ASSESSING THE AGRICULTURAL BIOMASS AND ORIENTATION FOR BIOENERGY DEVELOPMENT IN CHU SE DISTRICT, GIA LAI PROVINCE

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ABSTRACT

The study evaluates the amount of crop residues and their ability to turn into energy, suggesting the use of agricultural waste in Chu Se district for the cogeneration process. The rate of using waste burning in the field accounts for the highest rate of 52.93% followed by the use of waste to make fertilizer accounted for 39.80%. By using the method of estimating residue-to-product-ratios and calorific value of Thailand crop residues and using a 0.536 efficiency furnace; the results show that if the total amount of waste from rice, maize, peanut and coffee is collected and used for electricity generation, the total electricity generated from waste products in the whole district of Chu Se is about 580097 GJ/year equivalent to 161137.978 MWh/year. This is a very useful result for policy makers and managers in general and the environment in particular.

Keywords: *Crop residues, Biomass, Residue-to-product ratio, Agriculture.*

TÓM TẮT

Nghiên cứu đánh giá lượng phế phẩm cây trồng sau khi thu hoạch và khả năng chuyển đổi của chúng thành năng lượng từ đó đề xuất sử dụng phế phẩm nông nghiệp huyện Chư Sê cho quy trình đồng phát nhiệt điện. Tỷ lệ sử dụng phế thải đốt ngay tại ruộng chiếm tỷ lệ cao nhất 52,93% tiếp theo là sử dụng phế thải để làm phân bón chiếm 39,80%. Bằng việc sử dụng phương pháp ước tính lượng phế phẩm cây trồng dựa vào tỷ lệ phế phẩm theo sản lượng và giá trị nhiệt lượng phế phẩm cây trồng của Thái Lan và sử dụng lò đốt với hiệu suất 0,536; kết quả cho thấy nếu toàn bộ lượng phế phẩm lúa, ngô, đậu phộng, cà phê được thu gom và sử dụng để phát điện thì tổng năng lượng điện từ phế phẩm có trên địa bàn toàn huyện Chư Sê trung bình khoảng 580097 GJ/năm tương đương 161137,978 MWh/năm. Đây là kết quả rất hữu ích cho các nhà hoạch định chính sách và quản lý nhà nước nói chung và lĩnh vực môi trường nói riêng.

Từ khoá: *Phế phẩm cây trồng, Sinh khối, Tỷ lệ phế phẩm theo sản lượng, nông nghiệp*

INTRODUCTION

Fossil fuels have become the main source of global energy since the beginning of the 21st century. During this time, a great deal of oil, gas and coal were mined (Abdullahi, et al., 2011). Although fossil fuels play an important role in global economic and political development, many environmental and ecological challenges have led to the problem (Ramachandra et al., 2004). Therefore, the change in using a sustainable source of energy has been neccesary and it is becoming more urgent (Shinnawi et al., 1989; Fabian, 2003). Biomass energy technology is an optimal option, not only replacing fossil fuels but also contributing to waste disposal.

Vietnam is a privileged country with vast renewable energy resources, especially biomass. However, the use of biomass for energy applications can lead to competition for land use, environmental degradation and putting food security at risk. Methods of using bio-waste and agricultural residues cause less risk (Pham Van Lang, 2006). But up to now, the potential residue has not been widely exploited worldwide (UNEP, 2009). In order to have a sustainable social and economic development plan, a comprehensive understanding of bio-energy potential of the region is very necessary. In fact, information on the socio-economic aspects of bioenergy is limited.

Chu Se district of Gia Lai province has huge agricultural biomass which releases into the environment after crop. From the idea to convert agricultural residues to energy, this research was conducted with the aim of evaluating the biomass energy potential of post-harvest crop residues from coffee, pepper, rice, maize, cassava and peanut in Chu Se district and proposed orientations for development of biomass energy sources.

METHODS

Data collecting methods

The data were collected by surveying and interviewing farmers in Chu Se district. The questionnaire included: basic household information; area of cultivated land, type of crop, crop yield, seasonality of crop year, form of crop residue use, price of defective product and sale of crop residue. The surveyed group of 123 farmers planted 6 main crops, including coffee, pepper, rice, maize, cassava and peanut. Collecting opinions on the situation of agricultural production, using agricultural waste in the district was also conducted as the supporting data.

Collected data were supported by mobile software such as Locus free, Compass, MGH mobile and Dropsync. Locus free records the daily commute to determine the random route, choosing the direction of all production models in the district. Compass records the geographic coordinates of the survey site. Direct interviews were conducted with the MGH mobiles programmed to record information and images of the sample surveyed. Then all data collected will be saved on Dropsync. Data saved on Dropsync is processed and aggregated: Secondary data is processed by Microsoft Office Excel 2007; The data is then analyzed and compared with the variation in the quantity, type and size of the indicator as well as the factors reflecting the biomass of the crop. A comparative approach is used to assess the differences between crop groups according to the analytical criteria from which the relevant statements are derived.

The formula for assessing the status of crop residue emissions and the ability to convert agricultural by-products into energy.

The formula for calculating plant residue j (Pj) is based on formula (1) as follows:

$$Pj = Aj \times Nj \times Rj \qquad (1)$$

Where:

Pj: Total mass of residue j (ton);

Aj: Crop area (ha);

Nj: Productivity of crops (tons/ha);

Rj: Ratio residue to quantity.

The efficiency of the rice husk and rice husk burning equipment with reference data from the An Khe Biomass Thermal Power Plant is 0.536.

The formula for calculating the biomass energy that is burned from the co-incineration-electrical plant j (Mj) calculated by formula (2) with the moisture content and heat value of the reference waste (Bhattacharya et al., 1993)

$$Mj = Pj \times Bj \times n \times (1 - Wj) \qquad (2)$$

Where:

Pj: Mass of crop residues (tons/year);

Ex: Moisture content of waste products (%);

Bj: Waste heat (GJ/ton);

n = Efficiency of burning (= 0.536).

The above value is used as the greenhouse gas (ESF) savings factor to calculate the potential for greenhouse gas emissions from the total electricity generated from straw and husk (EP). Total greenhouse gas emission reductions are determined by the equation:

$$GHGsv = Mt \times ESF \qquad (3)$$

Where:

GHGsv = Greenhouse gas emissions are reduced when straw and rice husk are converted into energy (ton CO_2-eq/year);

Mt = Total electric power of straw (MWh/year);

ESF = GHG savings per MWh (ton CO_2-eq/MWh) is 1.252 (Suramaythangkoor and Gheewala, 2008).

RESULTS AND DISCUSSION

Cultivation occurrence of some crops in Chu Se district

Chu Se district has a total natural area of 64140 ha, of which 45631.70 ha is agricultural land, accounting for 71.14% of total natural area, of which 45000 ha is agricultural land. With the strength of land resources, Chu Se is a land suitable for many crops and for high productivity. Major crops produced in the region are coffee, pepper, rice, maize, cassava and peanuts. In 2010 - 2011, the total production of Chu Se crops will be 17822 tons, increasing to 20170 tons in the period of 2014 - 2015 as shown in Table 1.

Table 1. Crop productivity in years

Unit: ton

Crops	Season				
	2010 – 2011	2011– 2012	2012– 2013	2013– 2014	2014– 2015
Coffee	9036	9129	9339	9412	8941
Pepper	2121	2131	2483	3487	3750
Cassava	950	800	931	929	980
Rice	3600	4182	4330	3992	4169
Maize	1977	2139	1765	2150	2150
Peanut	138	160	132	284	180
Total	17822	18541	18980	20254	20170

Source: Statistical yearbook, 2015

Situation of collection and use of post-harvest waste from cultivation in Chu Se district

Based on the survey results of 123 households in Chu Se district, the percentage of waste used in each crop is determined as (Figure 2). Crop residue is burned in the field after each harvest with the highest proportion because of the farmers' economic standard. Therefore, waste used for cooking is less used. Particularly for the area as the town, people's living standards are higher, the use of coal, gas is gradually becoming popular. And with traditional farming traditions have long taken advantage of nature to improve. Naturally, in the face of growing population pressures, while the area of land for agricultural production is limited and there is a growing risk of severe degradation, intensification to increase resulting in crop productivity growing. That is aconcerned problem getting farmers' attention. Using agricultural waste to re-use land and improving land is one of the usual habits because of easy manipulation.

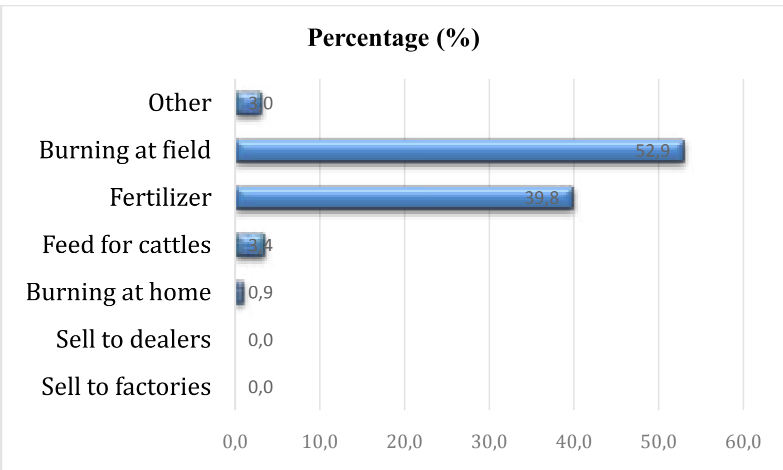

Figure 1. Ratio of residue utilization from crops

However, the use of agricultural waste burned directly in the field to obtain ash directly applying for the soil as fertilizer induces wasting the source of agricultural residues after harvest. On the other hand, residue burning causes environmental pollution that affects human health; it badly affects the lives and activities of people in the research area.

Mass of agricultural residues in Chu Se district

Based on data on major crop yields from 2011 to 2015, calculation of residues was examined from the average crop for years through the percentage of defective products collected. Data collected from the interviews of farmers in Chu Se district are not much different from those in FAO (1982) as shown in Table 2.

Table 2. Mass of residues from cultivation activities in Chu Se district

No.	Crops	Prod. (Ton/yr)	Residues: From production processes	Residues: On field	Residue ratio	Residue mass (ton/yr)
1	Coffee	21560		Branch and leave	2.1	45276
				Husk	1.4	30184
2	Pepper	10312		Branch and leave	-	-
3	Cassava	14810		Stem	0.062	918.2
4	Maize	10438	Cop		0.273	2849.8
				Stem	2.0	20877.6
				Husk	0.2	2087.76
5	Rice	15812	Husk		0.267	4220.8
				Straw	1.757	27782
6	Peanut	1700.6		Husk	3.5	5952

Electricity consume of Chu Se district

Over the five years from 2010 to 2015, although the electricity price increases continuously and reached the highest in 2015 as 1653 VND/kWh, the demand for electricity used by households in Chu Se district has not decreased. The corresponding increase in demand for electricity is relatively high. Transforming biomass from agricultural by-products to energy will create a new form of energy in rural areas that is complementary to traditional energy.

Table 3. Electricity production and trading data of electricity from 2010 to 2015 in Chu Se

Year	Electricity output (kWh)	Price (VND)	Customer	Customer 3P	Customer 1P	Electricity output (kWh/household)
2010	67798870	997	34949	1000	33949	1940
2011	56504949	1233	36135	1236	34899	1564
2012	67338270	1388	38105	1374	36731	1767
2013	63979791	1524	26122	872	25250	2449
2014	51658741	1581	27962	983	26979	1848
2015	58595023	1653	29395	1115	28280	1993

(Source: Statistical yearbook, 2015)

Estimation of power supply capacity from biomass of crop residues in Chu Se district

The energy potential of crop residues is calculated according to the research method (formula 2). The results of calculating using heat treatment of Thai crop residue in unit (GJ / ton): coffee husk: 12,38; maize stem: 5.25; maize cob: 16.28; rice husk: 19.33; rice straw:

16.02; Peanut stem: 12,38. Thailand's defected moisture content in units (%): coffee husk: 15; maize stem: 22; maize cob: 7.53; rice husk: 12.37; rice straw: 12,71; Peanut stem: 15. These are the best values to use in calculating the energy potential of crop residues (Suramaythangkoor T. and Gheewala S.H., 2008).

According to the calculation results of Chu Se district, the potential energy of coffee husk is 255372 GJ/year, equivalent to 70936.62 MWh/year, accounting for 44.02% of total energy potential of waste, followed by straw for energy purposes, would generate 208236 GJ/year, or 57843.33 MWh/year, accounting for 35.90% of total energy potential. The remaining 20.89% are the crop residues such as maize stem, maize cobs, rice husks, peanut stem.

Thus, if the total amount of rice, maize, peanut and coffee waste is collected and used for electricity generation, the total electricity from waste in the whole district of Chu Se is about 580097 GJ/year equivalent to 161137.978 MWh/year.

Table 4. Annually average energy potential from residues in Chu Se district

Crops	Residue kinds	Wet mass (ton)	Humidity (%)	Dried mass (ton)	Heat (GJ/ton)	Energy* (GJ/yr)
Coffee	Husk	45276	15	38484.60	12.38	255372
Maize	Stem	20877.6	22	16284.53	5.25	45823
	Cop	2849.79	7.53	2635.20	16.28	22994
Rice	Husk	4221.86	12.37	3699.61	19.33	38329
	Straw	27782.04	12.71	24250.94	16.02	208236
Peanut	Stem	1656.55	15	1408.07	12.38	9342
Total		103582.06		87543.44		580096

*Remarked: * The energy potential of residues with process efficiency is 0.536*

Suggested model for biomass energy use

Rice husk and rice husk residues can be used as co-incineration fuel, including the following main components: combustion chamber, boiler, turbine, generator, heat exchanger, dryer and other auxiliary parts.

Principle of working: The pump system will supply water to the boiler; fuel (rice husk, rice straw) will supply to the burner. The heat generated from the combustion process is provided to the boiler. The amount of heat generated by the combustion at the furnace is provided to the boiler to evaporate the steam. The superheated steam creates a spinning turbine that rotates the generator, releasing electricity. Pressure for the turbine is about 9.81 Mpa. This power supply can be supplied in-house for the dryer or in the milling system.

The combustion of some high-moisture fuels releases water in the combustion chamber. As a result, the formation and evaporation of water in the combustion chamber reduces the amount of thermal energy available to work. However, this system has a secondary condensation process, below the combustion step, which condenses the water vapor in the exhaust stream and recovers most of the latent heat that is carried. Recovered heat can be used more efficiently and maximize the amount of heat generated from crop residues. Heat from the steam from the turbine (steam) is used to dry agricultural products.

CONCLUSION

Transforming crop residues into electricity would create a new form of energy in rural areas, supplementing traditional energy sources which is insufficient for Chu Se District. The results show that if the total amount of rice, maize, peanut and coffee residues is collected and used for electricity generation, the total electricity generated from waste products in the whole district of Chu Se is about 580097 GJ/year equivalent to 161137.978 MWh/year.

Therefore, it is necessary to study the planning, collection and transportation of rice by-products as well as other agricultural by-products to determine the efficiency of investment in processing plants and the efficient use of crop residues with both economic and environmental concerns.

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