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POTENTIAL UTILISATION OF WOOD RESIDUE IN KEDAH: A PRELIMINARY STUDY

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ABSTRACT

Being an important resource-based industry in Malaysia, the wood industry plays a crucial role in the socioeconomic development of the country. In consequences, wood wastes generated exponentially increase annually. This paper views the current utilisation of wood waste production in the northern wood-based mills in Malaysia. The types of wood residue as well as the users of wood residue are identified. The result shows that 100% of wood residue are being used or sold for this population. However, the wood residue available in Kedah is able to potentially offer 0.005% of electricity generation in Malaysia. As a conclusion, this type of wood residue cannot create the opportunity for it to be used as fuel in electricity generation in the northern region of Malaysia, since the fuel supply is already limited and is being used for other purposes.

Keywords: *wood residue, potential utilisation, Kedah*

INTRODUCTION

The wood industry has become a major source of foreign exchange across the globe. Due to this, wood wastes represent wastes that are to be disposed of as a secondary resource to be exploited (Bergeron, 2016). In addition, most of the wood plants are being built up in developing countries such as Malaysia, Nigeria, and Indonesia, which are active in forest development to prevent the costly fossil fuel supply that are not affordable for the citizens. In this case, the use of wood residue might help in generating energy and the potential of sawmills to use wood waste as an investment asset implicates the assembly of heat generating plants. Based on Tokan, Sambo, Jatau, and Kyauta (2014), the use of wood increases every day, especially in the low technologically developed countries of the world. According to Kuti (2009), Nigeria does not support the burning of wood residue due to the environmental and pollution problems, and this practice has been discouraged; however, it has been found that wood waste, especially sawdust, has the potential to generate energy.

In the economic sector, sawmills have utilised wood residue especially sawdust and plywood in the timber industry, in which the use of sawdust plays an important role in generating energy in the most efficient method. It can be determined whether a timber business' operation is making

profit or loss due to the evaluation of the wood. Sawdust briquette has been well-received in several communities especially in Piura, Peru, based on the research by Sánchez, Milagros, Pasache, and García (2014), as it saves costs that involves high performance in terms of health and care issues. The energy content in sawdust briquette is considered sufficient for the local low income sectors that include different culture fuels in sawdust briquette that would increase costs that the people are unable to pay. Therefore, sawdust briquettes help low-income families that further extend the economical revaluation of wood waste and the mitigation of greenhouse gas emission. In Romania, according to Teodora DEAC, V.ROŞ, and M.DEAC (2011), sawdust has been issued as the most important renewable energy with regards to the high potential of use to produce heat production in the timber industry. Sawdust has been developed into forms of briquettes or pellets that are compacted in the natural forms. These forms of sawdust are efficient in the transformation of energy via the heating process and are also involved in all activities in the processing of sawdust for energy use. Therefore, the analysis of the sawdust pelletizing process has been implemented in aggressive ways to obtain high energy consumption in the process of useful energy. The briquettes and pellets from the wood biomass energy have increased the demands of finance that show the improvement in these few years and also the importance due to fuel popularity.

In the timber industry, wood wastes are produced as sawdust briquettes so as to ensure the quality is standardized. In other ways, wood waste is supportive in delivering the heat distribution and also in initiating the burning process. Moreover, it does not produce smoke and reduces the smells and the rate of ash value. As the starter of combustion, it has been used to maintain fire as fuel; it is a truly organic solid fuel that also has low humidity According to Ivanova, Kolarikova, Havrland, & Passian (2014), sawdust briquettes and pellets have low haze content, high calorific value, low ash content, are easy to manage, and are environmentally friendly. Besides that, the briquettes have enhanced the use of wood biomass in terms of managing feedstock, delivery, and combustion.

Nowadays, the use of sawdust has been developed in the timber industry in order to generate energy such as heat and electricity. The potential of sawdust use helps to reduce environmental pollution and grows with the advancement of the future as compared to the use of gas fuels, which are more costly and pollute the environment. As stated by Kuti (2009), the use of sawdust is based on the raw material in the production to be transformed into sawdust briquettes that might be produced in mass quantity as waste in a large amount of wood processing industries. It also has been identified that the transformation of sawdust waste through the briquetting process will minimise the waste disposal problems in most of the wood processing industries. In addition, it will also discharge the pollution in forests if sawdust waste is implemented in wood industries.

Moreover, most of the timber industries in this country have been ignoring the potential of sawdust, which is often taken for granted by the owners of industry. The wood industry is known to be the cause of wastage and environmental pollution. Therefore, some timber industries are now using sawdust in generating energy. Based on a research by Adeyemo, Adeyeye, Okunlola, Bello, and Alamu (2014), sawdust is very efficient in providing heat on time, has good ease of ignition, reduces the risk of danger by minimising smoke emission, and minimises production cost. It also involves less energy, saves time, and is economically better than fuel wood and

charcoal. This recycled method of waste material into fuel briquettes helps in solving urban cooking fuel and minimising the cost of energy supply as well as decreasing the production of wood residue on land and avoiding the damage of forest and encourage conductive and environmental sustainability. In accordance to Diji (2013), water contamination decreases because of less manure and pesticides that are used to be improve energy crops energy. Similarly, the maximum yield of food crops can help in collecting nutrients from the soil that will minimise soil erosion.

In Malaysia, the timber industry has been developed since 1995. In the tropical rainforest found in Malaysia, there are various types of species of trees that determine the development of the timber industries, especially in the processes of sawn timber or plywood that usually produced waste in mass quantity, for example sawdust and wood chips. According to Lim and Hii, Malaysia has produced around 0.266 million of dry tones of sawdust in 1995. Therefore, Cipta Briquette Sdn. Bhd. that is located in Sarawak, Bintulu, stakes on the large quantities of sawdust that are produced from the timber industry; there are around 30–40 various species that are used for the production and exportation of charcoal briquette. The best wood species in Malaysia are jati, cengal, meranti, balau, keruing, bitangor, kempas, and other species that are considered as the best wood in the local timber industry.

Furthermore, the Malaysian timber industry has generated 3.4 million m^3 of yearly wood wastes such as sawdust, wood chips, bark, slab, and other raw materials with a standard restoration rate of 55%, as stated by the Forest Research Institute Malaysia (FRIM). In fact, there are 1132 timber industries in Malaysia: 664 in Peninsular Malaysia, 178 located in Sabah, and 290 in Sarawak, according to the Malaysia Industrial Development Authority (MIDA). As per the Malaysia Industrial Development Authority (MIDA), there are 2400 furniture mills in Malaysia with a production amount of US$2.4 billion in 2005.

The objective of sawdust use is to reduce fuel and save the environment instead of increasing the greenhouse effect due to the thinning of the ozone layer that would be detrimental to the surface of the earth if the use of sawdust is not emphasised. Besides that, the benefits of sawdust in generating energy are as follows: it is smokeless, low ash content, unscented, extend the burning time, high burning temperature, easy to store, and chemical free. According to Akowuah, Kemausuor, and Mitchual (2012), the briquettes have advantages in terms of bringing greater heat intensity, cleanliness, and convenience in the way of using them that only need a small space for storage purpose.

The sawdust in the timber industry will be measured by using tones; however, it will face problems due to the type, size, capability, reliability, cost, and moisture content. Besides that, as there might be several people who lack the understanding, knowledge, and information on wood biomass, there will be difficulties in the community to accept the new concept. Based on Akowuah et al. (2012), comparing this situation with the developed countries, where there are successful briquette operations, it is found that it has not been widely practised due to the high cost of production, lack of awareness on its sustainability, lack of ready market and poor packaging, and the system in the distribution for the product.

In addition, the market of sawdust is important because some of the industries need to supply their products to the customers who purchase their sawdust; the timber industries also help in solving the economic and environmental issues indirectly. Therefore, the low price of sawdust has marked up the use of sawdust and it has high popularity as well as it can save the environment and reduce the pollution if most of the communities are practising the use of sawdust. According to Adebakin et al. (2012), in Nigeria, sawdust can replace sand as a renewable by-product for economic use and is able to accordingly produce cheaper blocks for lower-cost buildings. This shows that sawdust can help in providing cheaper blocks, besides generating energy; additionally, it can help build more save-cost buildings in developing countries.

In Malaysia, there are various types of species of trees in the rainforest and the moisture content of the sawdust is around 40% to 50%. Therefore, the timber industry will usually transform the sawdust into charcoal, briquettes, or pellets. According to Lim (2000), the quality of sawdust is very important especially in charcoal briquettes; in which the moisture content is 5.0% to 9.5% to make sure it can burn in a longer period; the volatile matter is 6.3% to 9.0% that shows the volatile content must be low, otherwise, the charcoal will burn and produce smoke and long-term flames. The low ash content is important as it allows the residue to be minimised around 1.1% to 2.5% so that the origin weight of the charcoal is accepted; the fixed carbon is 82% to 92% to ensure the temperature content is maximised, otherwise the other fixed carbon will decrease because there are many substances in the charcoal; and lastly, the calorific value is from 7,200 – 8,500kg, which is the lowest heating grade that shows the best due to the briquette production.

Wood waste is generated from by-products of wood-related activities and from non-commercial wood resources. There are two types of biomass energy that can be classified from wood waste, which are forest wood waste and wood waste from mills. Table 1 indicates the Malaysian forest statistic for 2014. Malaysian timber industries play an important role in the country, where 3,800 mills are operated under this sector and have created employability to 300,000 workers (MTIB, 2016). Peninsular Malaysia is currently harvesting about 1.2 million tonnes per year of logs; this only represents 60% to 65% of the total harvesting area. The remaining percentage is left to rot or burn. According to Antwi-Boasiako and Acheampong (2016), agriculture and wood waste are frequently hardly consumed. Figure 1 shows the type of wood residue in Malaysia (Biomass assessment).

Table 1

Malaysia Forest Statistic 2014 (Forestry Department of Peninsular Malaysia, 2016)

Production	Million cubic metres (m^3)
Logs	4.11
Sawn Timber	2.46
Plywood	0.38
Mouldings	0.10

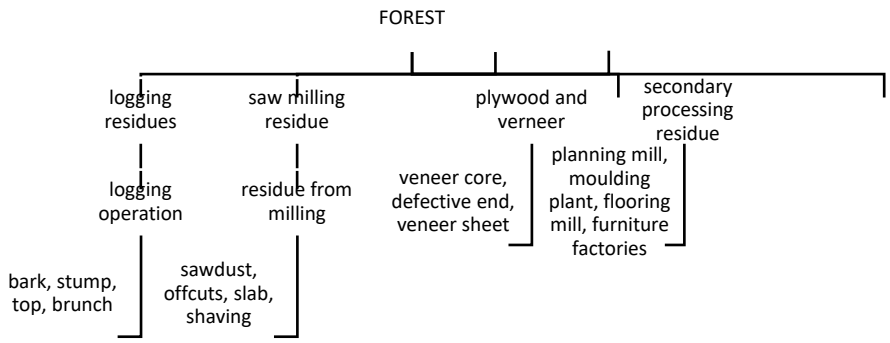


Figure 1
Type of available wood waste in Malaysia

Table 2
Wood waste generated from different wood industries in Peninsular Malaysia in 2010

Mills	Production (m^3)	Consumption (m^3)	Waste (m^3)
Sawmill	3,920,570	2,675,384	1,245,186
Plywood mill	681,741	459,253	222,488
Moulding mill	290,899	235,500	55,399
Total	4,893,210	3,370,137	1,523,073

Table 2 shows the production of wood waste generated in Peninsular Malaysia in 2010. About 31.13% of the wood industries generated the waste in Peninsular Malaysia. Currently, East Malaysia uses its wood residue for electricity generation. Table 3 shows the electricity generation from wood waste in Sabah and Sarawak. However, none wood mill in Peninsular Malaysia use their wood residue for electricity generation.

Table 3
Current electricity generation from wood waste in Malaysia

No.	Licenses	Location of installation	Type of fuel	Total Generation (GWh)
1	Bio Fuel Asia Sdn. Bhd	Sabah	Wood waste	26.2
2	Untung Ria Sdn. Bhd.	Sabah	Wood waste	17.37
3	Sabah Forest Industries Sdn. Bhd.	Sabah	Wood waste	52.6

This paper aims to: (1) study the current wood residue consumption; and (2) identify the amount of potential use of wood residue in electricity generation.

METHODOLOGY

This study started with an investigation on the extensive literature review based on wood residue potential. The potential of wood residue in the scope of energy production was investigated. A structured interview via telephone was used in investigating the current utilisation of wood

residue in Kedah, Malaysia. The sample has been randomly chosen within a variety of wood-based industries in Kedah.

The wood waste energy generation is calculated using Equation (1) to Equation (2) (Ghani, Ali, & Mahmood, 2014). Where RV is the residue volume (m^3), MPV is the main product volume (m^3), PRP is the residue production ratio (%), EP is the energy potential (GJ), and LHV is the low heating value (GJ/m^3). The PRP is 40% (Koopmans & Koppejan, 1997). The LHV (Suzuki & Yoshida, 2009) for logging residue is 7.4 GJ/m^3, while the sawmill and plywood residue is 8.4 GJ/m^3. The data for MPV is taken from the Forestry Department Peninsular Malaysia (FDPM, 2015).

$$RV = MPV \times PRP/100 - PRP \quad (1)$$

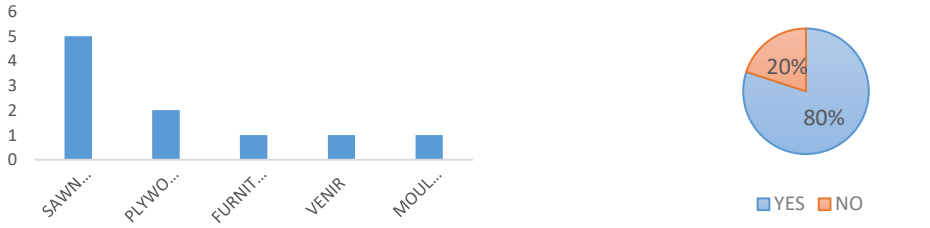
$$EP = RV \times LHV \quad (2)$$

RESULTS

Study Area

This study focuses on Kedah, the northern region of Malaysia. Kedah is a state in Northern Peninsular Malaysia between latitude 5 ° 5 '- 6 ° 35' North and longitude 99 ° 40 '- 101 ° 8' East. The influence of a tropical climate with high rainfall occurrence in the state has created a tropical rainforest, which is quite extensive at the height of over 150 metres above sea level. With a total area of 942.600 hectares, this state is an agricultural-based state, where paddy is the main crop, which has led to the state being known as the Rice Bowl of Malaysia. At the end of 2015, Kedah's forested land accounts for 342,431 hectares, which is 36% of the total Kedah area.

Current Wood Consumption in Kedah



(a) (b)

Figure 2

(a) Type of wood-based industry involved in this study; (b) Percentage of company generating wood residue

Figure 2 shows the percentage of generated wood residue in the mills. It is found that about 80% of the samples generated wood residue in their mills. However, 20% of the samples did not generate any residue in their mills. About 50% of the facilities came from sawn timber mills.

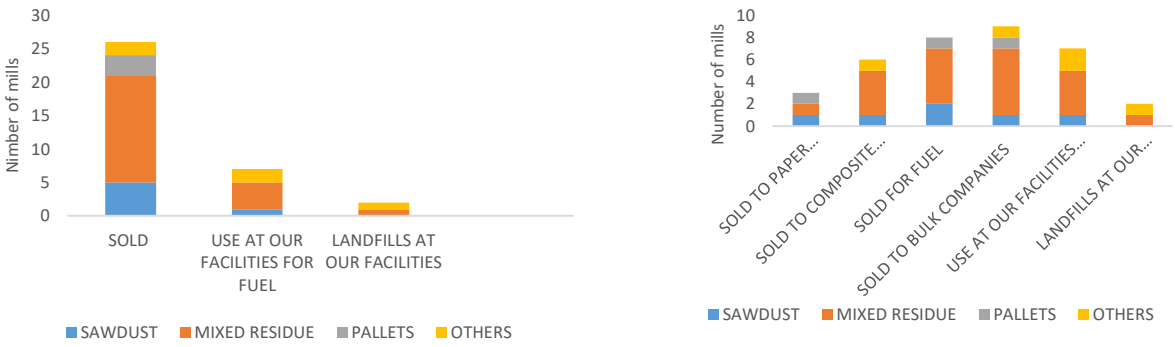


Figure 3
Type of wood residue and their current application

Figure 3 shows the type of available wood residue. There are four types of wood residue, which are sawdust, mixed residue, pallets, and others. About 74.3% of the mills have sold their wood residue to paper companies, composite manufacturers, and bulk companies. Only 20% of the samples used wood residue for fuel in their facility. Based on these results, mills owners in the northern region have high awareness regarding wood residue consumption in their facilities. All the residues are not being left in the mills without any action taken. Even small pieces of wood are being used to generate extra income for their company.

Figure 4 shows the generated income from selling their residue to other companies. Selling mixed residue can generate up to RM17k per month. According to Top (2015), there are two major types of solid wastes generated in furniture manufacturers: sawdust and small pieces of boards. The owners sell their residue in two types, which are sawdust and mixed residue.

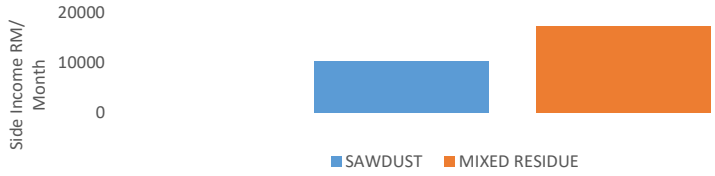


Figure 4
Income from selling wood residue

Potential Use of Wood Residue for Electricity Generation

Referring to the results from Figure 1 until Figure 3, it is shown that there is no wood residue left in their mills as waste. The mills have either sold the residue or used them for their fuel consumption. All the results indicated that there is no potentially available wood residue from the mills for power generation in the northern region of Malaysia. This is due to the limited resource supply available in this area. However, if wood residue is still not fully utilised, it may create a huge potential in electricity generation. Table 4 shows the potential of energy generation using wood waste in Kedah. Log residue is able to potentially generate 82.9 MW of electricity. The total wood waste in Kedah is able to potentially generate electricity equivalent to 155 MW, which is 0.005% from the total electricity generation in Malaysia in 2015.

Table 4
Potential of energy generation from wood waste in Kedah in 2015

Residue Type	MPV (m^3)	RPR (%)	RV (m^3)	EP (GJ)	Potential Capacity (MW)
Logs	530,531	40	353687.3	2617286	82.9
Sawn Timber	31,557	40	21038	176719.2	5.6
Plywood	128,694	45	105295.1	884478.8	28.0
Sawmills	48,487	38	29717.84	249629.8	7.9
Veneer / Plywood / Veneer Mills	139,453	45	114097.9	958422.4	30.4

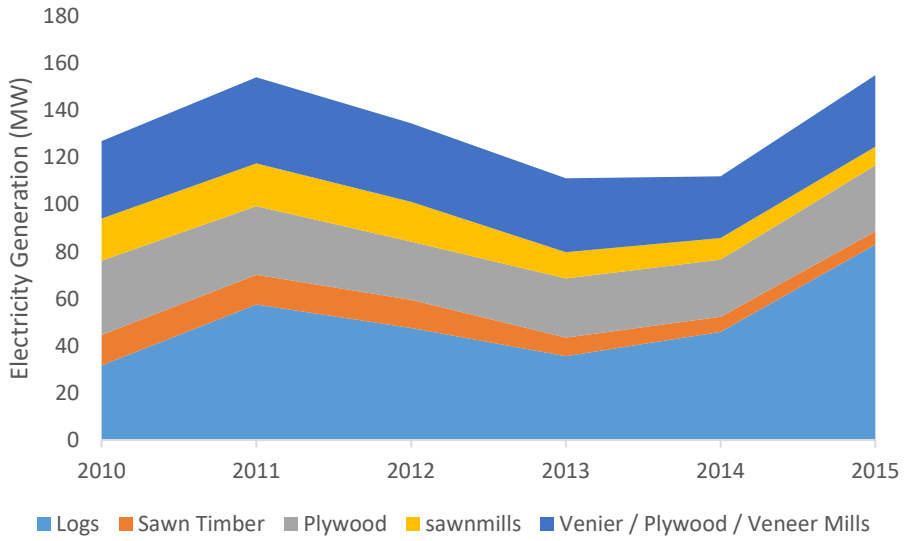


Figure 5
Potential electricity generation from wood residue in Kedah

Figure 5 shows the potential electricity generation from wood residue in Kedah from 2010 to 2015. This is could happen if the available wood residue is fed to the boiler. In the context of the environment, this could reduce the GHG emissions and also the cost of subsidy given to the conventional fossil fuel supply.

CONCLUSION

As a conclusion, mill owners have a high awareness regarding the consumption of wood residue. There is no unused wood residue indicated in the mills. However, the utilisation of wood residue for electricity generation is not encouraged due to the limited resource supply in the northern region of Malaysia, since the majority of mills have already sold their wood residue to paper mills, manufacturing companies, and bulk companies. These will generate extra income, and at the same time, can help them to dispose their waste in the mills. To apply wood waste for electricity generation in Kedah, it is not possible due to the limited sources. However, this can be achieved if the government gives an incentive toward biomass electricity generation in Malaysia.

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REFERENCES

Adebakin I. H., Adeyemi A. A, Adu J. T., Ajayi F. A., Lawal A. A, & Ogunrinola O. B. (2012). Uses of sawdust as admixture in production of lowcost and light-weight hollow sandcrete blocks. *American Journal of Scientific and Industrial Research*, 3(6), 458-463.

Adeyemo Y.A., Adeyeye, T. A., Okunlola, O. A., Bello, W. B., & Alamu, L. O. (2014). Comparative Study of Different Waste Product Utilization for Fuel Briquette. *Journal of Emerging Trends in Engineering and Applied Sciences*, 5(7), 78-81.

Akowuah, J. O., Kemausuor, F., & Mitchual, S. J. (2012). Physico-chemical characteristics and market potential of sawdust charcoal briquette. *International Journal of Energy and Environmental Engineering*, 3(20).

Antwi-Boasiako, C., & Acheampong, B. B. (2016). Strength properties and calorific values of sawdust-briquettes as wood-residue energy generation source from tropical hardwoods of different densities. *Biomass and Bioenergy*, 85, 144-152.

Bergeron, F. C. (2016). Energy and climate impact assessment of waste wood recovery in Switzerland. *Biomass and Bioenergy*, 94, 245-257.

Biomass assessment. From https://cdm.unfccc.int/filestorage/E/9/B/E9BNZ5TOP4QWJVKC3X0S72D6LFYU1A/Biomass%20Assessment_supporting%20Appn.7?t=VDl8bzE0cXZ6fDDu8GQn_Zc3hr0UByu-5bFM

Diji, C. J. (2013). Electricity Production from Biomass in Nigeria: Options, Prospects and Challenges. *International Journal of Engineering and Applied Sciences*, 3(4), 84-98.

FDPM. (2015). Annual Report. Kuala Lumpur: Foresty Department Peninsular Malaysia.

Forestry Department of Peninsular Malaysia. (2016). Forestry Statistics for The Year 2014 Retrieved 8 June 2016, from http://www.forestry.gov.my/index.php/en/pusat-sumber2/arkib-jpsm-3/perangkaan-perhutanan-2014

Ghani, L. A., Ali, N. A., & Mahmood, N. Z. (2014). A Study of Terengganu's Biomass Energy Potential from Forestry Wastes via Material Flow Analysis (Mfa) Approach. *Journal of Sustainability Science and Management* 9(1), 120-127.

Koopmans, A., & Koppejan, J. (1997). Agricultural and Forest Residues - Generation, Utilization and Availability. Paper presented at the Regional Consultation on Modern Applications of Biomass Energy, Kuala Lumpur.

Kuti, O. A. (2009). Performance of Composite Sawdust Briquette Fuel in a Biomass Stove under Simulated Condition AU J.T., 12(4), 284-288.

Lim, K. O., & Hii, P. B. Commercial Scale Carbonization of Briquetted Tropical Wood Sawdust. School of Physics, Universiti Sains Malaysia.

MTIB. (2016). Remark from the Minister. Retrieved 7 June 2016, 2016, from http://www.mtib.gov.my/index.php?option=com_content&view=article&id=47&Itemid=72&lang=en

Sánchez, E. A., Milagros B. Pasache, & García, M. E. (2014). Development of Briquettes from Waste Wood (Sawdust) for Use in Low-income Households in Piura, Peru. Proceedings of the World Congress on Engineering, 2.

Suzuki, H., & Yoshida, T. (2009). Current Situation and Concerns with Woody Biomass Use in ASEAN Countries. JARQ, 43(1), 37-43.

Tatiana Ivanova, Michel Kolarikova, Bohumil Havrland, & Passian, L. (2014). Mechanical Durability Of Briquettes Made Of Energy Crops And Wood Residues Engineering For Rural Development 29, 131-136.

Teodora Deac, V.Roş, & M.Deac. (2011). An Energy Analysis Of The Sawdust Pelletizing Process: A Systemic Approach. *Research Journal of Agricultural Science*, 43(1), 312-319.

Tokan, A., Sambo, A. S., Jatau, J. S., & Kyauta, E. E. (2014). Effects of Particle Size on the Thermal Properties of Sawdust, Corncobs and Prosopis Africana Charcoal Briquettes. *American Journal of Engineering Research (AJER*), 3(8), 369-374.

Top, Y. (2015). Waste generation and utilisation in micro-sized furniture-manufacturing enterprises in Turkey. *Waste Management*, 35, 3-11.