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BIOMASS FUEL POTENTIAL FROM AGRICULTURAL PRODUCT WASTES IN SOUTHERN BORDER PROVINCES, THAILAND

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ABSTRACT

The aim of this research is to study the properties and economic value of biomass briquette from various agricultural product wastes such as bagasse, rice husks, corn husks with cob, peanuts husks and Durian peel in order to reduce air pollution from burning wastes and use as alternative energy in biomass power plants and communities. The biomass sticks in this study was produced by hand-press machine mixing with pasty tapioca starch at the best ratios. The fuel properties of briquette were analyzed according to ASTM standards. The study results showed that the heating value of the various briquette is in the range between 3,299 (husks) - 4,661 (peanut husks) Kcal/g. The moisture, volatile, ash, and fixed carbon content are 7.24 (corn husks with cob) - 11.64 (bagasse), 61.65 (husks) - 75.91 (corn husks with cobs), 0.72 (bagasse) - 13.21 (husks) and 12.74 (corn husks with cob) - 16.97 (Durian peel and bagasse) %, respectively. The proper proportion for pressing fuel briquette is dry agricultural product wastes 1,000 g: pasty tapioca flour 150 g which produced from heated mixed tapioca flour 100 g with water 180 g. The economic value of biomass briquette production was analyzed using net present value (NPV), internal rate of return (IRR) and payback period (PB). The analysis results show that the biomass briquettes production from wastes of agricultural product is economically feasible. Moreover, the results show that the most influential risk factors of the biomass production are fuel price and number of fuel production daily, followed by specification and price of machines and number of agricultural productions.

Keywords: *biomass potential; agricultural product wastes; southern border provinces*

INTRODUCTION

Garbage is a major problem that all sectors have to take action to resolve and deal with in the area. Due to the impact on people living in the area directly year 2014-2018, Thailand has a total amount of waste 28.14 million tons. They are from the waste generated by the sanitary method, only 28.5 per cent, with unsanitary disposal and 31 per cent smuggled in unsuitable locations and 26 per cent are recycled. The residual waste in areas that are not collected or disposed of 32 percent of the increasing amount of waste each year, causing waste management problems in many communities. Some communities use a participatory waste management process has set up a waste bank Waste management is done by making organic compost. Waste is processed into renewable energy in the form of biogas and waste fuel and etc [1].

Using municipal waste to produce fuel pellets in addition is helping to solve the problem of municipal waste, it can also be used as a substitute for household cooking fuels as another form because the process is simple and for community is easy to do. Especially rural communities that have a way of life and behavior of using wood and charcoal for cooking. And using pellet fuel is another option for the community. In addition, the use of pellet fuel is developed at the industrial level and is the main fuel in power plants. There are more education and development but not suitable in this border area. The researcher expected that this would be another large channel for community development at a macro level while being able to manage community waste at the same time [2]. From the model of using pellet fuel as a renewable energy, many kinds of agricultural waste and waste materials have been researched into the production of pellet fuel such as durian husks, mangosteen peel, rice straw, twigs, leaves and corn cobs. The properties of this pellet fuel can be used as a substitute for firewood and wood charcoal as well. But the efficiency of using as fuel potential in southern biomass power plants has not been studied. Due to the southern area is quite a large amount of agricultural product, thus high agricultural residues and waste are disposed and burned. It also destroys the environment [3].

This research is to study experiments to develop pellet fuel from organic waste of agricultural products. Which is a waste that occurs in the community to produce pellet fuel for use as a renewable energy in the community. Especially for use in southern biomass power plants. As well as fuel to sell to power plants because the above agricultural residue contains cellulose, hemicellulose and flax with combustible properties [4]. And it is also another process that helps solve the problem of rubbish in the community.

STUDY AREA

The southern border consists of three provinces: Pattani, Yala and Narathiwat, located at the southern end of the country and bordering Malaysia. It has a border to the south and west with Malaysia. Total distance between Thailand - Malaysia 258 kilometers with mountains Sankalakiri ridge as a barrier. North and East Next to the Gulf of Thailand, a distance of 172.31 kilometers. The southern border has a total area of 6.84 million rai. Topography in the central and southern part of the region has the Sankalakiri mountain range (Yala and Narathiwat) resting in the east-west line and a border between Thailand and Malaysia in the east, it is a river plain along the Thai Gulf coast in Pattani and Narathiwat provinces.

Southern border is located near the equator. It is characterized by hot, humid, monsoon weather. The average temperature is 28 degrees Celsius. It is influenced by the southwest monsoon. During the period from mid-May to mid-October This causes a lot of rain in the western part of the region and is influenced by the northeast monsoon wind that prevails in mid-October to mid-February. Causing a lot of rain around the area East side of the region the average number of rainy days is 148.7 days per year and the average rainfall is 1,781.7 millimeters per year [5].

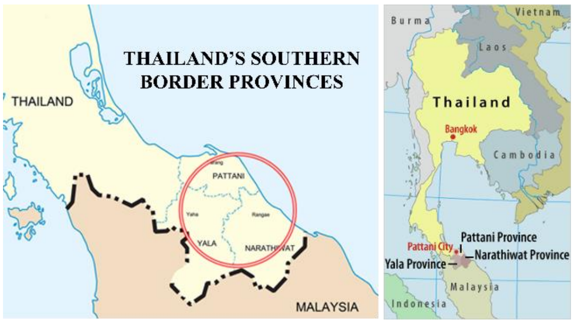

Fig.1 The southern border Provinces (https://www.thailand-business-news.com/wp-content/uploads/2011/09/thailandsouthmaplegend) (http://www.pbs.org/frontlineworld/rough/roughimages/thai_map_sm.gif)

In 2018-2019, there was a total area of 6.8 million, with land utilization classified as a forestry area, not 1.7 million rai or 25.0 percent of the total area. Mangrove area 0.22 hundred thousand or 0.33 percent of agricultural area 3.4 million rai (rubber, palm, fruit and rice fields) or 50.0 percent of the total area. And other utilization areas 1.66 million rai or 24.5 percent of the area of the region. In 2018, the agricultural sector accounted for 31.1 percent of the region's products. The agricultural sector's economic activity is important as the majority of people work in agriculture. However, the share of the agricultural sector is likely to decline compared to 38.1% in 2013. This is because the prices of major agricultural products, especially rubber, have continued to decline. Industry sector is relatively stable. The percentage of production was 10.1 percent, while the service sector tended to increase. In particular, the education service and government service sector have an increasing trend from allocating government budgets to develop and improve the quality of life of the people and resolve the unrest in the border provinces in the Deep South.

The agricultural production of the southern border is still the same as it has been processed. In 2017, agricultural products were valued at 44,048 million baht that accounting for 31.1 percent of the region's product value. Decreased from the year 2013 with a value of 50,192 million baht. The expansion of the agricultural sector contracted by 7.9 percent compared to the previous year [5].

The amount of solid waste tends to increase slightly in the period 2013 - 2017, the southern border region, the rate of solid waste has increased by an average of 2.20 percent per year, with the year 2017 the amount of waste generated 0.74 million tons or 2,030. Tons per day or equivalent to 2.70% of the total amount of waste generated in the country. An increase from 2016 in the amount of 13,518 tons or 0.1% increase [6].

The development of strategy 1: Develop agro industry and agricultural processing industry to stabilize the manufacturing sector encourage smallholder farmers to adjust their production systems to be self-sufficient and to promote sustainable agriculture such as new theory agriculture, integrated agriculture, organic agriculture. It is a safe and environmentally friendly agriculture.

The southern border provinces of Thailand are Yala, Pattani and Narathiwat with fertile areas and natural resources. There is a forest, hills, trees. Animal species also in the area of Pattani and Narathiwat, adjacent to the Gulf of Thailand

Such fertility conditions, therefore, the southern border provinces are areas which is very conducive to farming Whether it is growing both short-term biennial crops and Perennial plants, animal husbandry, both terrestrial and aquatic animals Agricultural service or even a business agricultural related trade.

There are 247,090 farmers households out of the total 329,255 households.

Which accounts for 75.00 percent of the total number of households living in the three southern border provinces.

The economic structure of these provinces depends on Agricultural production is the main in which 72.00 percent of the total agricultural area is planted rubber [7] But dealing with agricultural waste in the southern regions Most often, use a simple and easy way. That is, burning in the open air which tends to burn more every year especially the higher the price of agricultural products, the higher the incineration of agricultural waste.

MATERIAL AND METHODOLOGY

Agricultural waste-pellets preparation

The fuel pellets in this research were used cold-press technique by using tapioca starch water as a binder. Because tapioca starch is a binder with high thermal value and can bind the material to homogenize and enhance physical properties [8] At this stage, the properties of the raw materials used in it are analyzed. Fuel briquettes include Para-rubber wood, bagasse, corn husks with cobs, rice husks, bean husks and agricultural waste with durian husks which is the main raw material of fuel and tapioca starch which acts as a binder and heat (heating value) of all raw materials according to ASTM D7582 Standard [8].

Fig. 2 waste-pellets material preparation

Waste pellets properties analysis

Fuel Properties Analysis of Fuel Bars by using briquettes of biomass fuel to analyze the fuel properties by analyzing different quantities as follows:

(1) Heating value is analyzed according to BSEN14918 standard.
(2) Moisture content was analyzed according to ASTM D7582 standard method.
(3) Ash content was analyzed in accordance with ASTM D7582 standard method.
(4) Volatile matter content was analyzed in accordance with ASTM D7582.
(5) Fixed carbon analyzed in accordance with ASTM D7582.

Waste pellets Economical analysis

This research analyzes the reduction in greenhouse gas emissions, net received energy and economic cost-effectiveness of biomass briquette production from agricultural waste. Considerable environmental benefits, in this research, the amount of greenhouse gases that can be reduced in the form of carbon dioxide equivalent (CO2e) using kilograms This quantity can be calculated is obtained from the following equation [9],

$$ER = BE\text{-}PE \qquad (1)$$

Where ER is the reduction in greenhouse gas emissions from activities (greenhouse gas emission reduction) (kgCO2eq)

BE is the amount of greenhouse gas emissions in base case or amount of greenhouse gas emissions when No activity (baseline emission) (kgCO2eq)

PE is the amount of greenhouse gas emissions in the event that the project or business (project emission) (kgCO2eq)

In case of net received energy
It is calculated from the following equation [10],

$$Enet = E0\text{-}Ei \qquad (2)$$

where Enet is net energy (kcal/kg)
Eo is the energy received (kcal/kg)
Ei is the energy required for the activity (kcal/kg).

This analysis was to assess the suitability in practice The project yield was analyzed to assess whether the benefits from agricultural waste disposal to produce briquettes, is it worth the cost of investment and management? Can it be an alternative for farmers to use as a way to manage agricultural waste and be able to operate sustainably? In addition, project risks were analyzed in order to identify the risk factors for the implementation of the project in practice with the steps project return analysis and sensitivity analysis.

1) project return analysis such as net present value, NPV), internal rate of return (IRR), and payback period, PB).

1.1) Net present value (NPV) is the net present value of the net cash flows over the project life at the desired rate of return or the cost of investment in the NPV project. can be calculated from the following equation.

$$NPV = \sum_{t=1}^{n} \frac{CF_t}{\left(1+\frac{i}{100}\right)^t} \qquad (3)$$

Where n is the age of the project (years), t is the year index over the project period (years), t =1, 2, 3, …, n, and CF_t is the project's net cash flow in year t equal to cash inflow in year t - cash outflow in year t (Baht), i is the discount rate or the desired rate of return (%)

The criterion for making decisions is investment. is a project that yields value when NPV ≥ 0, and Not worth when NPV < 0

1.2) Internal rate of return (IRR) refers to the rate of return made. Let the present value of net cash flows over the project life be zero. represents the rate of return. The average project life cycle IRR can be calculated from the following equation.

$$NPV = \sum_{t=1}^{n} \frac{CF_t}{\left(1+\frac{IRR}{100}\right)^t} \qquad (4)$$

Where n is the age of the project (years), t is the year index over the project period (years), t =1, 2, 3, …, n, and CFt is the net cash flow of the project in year t equal to cash inflows in year t - cash outflows in year t (Baht), IRR is the internal rate of return (%).

1.3) The simple payback period (PB) refers to the period during which the accumulated cash inflows equal the cash outflows from investments. It is a measure of the project's risk profile. The decision criterion is to accept the project when PB ≤ target payback period.

2) sensitivity analysis to analyze project risks with the following steps;

2.1) Determine the variables with uncertainty to be studied.

2.2) Specify the scope of possible values or the range of interest for each variable.

2.3) Change the value of the variable of interest one by one with the remaining variables fixed, and calculate the NPV, IRR and PB values of each case to analyze the relationship of NPV, IRR and PB with the changes of each variable. In this research, the sensitivity of four factors affecting project returns is analyzed: the amount of fuel produced per day; machine price Labor cost and number of days of production per year [10].

RESULTS AND DISCUSSION

Prepared Agricultural Waste-Pellets

Appropriate ratio between crushed agricultural waste and binder with ratio between tapioca starch and water at 1:1.8 is obtained. Mixture of shredded material and binder at 100 g per 15 g. By specifying that the fuel obtained must not exceed the size of the biomass fuel rod used in the biomass power plant (not more than 10 centimeters in length and not more than 1 centimeter in diameter).

Fig.3 Agricultural Waste-Pellets

Waste pellets properties

Table 1 The physical properties of Waste pellets

Waste pellets Type	Density	Moisture content	Volatile
Para rubber wood	0.85	9.05±0.04	74.82±0.47
bagasse	0.82	11.64±0.07	74.90±0.09
rice husks	0.84	10.64±0.03	61.65±0.12
bean husks	0.99	10.03±0.02	67.84±0.12
corn husks with cobs	0.74	7.24±0.04	75.91±0.59
Agri-waste with durian husks	0.67	8.47±0.02	69.54±0.47

The moisture content test showed that corn husks with cobs and Agri-waste with durian husks had the lowest moisture content, while bean husks, rice husks and bagasse had similar and higher moisture content than the rubberwood fuel used in power plants but still had the highest moisture content. within the standard of the power plant. Therefore, the development of biomass fuels in terms of moisture should consider adding corn husks with cobs as they can reduce the amount of moisture remaining after drying. which will directly affect the heat value Because if the waste has a lot of moisture, there will be a loss of heat due to the evaporation of moisture during combustion. lower the heat value.

Volatile Matters testing showed that corn husks with cobs and bagasse had a high content of volatile waste. When heated, waste with such high volatile content tends to have a high calorific value. However, it is necessary to study the properties of certain volatile substances that may cause problems for materials or equipment that use fuel materials, such as alkaline substances in palm bunches. Will become sticky rubber sticks to the water pipes in the combustion chamber. causing the efficiency of the radiator to decrease [10], [11]

Table 2 The chemical properties of Waste pellets

Waste pellets Type	Fixed carbon	Ash	Heating value
Para rubber wood	14.73±0.52	1.40±0.02	4,039±64
bagasse	12.74±0.17	0.72±0.04	3,618±18
rice husks	14.50±0.09	13.21±0.00	3,299±16
bean husks	14.00±0.25	8.13±0.35	4,661±92
corn husks with cobs	15.11±0.55	1.74±0.02	3,907±12
Agri-waste with durian husks	16.97±0.48	5.02±0.01	3,932±108

Fixed Carbon Test which is a difficult volatile compound which will remain in the waste after incineration of volatile substances at 750 degrees Celsius. Agri-waste with durian husks and corn husks with cobs have the highest amount of Fixed Carbon and higher than Para rubber wood fuel. So it has a long burning time. Therefore, to develop biomass fuels that provide a long and consistent combustion period. Consideration should be given to increasing the content of corn husks with cobs and durian husks with high carbon content [11]

However, when using Agri-waste with durian husks, there may be a problem of ash content or the ash content of inorganic substances in the sample which has been burned at high temperatures so that the substance is Organic (Organic substance) burns out. which from the test It was found that the fuel from rice husks, bean husks and the addition of durian husks produced the most ash. And it will be a problem to burn and complicate the removal of the ash produced but using corn husks with cobs and bagasse can help reduce the amount of ash.

The heat value test found that bean husks provide higher heat value than rubber wood fuel. and the development of fuels using the proportions of different components of agricultural waste. It will help to increase the heat as well. In particular, corn husks with cobs and bagasse are used as a major component of at least 40% of biomass fuels combined with other feedstocks. It helps to increase the efficiency of fuel in terms of low humidity. high heat It burns for a long time and reduces the amount of ash. in the durian peel Which parts of the bark need to be further studied (outer or inner) that can increase fuel efficiency in terms of humidity Long burning and low ash content. including other improvements Including the development of compression and drying processes of fuel rods before use. will cause the water in the waste to be removed. Increase efficiency and value for biomass fuels from the agricultural sector [10], [11].

Waste pellets economy

Table 3 The comparison of energy production

Management approach	Net Power (kgCO2eq/kg dry agricultural waste)		
	Eo	**Ei**	**Enet**
Biomass briquettes (This research)	2,740	7,425	4,685
Biogas production	285	0	285

The development of biomass pellets could give more energy than method of another one like biogas production.

Table 4 The comparison of greenhouse gas reduction

Management approach	Greenhouse Gas Reduction (kgCO2eq/kg dry agricultural waste)		
	BE	**PE**	**ER**
Biomass briquettes (This research)	15.75	0.073	15.677
Biogas production	5.53	0	5.53

The development of biomass pellets could reduce more greenhouse gas than method of another one like biogas production.

Table 5 The economical description

Indicators	Value	Description
NPV	9,798 Baht	NPV > 0 Show that the project investment is worthwhile.
IRR	7.6 %	IRR > The interest rate of 6.15% indicates that the project investment is worthwhile.
PB	7 years	The payback period is less than or equivalent to the service life of the machine. Shows that the project has an acceptable level of risk.

CONCLUSION

The Results of a study on the use of agricultural waste to produce biomass briquettes by cold compression method using cassava oil as a binder. It was found that the fuel rods could be extruded well when the mixture ratio by weight of tapioca starch after the measurement of agricultural waste was 100 g: 15 g or more. The resulting fuel had calorific value in the range of 3,299-4,661 kcal/kg. which is sufficient for use as an alternative fuel for biomass power plants and communities Compared to the use of rubber wood fuel used in the area. Which is a biomass fuel that is widely used in power plants in the three southern border provinces today. And the moisture, ash, volatile matter and carbon content were stable in the range similar to that of the green fuels made from other raw materials compared. Which is enough to conclude that In case of wanting to increase the heat value of briquette fuel May consider using waste material or husks from legumes. In case of wanting to reduce humidity Increasing the heating power should consider the waste material from corn and sugar cane. The use of durian peel material will help the fire last longer. But further studies may be needed to reduce the amount of ash feeding.

The comparison of the energy production and environmental benefits of management approaches in this research with agricultural waste measurements for biogas production. It was found that the net energy of 4,685 kcal/kg by using agricultural waste to compress fuel rods was able to reduce greenhouse gas emissions by 15.677 kCO2eq/kg, which was higher than other management approaches.

The economic cost-effectiveness study found that the production of biomass briquettes from agricultural waste It is economically worthwhile, with NPV = 9,798 > 0 and IRR = 7.6 % > 6.15 %, indicating that the return is worth the investment. can be implemented in practice In addition, the project has a payback period (PB) = 7 years, which is not very long compared to the average service life of the machines. This makes the project have a low risk of loss.

The results of a sensitivity analysis show that project returns are the most sensitive to fuel prices. and the maximum amount of fuel produced per day followed by workers' wages Number of production days and machine prices, respectively.

Therefore, the management of production of this fuel to be the main alternative fuel in power plants. Therefore, raw materials should be gathered in sufficient quantities. and then began to compress the fuel rods would be more appropriate than frequent small fuel briquette operations.

Processing agricultural waste into briquette biomass fuel is one of the most useful and efficient methods of agricultural waste disposal. Can be used as an alternative energy to replace the main fuel for biomass power plants and help reduce environmental impact at the same time.

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