Biomas Energy Potential in Kampar Regency

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Abstrak

Kabupaten Kampar – Propinsi Riau dipercaya memiliki potensi energi biomassa besar, namun belum dimanfaatkan secara optimal karena minimnya data dasar. Artikel ini adalah hasil studi penilaian potensi energi biomassa di Kabupaten Kampar menggunakan pendekatan berdasar sumber daya dengan metode statistik dasar. Prosedur dari Biomass Energy Europe digunakan untuk menilai potensi teoritis biomassa hutan, tanaman energi, residu pertanian, dan limbah organik. Total potensi teoritis energi biomassa di Kabupaten Kampar adalah 127.635.417,90 GJ/tahun di mana 97,933 % residu pertanian, 2,066 % biomassa hutan dan 0,001 % limbah organik. Pada penelitian ini residu pertanian juga mencakup residu perkebunan (kelapa sawit dan kelapa) dan residu kotoran ternak (sapi, kerbau, kambing, dan unggas). Kelapa sawit menyumbang 88,15%, diikuti oleh ayam dan itik (5,28%), padi dan jagung (3,77%), dan residu hutan primer (2%). Pelepah sawit menyumbang 58,8% pada total potensi energi dari kelapa sawit dan 51,8% pada total potensi energi biomassa di Kabupaten Kampar.

Kata Kunci – *biomassa, energi, Kampar, potensi, statistik.*

Abstract

Kampar Regency - Riau Province is believed to have large potential for biomass energy, but has not been optimally utilized due to lack of baseline data. This article presents the result of a biomass energy resource assessment in Kampar Regency that used resource-based approach with basic statistical method. The procedure from Biomass Energy Europe was applied to assess the potential of forest biomass, energy crops, agricultural residues and organic wastes. The total theoretical potential of biomass energy in Kampar Regency is 127,635,417.90 GJ/year where 97.933% come from agricultural residues, 2.066% forest biomass and 0.001% organic waste. In this study the agricultural residues also included residues from plantations (oil palm and coconut) and animal residues (cow, buffalo, goat, and poultry). Oil palm contributes to 88.15%, followed by chickens and ducks (5.28%), rice and maize (3.77%), and primary forest residues (2%). The oil palm fronds are the largest contributor i.e. 58.8% of the total oil palm potential and 51.8% of the total biomass energy potential in Kampar Regency.

Keywords – *biomass, energy, Kampar, potential, Statistics.*

1. Introduction

Indonesia has various types of energy resources in a large capacity, both fossil and non-fossil fuels. The utilizations of fossil fuels however, have been facing a number of issues such as significant decrease of production (especially petroleum), increasing demand, unstable and constantly rising of prices, economic burden of fuel subsidies, and environmental problems from fossil fuel burnings.

Amid the rising demands, access to a reliable, equitable, affordable and environmentally friendly energy for all Indonesian is the main requirement for the future. In this instance, the utilization of renewable energy should be increased by means of an energy-mix scheme through supporting regulations to encourage the growth of renewable energy. Although in national level the utilization of renewable energy has been increasing during last dacade, the same trend has not occurred in Riau Province.

One of the main factors causing the slow growth of renewable energy development in Riau Province is due to the lack of baseline data so that the potentials, suporting and hidering factors, have not yet accurately and completely identified. Consequently, a number of renewable energy projects implemented in Riau Province were not based on an accurate and comprensive grand strategy. Therefore, there were errors in selecting the locations, the targeted communities, types of technologies, implementations strategies, and financing mechanisms. It is obvious that not a few renewable energy projects in Riau Province have failed.

The study was aimed at obtaining information about the theoretical potential of various biomass energy resources in Riau Provice. For the first stage, Kampar Regency was selected being the first study location.

ISSN : 2085-9902

2. Research Method

2.1. Reference

The assessment procedure used in this study referred to a guideline developed by the Biomass Energy Europe [1] titled "Harmonization of Biomass Resource Assessments, Volume I: Best Practices and Methods Handbook." This guideline was used because of its accuracy and completeness. It was formulated by the Biomass Energy Europe; consisted of 17 universities, consulting firms, and other research institutions in Europe. The Biomass Energy Europe conducted in-depth analysis on 250 approaches and methodologies on the assessment of biomass energy potential from various countries, and formulated a more complete and accurate guideline [2].

2.2. Scope

This study used a resource-based approach with basic statistical methods. Four groups of biomass discussed in this study included forest biomass, energy crops, agricultural residues and organic wastes. In general, this study was carried out through several phases, include: (1) preparation; (2) secondary data collection; (3) field surveys; (4) data analysis; and (5) interpretation of analysis results.

2.3. Types and Sources of Data

In general, the data for this study were classified into socio-economic and biophysical data. Socio-economic data covered the administrative, population, economic and financial, and institutional aspects. Biophysical data included the land resources data (topography, soil, climate and hydrology, and land use patterns). While the biological resources data included types and condition of forests, crops, vegetables, tree crops, and municipal wastes.

This study mainly used secondary data obtained from various institutions in Kampar Regency. They included Bureau of Statistics; Office of Animal Husbandry; Office of Plantation; Office of Agriculture and Foods; Office of Forestry; and Office of Markets, Hygiene, and Parks. This research would have been better if supported with data from the Kampar Regency's Office of Mines and Energy, Office of Development Planning, and Office of Environment. However, until the deadline for the research report submission, information from those institutions could not be obtained. Alternatively, data from the Provincial offices of Mines and Energy, Development Planning, and Environment, were used instead.

2.4. Data Analysis

Data analysis was conducted using a quantitative approach with specific mathematical equations and other parameters. The data of biomass resources were grouped into four types i.e. forest biomass, energy crops, agricultural residues and organic wastes. Furthermore, various parameters required to determine the potential of biomass were obtained from the literature. Secondary data and other parameters then were inserted into the equations from the Biomass Energy Europe Guidelines to produce the amount of biomass energy potential. In the final section, the potential of existing biomass were converted into primary energy unit (gigajoule) using a variety of low heat values (LHVs) based on the type and nature of each biomass.

3. Results and Analysis

3.1. Assessment Method for Biomass Energy Potential

This section briefly presents the methods for assessing the potential for biomass energy adapted from the Biomass Energy Europe. Although it was used for Kampar Regency, this method can also be applied fior other Regencies in Riau Province or even in many other regions of Indonesia.

3.1.1. Forest biomass

Forest biomass assessment methods are based on the information about the current or future increases or decreases of forest volume (net annual increment, NAI). In the bioenergy context, forest biomass includes all types of woody raw materials obtained from the woods or from wood processing for energy production.

Total potential for forest biomass is calculated by:

$$TP\_FWB_{x,y} = TP\_SW_{x,y} + TP\_PFR_{x,y} + TP\_SFR_{x,y} \quad \text{--- (Eq. 1)}$$

where:
$TP\_FWB_{x,y}$ = total potential of forest woody biomass in region x in year y, (m^3/year)
$TP\_SW_{x,y}$ = potential of stemwood in region x in year y, (m^3/year)
$TP\_PFR_{x,y}$ = potential of primary forestry residues in region x in year y, (m^3/year)
$TP\_SFR_{x,y}$ =potential of secondary forestry residues in region x in year y, (m^3/year)

3.1.2. Energy Crops

The assessment of the energy crops potential is relatively simple and straightforward because it only takes the available land for energy crops and estimation of the harverst into account. Since the production of bioenergy crops should not compete with food crops, only the surplus agricultural land and the land not suitable for food or feed production are considered here.

Energy potential of energy crops is calculated using the following equation:

$$P = \sum A_i \; x \; Y_i$$ ----- (Eq. 2)

where:
P = potential of energy crops i (tonne)
A = area surplus agricultural land suitable for energy crop i (ha)
Y = yield energy crop i (t/ha)

3.1.3. Agricultural Residues

Primary Agricultural Residues

Primary agricultural residues is calculated with:

$$THP\_PAR = \sum (CA_i x\; AP_i x PtR_i x\; Av_i)$$ ---- (Eq. 3)

where:
THP_PAR = primary agricultural residues (e.g. straw, stalks), in tonnes
CA_i = cultivated area of i crop, in hectares (ha)
AP_i = agricultural production of i crop, in tonnes per hectare (t/ha)
PtR_i = product to residue ratio of i crop
Av_i = availability of residues for i crop according to current harvesting system

Manure

Methods to estimate the theoretical potential of manure is based on the factor "heads of livestock of animal and poultry." By multiplying the number of heads with the ratio of "manure per head" for a certain type of livestock, one can estimate the total amount of manure produced, which is expressed by the following equation:

$$THP\_manure = \sum NHead_i \; x \; MpH_i$$ ---- (Eq. 4)

where:
THP_manure = theoretical potential of manure (tonnes/year)
$NHead_i$ = the number of heads for the i type of livestock
MpH_i = amount of manure for the i type of livestock, in tonnes per head
i = type of livestock, i.e. cattle, pig, poultry etc.

Biogas is the main product of the digestion of manure to produce energy. Therefore, to provide energy potential, the amount of manure is multiplied with the specific biogas yield and energy content of the biogas (Eq. 5).

$$Energy\_manure = \sum NHead_i \; x \; MpH_i x \; BY_i \; x \; GEC_i$$ --- (Eq. 5)

where:
BY_i = biogas yields for the i type of livestock manure, in cubic meters (m^3) per tonne
GEC_i = energy content of gas produced from the i type of livestock manure, in Joule/m^3

3.1.4. Organic Waste

Organic waste, also called biomass waste, bio waste, or tertiary residues; derived from the end-use of products containing biomass, such as biodegradable municipal waste, demolition wood from construction and sewer mud. In contrast to energy crops, organic waste is not specifically produced for energy use.

Biodegradable Municipal Waste

A direct method to determine the theoretical potential (and technical potential) of biodegradable municipal waste (BMW) by thermal applications (such as incineration) is described in Eq. 6.

$$TP\_BMW_{x,y} = MSW_{x,y} \; x \; POP_{x,y} \; x \; ACC_x \; x \; OC_x \; x \; LHV_{BMW}$$ -- (Eq. 6)

where:
$TP\_BMW_{x,y}$ = biomass potential of BMW of country x in year y (PJ/year)
$MSW_{x,y}$ = municipal waste production per capita of country x in year y (tonnes/person/year)

$POP_{x,y}$ = population of country x in year y (persons)
ACC_x = percentage of the population served by municipal waste services (%)
OC_x = organic content of MSW in country x (dimensionless)
LHVBMW = lower heating value of BMW (GJ/tonne), from [3].
x = country/province/city/region
y = year

Gas in Landfills

To determine the energy potential from gas in landfills, information about the methane production from the solid waste disposal site can be used (Eq. 7).

$$TP\_LFG_{x,energy} = CH_4\ generated \times LHV_{CH4} \text{ ----- (Eq. 7)}$$

where:
$TP\_LFG_{x,energy}$ = theoretical / technical potential of landfill gas in country x (PJ)
CH_4 *generated* = amount of methane (CH_4) generated from decomposable material (ktonnes CH_4).
CH_4 *generated* = lower heating value of methane (PJ/ktonne)

3.2. Biomass Energy Potential in Kampar Regency

Table 1 summarizes the potential of biomass energy in Kampar Regency. The total theoretical biomass energy potential in Kampar Regency is 127,635,418 GJ/year. This value did not not include the potential of stem wood, energy crops, and some types of agricultural residues such as cassava and sweet potatoes. In addition, due to the lack of data availability, the energy potential from municipal waste such as construction and demolition residues and residues from wastewater (sewage sludge and waste gas), were also not included.

When converted into secondary energy units (e.g. electricity), the biomass energy potential in Kampar Regency is equivalent to 35,454 GWh of electrical energy. For comparison, in 2009, the production of electrical energy for the entire region of Riau Province was 2.495 GWh [4]. Therefore, the theoretical potential of biomass for electrical energy in Kampar Regency is equivalent to 1,421 times of the production of electrical energy throughout Riau Province in 2009. However, it should be noted that not all of these primary energy potential could be utilized into secondary energy due to various restrictions and limitations. These limits are usually assessed through technical, economical, implementation, and sustainability analyses. Table 1 summarizes the theoretical potential of biomass energy in Kampar Regency.

Tabel 1- Summary of the theoretical potential of biomass energy in Kampar Regency.

NO	Biomass resource group	Potential		Energy Potential (GJ/year)	Energy Potential (GWh/year)
		Volume	Unit		
A	**Forest biomass**	**1,87,999.92**		**2,636,974.40**	**732.49**
A.1	Stemwood	837,738.23	m^3/year	-	-
A.2	Primary forest residues	1,031,030.34	m^3/year	2,629,127.40	730.31
A.2	Secondary forest residues	5,231.35	m^3/year	7,847.00	2.18
B	**Energy crops**	**35,649.56**		-	-
B.1	Critical land	35,649.56	Ha	-	-
C	**Agricultural residues**	**12,049,656.97**		**124,997,097.00**	**34,721.42**
C.1	Primary agricultural residues	**215,044.01**		**3,161,147.20**	**878.10**
	- Wet rice straw	179,888.34	ton/year	2,644,358.60	734.54
	- Dry rice straw	14,515.17	ton/year	213,373.00	59.27
	- Corn trunk	20,640.50	ton/year	303,415.60	84.28
C.2	Secondary agricultural residues	**11,274,701.96**		**114,178,825.60**	**31,716.34**
	- Wet straw and rice husks	125,921.80	ton/year	1,473,285.50	409.25
	- Dry straw and rice husks	10,160.60	ton/year	118,879.20	33.02
	- Corn Cob	2,817.43	ton/year	36,626.60	10.17
	- Corn skin	2,031.17	ton/year	26,832.70	7.45
	- Coconut shell	125.50	ton/year	2,510.40	0.70
	- Coconut fiber	366.10	ton/year	5,857.60	1.63
	From the community-owned plantation:				
	- Oil palm fibers	80,577.62	ton/year	913,750.20	253.82
	- Oil palm shells	30,335.10	ton/year	571,210.00	158.67
	- Oil palm bunches	104,276.90	ton/year	850,899.70	236.36
	- Oil palm kernel	30,335.10	ton/year	515,696.80	143.25
	- Oil palm POME	577,136.84	m^3/year	363,596.20	101.00
	- Oil palm fronds	524,992.00	ton/year	8,252,349.20	2,292.32
	From the private-owned plantation:				
	- Oil palm fibers	998,002.70	ton/year	11,317,350.40	3,143.71
	- Oil palm shells	375,718.70	ton/year	7,074,782.30	1,965.22
	- Oil palm bunches	1,291,532.90	ton/year	10,538,908.30	2,927.47
	- Oil palm kernel	375,718.70	ton/year	6,387,217.10	1,774.23

 ISSN : 2085-9902

	- Oil palm POME	2,524,359.70	m^3/year	4,503,360.10	1,250.93
	- Oil palm fronds	3,414,746.40	ton/year	53,676,398.70	14,910.11
	From the government-owned plantation:				
	- Oil palm fibers	87,580.60	ton/year	993,164.00	275.88
	- Oil palm shells	32,971.50	ton/year	620,853.70	172.46
	- Oil palm bunches	113,339.60	ton/year	993,164.00	275.88
	- Oil palm kernel	32,971.50	ton/year	560,515.80	155.70
	- Oil palm POME	270,789.90	m^3/year	170,597.60	47.39
	- Oil palm fronds	267,893.60	ton/year	4,211,019.50	1,169.73
C.3	Manure	**559,911.00**		**7,657,124.20**	**2,126.98**
	- Cow dung	21,465.00	ton/year	321,975.00	89.44
	- Buffalo dung	35,690.40	ton/year	531,787.00	147.72
	- Goat dung	3,758.20	ton/year	66,896.30	18.58
	- Broiler chicken dung	480,353.60	ton/year	6,484,773.30	1,801.33
	- Range chicken dung	17,363.00	ton/year	234,400.70	65.11
	- Duck dung	256.40	ton/year	3,461.80	0.96
	- Manila duck dung	1,024.40	ton/year	13,830.10	3.84
D	**Organic waste**	**541.20**		**1,346.50**	**0.37**
D.1	Municipal waste	492.00	ton/year	116.50	0.03
D.2	Organic waste	49.20	ton/year	1,230.00	0.34
	Total	**13,959,847.65**		**127,635,417.90**	**35,454.28**

As shown in the following Figure 1, the majority of biomass energy potential in Kampar regency comes from agricultural residues (97.933%), while forest biomass and organic waste only contribute to 2.066% and 0.001%, respectively. It should be noted that in this study, the agricultural residues also include agricultural residues (oil palm and coconut) and livestrock residues (cow, buffalo, goat, and poultry).

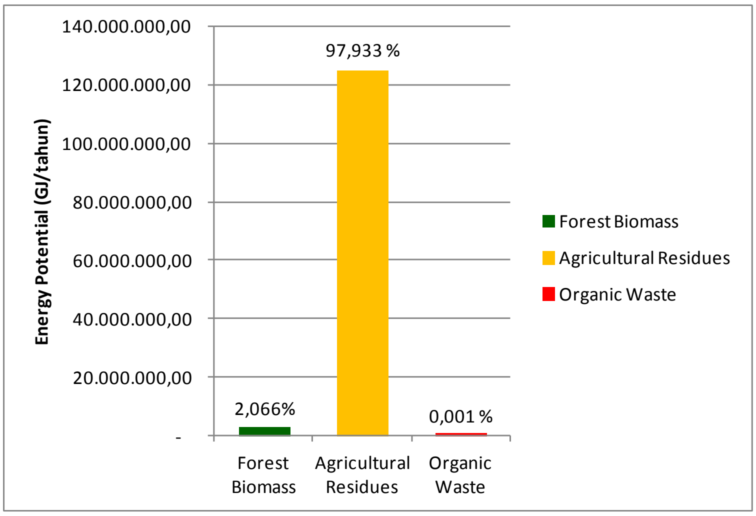

Figure 1- Shares of forestry, agricultural and organic waste sectors on the biomass energy potential in Kampar Regency

Figure 2 shows the contribution of each commodity on the biomass energy potential in Kampar Regency. Palm oil is the major contributor (88.15%), followed by chicken and ducks (5.28%), rice and corn (3.77%), and primary forest residues (2%).

 ISSN : 2085-9902

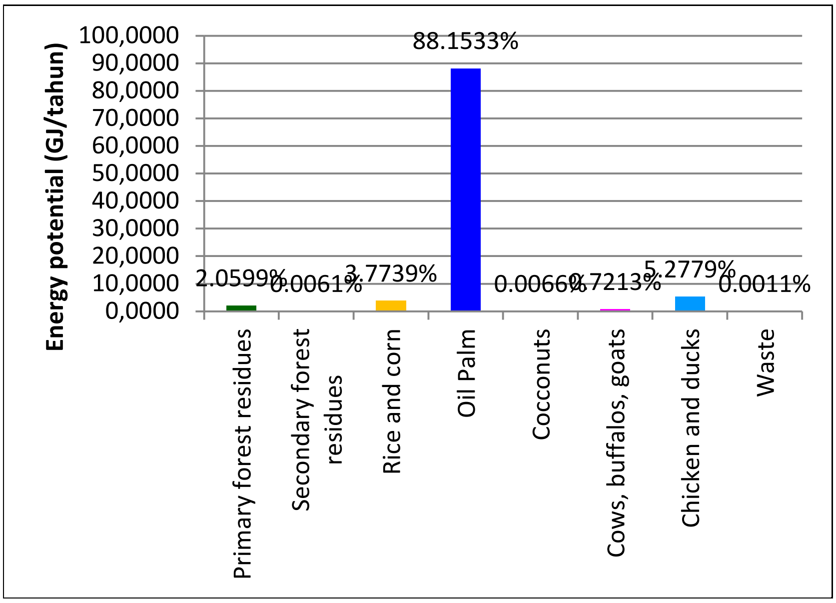

Figure 2- Biomass energy potential in Kampar Regency by commodity

If the energy potential of each commodity shown above is converted in to electricity, it would produce the amount of electrical energy as shown in Table 2. It can be seen that oil palm has the potential to produce an amount electrical energy which us equivalent to 1,253 times the electrical energy production throughout the province of Riau in 2009.

Tabel 2- The potential of electrical energy production from biomass energy in Kampar Regency

Commodity	Electrical energy production potential (GWh/year)	% compared to electrical energy production in Riau Province in 2009
Primary forest residues	730.31	29.27
Secondary forest residues	2.18	0.09
Rice and corn	1,337.99	53.63
Oil palm	31,254.12	1,252.67
Cocconut	2.32	0.09
Cows, buffalos, and goats	255.74	10.25
Chicken and ducks	1,871.24	75.00
Waste	0.37	0.01
TOTAL	35,454.28	1,421.01

If viewed from the components of an oil palm tree that have energy potential, the contribution of each component is shown in Table 3. The oil palm frond is the largest contributor i.e. 58.8% of the total energy potential of the oil palm and 51.8% of the total biomass energy potential in Kampar regency. It should be noted that only the oil palm plantations owned by private and government that have sewage treatment plants. Therefore, technically, the POME potential of oil palm plantations owned by the community is difficult to be implemented.

Tabel 3- Energy potential of the oil palm tree components in Kampar Regency

Components of oil palm tree for energy	Energy potential (GJ/year)	Energy potential (GWh/year)	% of the total energy potential of oil palm	% of the total energy potential of biomass
Frond	66,139,767.40	18,372.16	58.78	51.82
Fiver	13,224,264.60	3,673.41	11.75	10.36
Stem	12,382,972.00	3,439.71	11.01	9.70
Shell	8,266,846.00	2,296.35	7.35	6.48
Kernel	7,463,429.70	2,073.17	6.63	5.85
POME (from plantations owned by private and government)	4,673,957.70	1,298.32	4.15	3.66
POME (from plantations owned by community)	363,596.20	101.00	0.32	0.28
TOTAL	112,514,833.60	31,254.12	100.00	88.15

4. Conclusion

This study has produced baseline information about the theoretical potential of different sources of biomass energy in Kampar Regency - Riau Province. There were four types of biomass energy potential assessed in this study, include: (1) forest biomass, (2) energy crops, (3), agricultural residues, and (4) of organic waste. Of the three types of forest biomass, only the energy potential of the primary and secondary forest residues that caould be assessed, while the energy potential from the stemwood was not assessed because there has not been an effort to utilise the stemwood through a sustainable forest conversion management practices in Kampar regency. In addition, the energy potential from energy crops by utilizing of degraded land and low productivity agricultural/plantation land, was not also calculated due to lack of data. Several types of agricultural residues such as cassava and sweet potatoes, and municipal waste such as construction and demolition residues and residues from wastewater (sewage sludge and waste gas), were not also included because of lack of data.

The total theoretical potential of biomass energy in Kampar Regency is 127,635,417.90 GJ/year which is equivalent to 35,454.28 GWh of electricity per year, and is equivalent to 1,421 times of the electrical energy production throughout Riau Province in 2009. However, it should be noted that not all of these primary energy potential can be practically utilized as a secondary energy due to various restrictions and limitations. These limits are usually assessed through the analysis the technical, economical, implementation, and sustainability potential.

The majority of the biomass energy potential in Kampar Regency is derived from agricultural residues (97.933%), while forest biomass and organic waste only account fo 2.066% and 0.001%, respectively. It should be noted that in this study the agricultural residues also includes plantation residues (oil palm and coconut) and livestock residues (cow, buffalo, goat, and poultry).

Oil palm is the primary contributor (88.15%), followed by chicken and ducks (5.28%), rice and corn (3.77%), and primary forest residues (2%). Oil palm has the potential to produce electrical energy equivalent to 1,253 times the electrical energy production throughout the Province of Riau in 2009. Oil palm fronds are the largest contributor that is 58.8% of the total energy potential of the oil palm and 51.8% of the total energy potential of biomass in Kampar Regency.

5. Acknowledgements

The author thanks the Head of the Research and Development (LPP) of UIN Suska Riau University for financial support to this study. A special gratitute to Devi Nuryadi for his help in writing parts of this study report and undertake the literature searches. Many thanks to Raja Saleh, Ade Akhyar, Rajes, and Erlian Zurhas for their great assistances in doing the field survey in Kampar Regency. High appreciation to Petir Papilo for providing some important data, and to Nesdi Evrilyen Rosanda and Novriyanto for their valuable thoughts during the early stage of this study.

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