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Biomass profiling of identified wood and non-wood resources in Misamis Oriental and Bukidnon, Philippines

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Abstract

Biomass is a renewable and sustainable source of fuel to produce energy, and it can be developed from organic materials like wood and non-wood resources. The study sought to gather data on the annual volume production, annual waste produced and determine the amount of energy that can be generated from the selected biomass resources namely; coconut, corn, rice, sugarcane and wood in the provinces of Misamis Oriental and Bukidnon. The study employed a descriptive-quantitative type of research and calculates the energy generated from each identified biomass. From the gathered data, the annual waste production with the fuel equivalent of each resources and the energy generated for both provinces were calculated. Based on the results of the study, Misamis Oriental and Bukidnon have an increasing trend of production as well as the amount of energy generated for the past ten (10) years, 2000 to 2009. In 10 years (2000-2009) frame, sugarcane has the highest production in Bukidnon followed by corn, while production of wood has the lowest. Misamis Oriental on the other hand, showed the coconut production as the highest and sugarcane production as the lowest. The volume of waste produced from identified resources are directly proportional to its production and the generation of energy that is calculated, based on its calorific value showed that both provinces of Misamis Oriental and Bukidnon have potential to produce sustainable alternative energy source.

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Introduction

The increasing worldwide demand for energy together with the over reliance of fossil fuels and increasing greenhouse gas emissions has led to global warming (Bilgen *et al.*, 2008). In order to reduce the harmful effects and climate change, greenhouse gas emission must be reduced, and to do this, there is a need to develop greener fuels from biomass and energy crops.

Due to the increase in energy demand and environmental concerns over fossil fuel consumption, biomass has been of interest in recent years in terms of renewable energy source. Biomass is a renewable energy source which is considered carbon neutral and it absorbs the same carbon dioxide during its growth and it releases when it is burned for fuel (Wannapeera *et al.*, 2011).

Biomass refers to all organisms living on earth. It includes agricultural crops and residues; forest products and residues; animal wastes and residues and byproducts from food, feed, fiber, wood, and materials processing plants; as well as post-consumer residues and wastes, such as municipal solid wastes and landfill gases. These biomass resources could be used to produce power, heat, transportation fuels, and various chemical products (Montgomery, 2004).

In the country, increasing fuel costs is one of the problems that the government is facing today. Also, power outages are very common especially during summer months where hydropower source in the country is limited. El Niño phenomenon is a factor that contributes dwindling water levels which affected the generating capacity of hydropower plant (Chavez *et al.*, 2002).

Electricity becomes a scarce commodity due to its limited sources. According to BERR Energy Trends, 2007, the annual average energy consumption in a typical household is 3,300 kilo Watt per hour (kWh), where 1 kilo calorie is equivalent to $1.163x10^{-3}$ kWh. This demand for electricity increases over time due to population increase and urban development.

In the Philippines, especially in Mindanao area, effects of power outages hinder daily activities of domestic, commercial and institutional sectors. It is greatly affecting the country and many people complained of "brownouts".

It is for these reasons that this study attempts to find alternative source of power by evaluating and profiling selected biomass which has potential capacity to become sustainable source of energy. It is on these realities that the researchers find to conduct a research that would explore alternative energy resource to supplement the needs for energy requirement of the country. Specifically, the study focus on the gathering and consolidation of the annual volume production data, and annual volume of waste generated of the identified wood and non-wood resources from the selected provinces of Bukidnon and Misamis Oriental.

The amount of energy that can be generated out of the identified wood and non-wood waste is also calculated based on the calorific value or fuel heating equivalent of each resource.

Materials and methods

Research Design

The study sought to gather production data on selected biomass resources and determine the quantity of energy that can be produced from these identified wood and non-wood resources in the province of Misamis Oriental and Bukidnon. It makes use of descriptive quantitative type of research. Secondary data determines the estimated volume of waste per resources that was gathered from the different government agencies such as Department of Agriculture Office -Bureau of Agricultural Statistics (DA-BAS), Department of Environmental and Natural Resources -Forest Management Bureau (DENR-FMB), and Philippine Coconut Authority (PCA).

Research Setting

Data gathering was conducted in the province of Misamis Oriental and Bukidnon namely: Philippine Coconut Authority, Department of Environment and

Natural Resources -Forest Management Bureau, and Department of Agriculture-Bureau of Agricultural Statistics. Misamis Oriental is located along the northern coast of the island of Mindanao. Bukidnon on the other hand is a landlocked plateau in North Central Mindanao.

The province is considered by many to be the food basket of Mindanao because it is the major producer of rice and corn in the region and has vast plantations of pineapples, bananas and sugarcane (Gerpacio & Pingali, 2007). These municipalities have a large number of sawmills and agricultural crop wastes and residues.

Data Collection

Secondary data was gathered to determine the volume of production and its biomass from the different government agencies. For the wood resources the data was gathered in the office of DENR Region 10 Forest Management Bureau (FMB) Department; Philippine Coconut Authority (PCA) Region 10 for the coconut; and Department of Agriculture (Bureau of Agricultural Statistics) for the agricultural crops including sugarcane. Field ocular inspection of wood and non-wood resources was done in selected areas of Misamis Oriental and Bukidnon. Various activities conducted for the gathering of data and calculation is shown on Fig. 1.

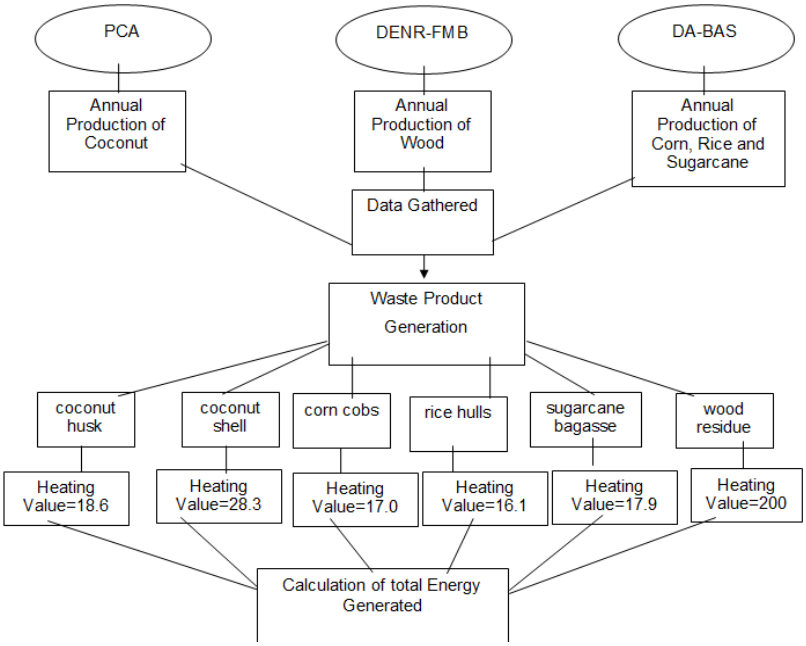

Fig. 1. Schematic diagram of Data collection and calculation.

From the gathered data on annual production of wood and non-wood resources, certain percentage of waste product is generated. Each of these waste resources have its own heating values or fuel energy equivalent as shown in table 1 which leads to calculation of total energy generated in Misamis Oriental and Bukidnon. For the calculation of the production of waste and the potential amount of energy generated each year, the following formulas were used;

Waste Production

Wp= Pn (ton) x %W

Potential Energy Generated

Eg= Wp (ton) x Feq (Gj / ton) x 238845.89662275 (kcal / Gj) $Eg_T = Eg_1+Eg_2+Eg_3+Eg_4+Eg_5+Eg_6$

Table 1. Estimate yields and fuel energy equivalents.

Biomass Resources	Fuel Energy Equivalent
Coconut Husk	18.6 GJ/tonnes
Coconut Shells	28.3 GJ/tonnes
Corn Cobs	17.0 GJ/tonnes
Rice Hulls	16.1 GJ/tonnes
Sugarcane Bagasse	17.9 GJ/tonnes
Wood Residue	20.0 GJ/tonnes

Adapted from Kinoshita et al 1998, Beagle et al 1978.

Where;

Wp= Waste Produced

Pn= Resource Production

%W= Percent waste in a resource

Eg= Energy Generated

Feq= Fuel Energy Equivalent

Eg_T= Total potential energy generated by the biomass

Eg_1= Potential Energy generated by coconut husk resources

Eg_2= Potential Energy generated by coconut shell

Eg_3= Potential Energy generated by corn cobs

Eg_4= Potential Energy generated by rice hulls

Eg_5= Potential Energy generated by sugarcane bagasse

Eg_6= Potential Energy generated by wood waste

Results and discussion

Annual Production of Selected Resources in Bukidnon and Misamis Oriental

As shown in Fig. 2, sugarcane has the highest production among the resources for the past 10 years (2000-2009) in Bukidnon, followed by corn and rice while the lowest is wood and followed by coconut. Fig. 3 on the other hand shows that Misamis Oriental contrary to Bukidnon, has a low production of sugarcane but high in wood, coconut shell and corn.

Most of the matured coconut fruit when harvested are often peeled, to remove the husk and the shell, in which meat is separated and sold in coconut oil industry, and at the same time, coconut shell is also process to produce charcoal. There are several factors that affect the production of these resources and can be attributed to the increasing and decreasing trend that was shown in the graph. Generally, plant production depends upon the availability of its basic needs namely; light, water, temperature and nutrients. In other words, it depends on the weather (rainfall distribution, wind), soil (type, fertility, depth) and often times on the farmer's wisdom.

As the production affected by these factors, the volume of waste and the potential energy it will generate will also be affected.

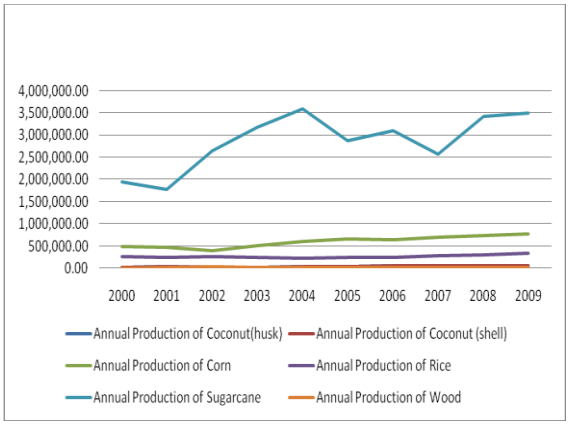

Fig. 2. Graph showing the annual production of the resources in Bukidnon.

Fig. 3. Graph showing the annual production of the resources in Misamis Oriental.

Annual Coconut husk production and its corresponding potential energy in Bukidnon and Misamis Oriental

According to Jackson *et al.,* (2004), a whole coconut is consists of 50% husk, 15% shell, 25% meat and 10% water. The annual coconut production and the potential amount of energy that will be generated from 2000-2009 in Bukidnon and Misamis Oriental are shown in Fig. 4 and 5 respectively.

The two Fig.s show that the volume of coconut husk and the potential amount of energy that is produce are directly proportional. It means that as the volume of the coconut husk increases the potential amount of energy produced also increases. Husk has a higher percentage in terms of waste but has a lesser equivalent fuel energy than of shell.

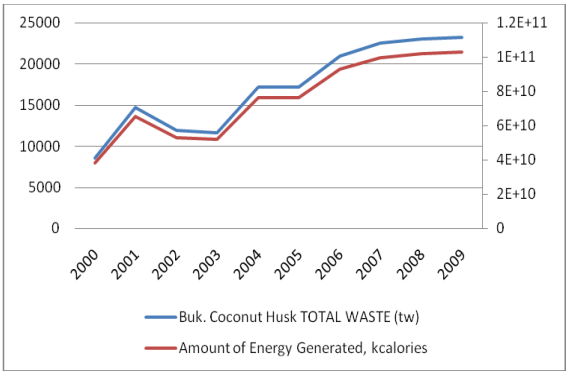

Fig. 4. Annual volume of coconut husk and the potential energy it will produce in Bukidnon.

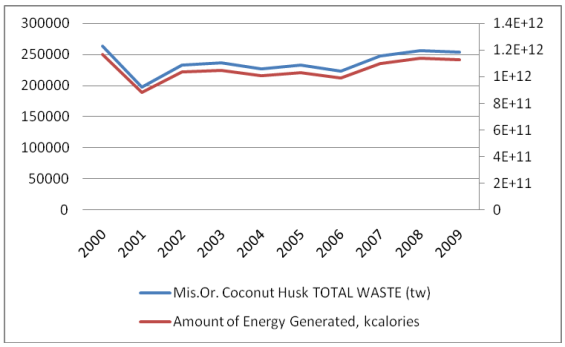

Fig. 5. Annual volume of coconut husk and the potential energy it will produce in Misamis Oriental.

Annual Coconut shell production and its corresponding potential energy in Bukidnon and Misamis Oriental

Fig.s 6 and 7 show the annual volume of coconut shell and the potential amount of energy that was generated in Bukidnon and Misamis Oriental respectively for the past 10 years. As it was shown in the graphs, the province of Misamis Oriental has higher volume of coconut husk and coconut shell than that of Bukidnon. This is because of the topographical location of Misamis Oriental. One factor that affects the coconut production is its distance to the sea. Closer distance to the sea has considerable effect on the climate as well as on the soil. The coastal climate is always more humid and less subject to wide fluctuations of temperature and these conditions are favorable to the palm, hence favorable to Misamis Oriental since the province is near to the sea. As stated in the study of Krishna, 2013, another favorable feature of coastal areas is that they generally possess better sub-soil water supplies than those in the interior, because they have at the back of them, higher country and the rain which falls there partly sinks into the soil and moves towards the sea bringing with it dissolved nutrients for the palm's nourishment.

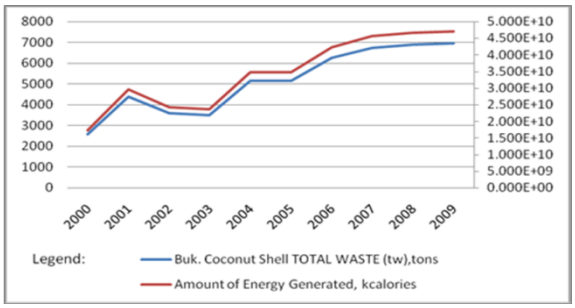

Fig. 6. Annual volume of coconut shell and the potential energy it will produce in Bukidnon from 2000-2009.

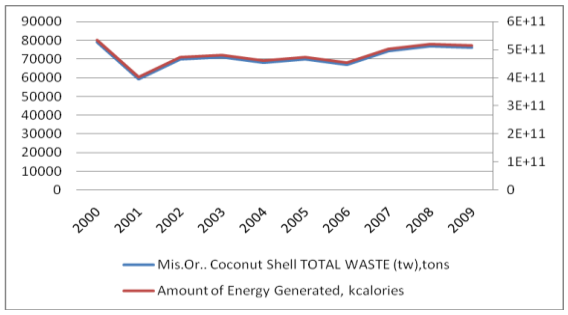

Fig. 7. Annual volume of coconut shell and the potential energy it will produce in Misamis Oriental from 2000-2009.

Annual Corn cob production and its corresponding potential energy in Bukidnon and Misamis Oriental

The percentage of corn cob in corn is approximately 22% (Basalan, *et. al.,* 1995.). Fig.s 8 and 9 shows the volume and potential energy trend of corn cobs for the past 10 years (2000-2009) in both Bukidnon and Misamis Oriental. Fig. 8 shows that corn cob has lowest production in year 2002 but it gradually increases in the next 3 years. A slight decrease was shown in year 2006 but steadily increases until 2009. It also follows that, year 2002 has lowest amount of energy generated and year 2009 as the highest. On the contrary, Fig. 9 shows the production of corn cobs and the amount of energy it generated is steadily increasing throughout 10 years except in the year of 2007 where the graph slightly goes down. Highest energy generated was shown in year 2009. Many factors can affect corn yields, but University of Illinois plant pathology Professor Fred Below said that weather is the first of the wonders.

While farmers have the least control over weather, it has the most impact on the yield of the crop. Drought, rain, temperature and frost all have a major impact on the ending crop yield (Leakey *et al.,* 2006).

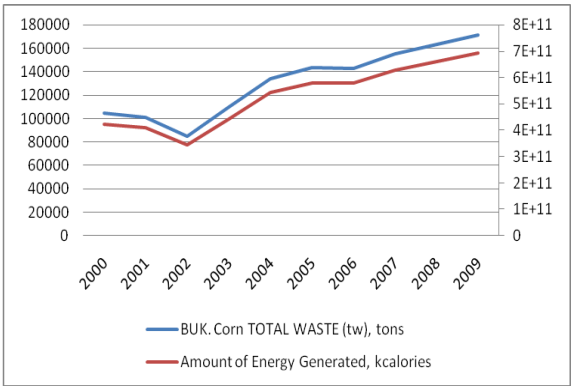

Fig. 8. Annual volume of corn cobs and the potential energy it will produce in Bukidnon from 2000-2009.

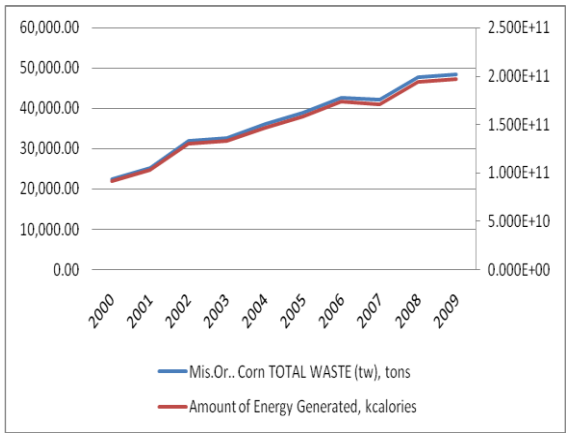

Fig. 9. Annual volume of corn cobs and the potential energy it will produce in Misamis Oriental from 2000-2009.

Annual Rice Hull production and its corresponding potential energy in Bukidnon and Misamis Oriental

In a study of "Biomass as Energy Source in the Philippine" of Elauria *et al* 2007, it mentioned that in the annual production of rice, 22% of it is rice husk. The Fig.s 10 and 11 show the annual volume of rice hulls and its corresponding possible amount of energy in Bukidnon and Misamis Oriental in year 2000-2009. As shown in Fig. 10, Bukidnon has its lowest produced rice hulls in the year 2004, but it gradually increases in the next 5 years, as well as its generated energy. In Fig. 11, it shows that the production of rice by -product, which is rice hulls, and the amount of the energy it produced are gradually increasing except for the years of 2003 and 2005 where it slightly decreases.

Rice-growing environments are based on their hydrological characteristics. It also grows in a wide range of environments and is productive in many situations where other crops would fail (International Rice Research Institute), hence favoring the province of Bukidnon where the land area used in rice production is 40,278 hectares while Misamis Oriental is only 3,545 hectares (Kim & Dale, 2004). This would explain the reason why Bukidnon has a higher rice hull production and potential energy generated as shown in Fig.s 10 and 11 than of Misamis Oriental.

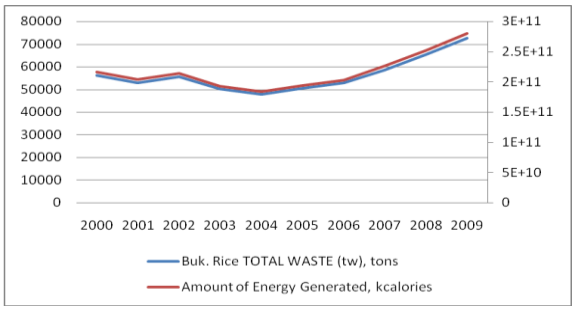

Fig. 10. Annual volume of rice hulls and the potential energy it will produce in Bukidnon from 2000-2009.

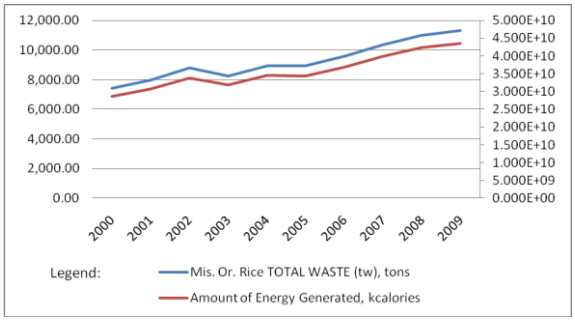

Fig. 11. Annual volume of rice hulls and the potential energy it will produce in Misamis Oriental from 2000-2009.

Annual Sugarcane Bagasse production and its corresponding potential energy in Bukidnon and Misamis Oriental

Sugarcane is widely planted by people in the province of Bukidnon. According to Philippine Journal of Crop Science (PJCS) April 2006, a conservative estimate of excess bagasse in mill with a raw sugar factory only is about 30% (TC, *et al.,* 2002). Fig.s 12 and 13 show the annual volume of sugarcane bagasse and its potential energy generated in Bukidnon and Misamis Oriental in 2000-2009.

Since sugarcane is widely planted in Bukidnon, it follows that higher amount of by-product- specifically its bagasse- is also produced as it was shown in the graph. The graph shows the up and down trend of production and generated energy of rice hulls for 10 years, with 2004 as its highest year of production and 2001 as the lowest.

In Fig. 13, data were not available in years 2000 to 2003 and 2008 to 2009, that the graph shows a drastic increase in the year 2005 which has the highest recorded volume of sugarcane bagasse in Misamis Oriental. Possible reasons of the unavailable data may include; less demand in market or there was no recorded data because there was no reporting happened in those years. Sugarcane is a tall-growing perennial plant that is cultivated in the tropical and subtropical regions of the world.

It is essentially a plant of the warm tropics and grown best when frequent heavy rainfall is interspersed with bright sunshine. There are many factors affecting sugarcane production such as choice of cane variety, climatic and soil conditions and availability of water. The most important of these factors is the water availability (Inman-Bamber and Smith 2005).

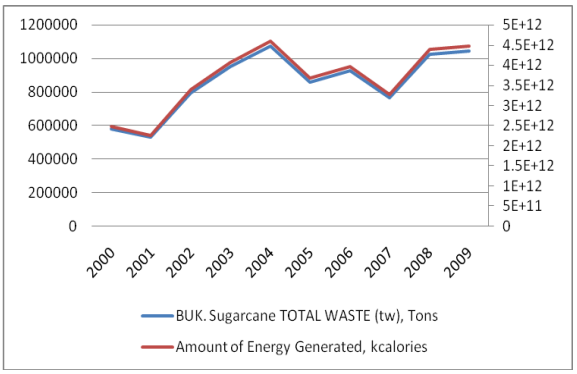

Fig. 12. Annual volume of sugarcane bagasse and the potential energy it will roduce in Bukidnon from 2000-2009.

Annual Wood Waste production and its corresponding potential energy in Bukidnon and Misamis Oriental

In terms of energy content per hectare per annum, the sustainable production of biomass residue available for fuel from plantation and agricultural land is about 30% of the sustainable yield of wood fuels from natural forest land Regional Study on Wood Energy today and tomorrow in Asia (FAQ, 1997). The Fig.s below show the annual volume and potential amount of energy that will be generated of wood for the past 10 years (2000-2009) in Bukidnon and Misamis Oriental. A drastic increase of wood waste in years 2000 to 2002 as shown in Fig. 14, can be attributed to the production of wood in Bukidnon in those years since the produced waste is dependent on its production. But it gradually decreases in the following years until 2007, it slightly increases again in the next year and decreases in 2009. As it was shown in Fig. 14, year 2000 has a low production of wood waste in Bukidnon while a high production was shown in the year 2002.

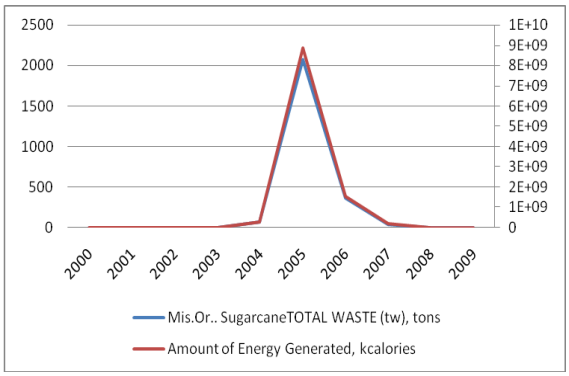

Fig. 13. Annual volume of sugarcane bagasse and the potential energy it will produce in Bukidnon from 2000-2009.

As compared to Bukidnon, Misamis Oriental has higher production on wood residues, also it follows that higher generation of energy is expected in Misamis Oriental, which was shown in Fig. 15. One of the decisive factors that are accountable to the yield of wood is the availability of wood source, which is dependent on the size of the plantation estate, the plantation growth rate, and land availability within reasonable proximity to the mill (Kanninen, 2010). Bukidnon has a wide plantation of wood but has a diminutive number of wood processing plants- where the data were considered- that would explain the poor performance of wood residues over 10 years (2000-2009). While Misamis Oriental on the other hand, have several wood processing plants in its districts.

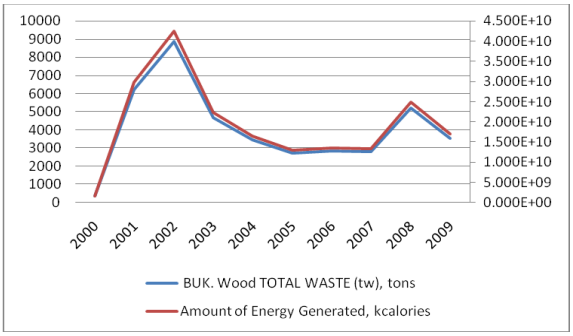

Fig. 14. Annual volume of wood waste and the potential energy it will produce in Bukidnon from 2000-2009.

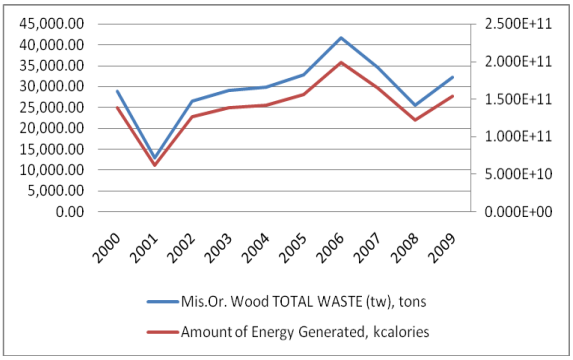

Fig. 15. Annual volume of wood waste and the potential energy it will produce in Misamis Oriental from 2000-2009.

Presentation of Total Energy Generated from each Biomass Resources in Bukidnon

The potential amount of energy that will be generated per resources is dependent on its fuel equivalent energy that was presented in Table 1 and its type of the corresponding waste. Fig.s 16 and 17 shows the trend of the potential amount of energy generated of all the resources from 2000 to 2009 in Bukidnon and Misamis Oriental respectively.

The annual potential energy generation (Fig. 16) of each resources in the province of Bukidnon are shown. It showed in this graph that out of the six (6) biomass, wood waste gives the lowest potential energy for the past 10 years, followed by coconut husk and shell. On the other hand, sugarcane bagasse shows the highest potential generated energy, followed by corn cobs. It has been known that the type of soil in the province of Bukidnon is favorable for the growth of sugarcane and least for the growth of coconut.

The annual potential generation of energy (Fig. 17) in the province of Misamis Oriental shows that contrary to Bukidnon, sugarcane bagasse has the lowest generated energy for 10 years, while coconut husk has the highest, followed by coconut shell.

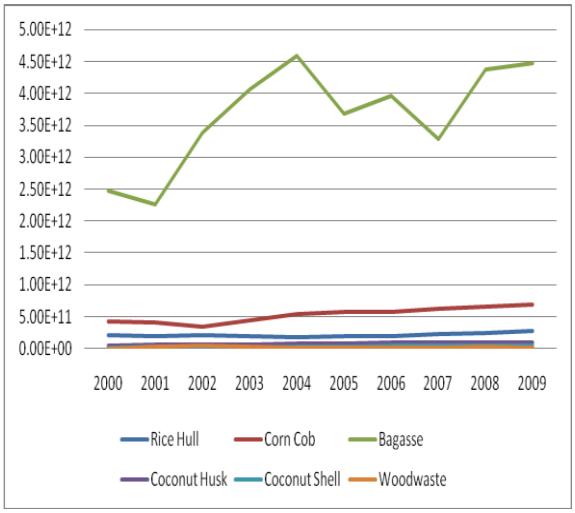

Fig. 16. Annual potential energy generated of each biomass resources in Bukidnon**.**

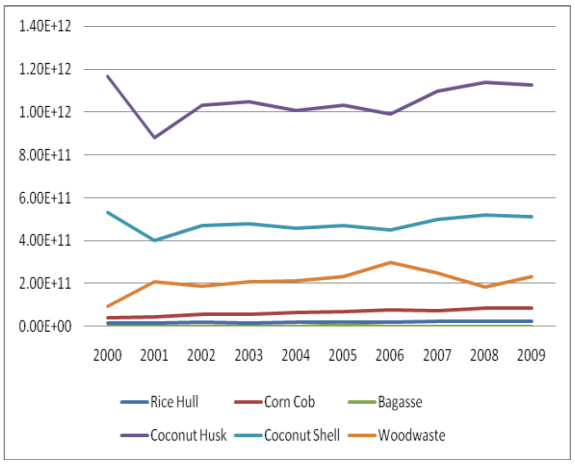

Fig. 17. Annual potential energy generated of each biomass resources in Misamis Oriental**.**

Annual Total Potential Energy Generated in Bukidnon and Misamis Oriental

As shown in Fig. 18, Bukidnon and Misamis Oriental provinces show an increasing trend of potential energy generated from the identified biomass resources from the year 2000 to 2009. This implies that the resources have a prospective volume of biomass that can be used as an alternative source of energy in the said provinces.

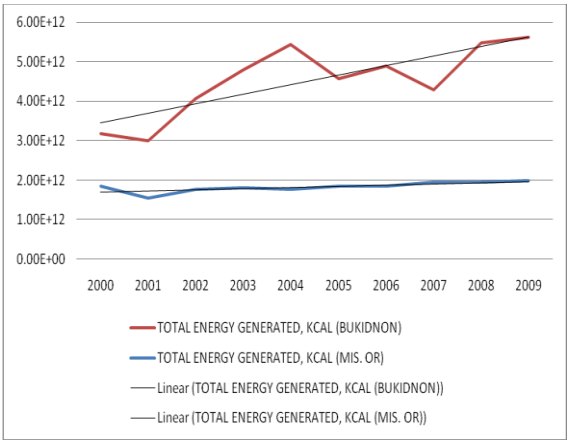

Fig. 18. Annual total potential energy generated of all resources in Bukidnon and Misamis Oriental from 2000 to 2009.

Conclusion

The result of the study revealed that for the past 10 years, among the selected wood and non-wood biomass resources, it is the sugar cane followed by corn which is the most abundant resource in the province of Bukidnon, and wood and coconut is the least. On the contrary to Bukidnon, Misamis Oriental is abundant in wood and coconut but is least in sugarcane and rice. The actual volume of waste resources is directly proportional to the annual production of identified wood and non-wood biomass resources. It follows that Misamis Oriental has a high volume of coconut husk and coconut shell but low in rice hulls, corn cobs and bagasse. Bukidnon on the other hand, has bagasse and corn cobs as the highest and wood waste and coconut shell as the lowest.

Base on energy generated for each resources, Misamis Oriental has a highest volume of energy generated from coconut husk and coconut shell but low in rice hull, corn cobs and bagasse. On the other hand, Bukidnon, has corn cobs and bagasse as the highest energy generated but low energy being derived from rice hull and wood waste. Graphical presentation shows that Misamis Oriental and Bukidnon have a potential volume of resources that can be used as an alternative energy source. Both provinces have an increasing trend of energy generated from biomass resources since year 2000 to 2009.

The study would like to recommend that the local government should further evaluate the potential of the studied biomass as an alternative source of energy or to further assess for possible biomass power plant in either of the two provinces of Misamis Oriental and Bukidnon.

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