmers were found to have overall awareness in the highest zone with a mean value of 4.26, while opinions about obstacles to gathering were in the moderate zone with a mean value of 3.05 (TABLE I). Labor obstacles (LABO) and inconvenience factors (INCO) such as difficulty and challenges in gathering materials were found to pose significant obstacles to gathering materials. Both factors were rated in the highest zone with mean values at 4.61 and 4.47, respectively (Fig.4 (b)).

C. The analysis of factors correlated with willingness to gather materials

Upon considering the analysis results and factors related to willingness to gather materials analyzed by using Pearson' product moment correlation coefficient, the obstacles to gathering were found to be the only factor correlated with willingness to gather materials with statistical significance at 0.05 with a moderate inverse correlation. (R = -0.59). Hence, it can be interpreted that reducing the obstacles to gathering will increase willingness to gather materials (TABLE II).

Furthermore, correlation analysis was conducted again with the inclusion of only factors sharing correlations between obstacles to gathering and willingness to gathering materials. In-depth considerations were made on each sub-issue. For obstacles to gathering, there were labor factors, time (TIME), terrain inconveniences, storage facilities (STOR) and uncertainty regarding material prices (PRIC). The material types were crown leaves, leaves, root stalk and stubble. Ground suckers were not included in the analysis because the material is already fully utilized.

The analysis found two material types to be correlated with obstacles with statistical significance, namely, root stalk and stubble. For root stalk, only the storage factor had no influence on material gathering behaviors, while labor, time, inconvenience and price uncertainties were all correlated with the decision to gather root stalk with statistical significance. All of them had inverse variations with the willingness to gather materials. In other words, farmers would have greater willingness to gather root stalks only with the decrease in all of the four aforementioned factors (TABLE II). As for stubble, inconveniences, labor and storage were found to be significant factors that had inverse correlations with willingness to gather stubble (TABLE II). This means that the application of technology to facilitate gathering stubble is an option that should be considered.

IV. Conclusion

It is generally known that the current environmental and energy problems are at a critical stage and that cooperation is required to resolve these problems in a structured manner. The use of alternative energy is a means of resolving the aforementioned problems, especially alternative energy derived from biomass. From past to present, there have been several research publications that have endeavored to utilize leftover biomass materials from agriculture as raw materials for energy production such as through the conversion of rice hay and discarded longans into fuel lumps for thermal energy production [6] and biogas electricity production using biomass containing high levels of lignocellulose (hay, sugarcane husks, rice husks and maize) [7], etc. However, biomass derived from pineapple was not found to be currently used in the same manner.

In any case, the aforementioned findings concluded a preliminary study that pointed out the feasibility of using agricultural leftover materials in energy production. They are guidelines for planning that can be used to accompany decisions about development. The aforementioned also described perspectives about management and investment guidelines on pineapple biomass. The significant findings of the study are as follows: The leftover biomass derived from pineapples is composed crown leaves, leaves, ground suckers, root stalks and stubble. Crown leaves are the materials farmers are most willing to gather, followed by leaves. The material pineapple farmers are least willing to gather is stubble. For approaches to gathering materials, farmers' associations/groups/clubs were found to be the most suitable parties for gathering and purchasing materials, followed by government agencies. In terms of obstacles to gathering, labor and inconvenience were significant obstacles to gathering and rated at the highest level, while storage was moderate. In addition, on the factors correlated with willingness to gathering materials, obstacles to gathering were the only factor found to be correlated with willingness to gather materials. In-depth analysis on the individual issues found that willingness to gather root stalks and stubble had inverse correlations with obstacles to gathering with statistical significance. If farmers' willingness to gather the two aforementioned types of materials is to be increased, it might be necessary to play studies or adopt technologies to support harvest or gathering in order to solve labor, time and inconvenience problems as well as to boost price confidence to a level deemed acceptable by farmers, all of which will positively affect biomass gathering on pineapple plantations.

Fig. 4 (a) Findings on Material Types and Gathering Guidelines,
(b) Findings on Incentives, Opportunities for Participation and Obstacles to Gathering

TABLE I
ANALYSIS OF FACTORS CORRELATED WITH WILLINGNESS TO GATHER MATERIALS

Factor	Descriptive Analysis			Pearson Correlation Analysis WILLIN		
	$\tilde{x}$	S.D.	Level	R	Sig.	Relation
INCENT	4.6	0.2	Highest	0.087	0.22	Lowest
IN_INCENT	3.5	0.8	High	0.075	0.29	Lowest
OPPOR	4.3	0.3	Highest	0.037	0.6	Lowest
OBSTAC	3.1	1	Moderate	- 0.59*	0.02	Moderate
WILLIN	**3.2**	**0.4**	**Moderate**	**1**	-	-

* Correlation is significant at the 0.05 level (2-tailed).

TABLE II
ANALYSIS OF FACTORS CORRELATED WITH OBSTACLES AND MATERIAL TYPES IN GATHERING

Type	Result	Obstacle Factor				
		LABO	**TIME**	**INCO**	**STOR**	**PRIC**
CRW	R - Value	0.11	0.05	0.04	0.03	0.04
	Relation	Lowest	Lowest	Lowest	Lowest	Lowest
LEA	R - Value	0.05	-0.03	-0.015	-0.023	-0.02
	Relation	Lowest	Lowest	Lowest	Lowest	Lowest
STK	R - Value	-0.27**	-0.28**	-0.32**	-0.02	-0.31**
	Relation	Lowest	Lowest	Low	Lowest	Low
STB	R - Value	-0.15*	-0.09	-0.29**	-0.15*	-0.03
	Relation	Lowest	Lowest	Lowest	Lowest	Lowest

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

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