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Potential Surplus of Rice Straw as a Source of Energy for Rural Communities in Indonesia
Abstract :This study was conducted to identify the potential surplus of rice straw as a source of energy for rural communities in Indonesia. Rural communities need a source of energy for electrical energy and small industry. Determination of the potential surplus of rice straw performed by compared the total potential of rice straw produced and portion used for other usage such as animal feed and raw materials for industry. The remainder wasted was named as a potential surplus of rice straw in this study that can be used as fuel.

The study shows the potential of rice straw in total, for animal feed, for industries raw materials, and for energy source. Each of which has increased average about 2% per year or increased about 10% over 5 years (2009-2013). The study is expected to be one of the alternative sources of energy to meet the electrical energy needs and energy requirements for small industries on rural communities in Indonesia. Keywords: Rice straw, Potential surplus, Source of energy, Rural communities.

Introduction The potential of rice straw (RS) produced in Indonesia was quite large and increasing every year. Over 5 years of period, the potential of RS produced was about 96.60 million tons, 99.71 million tons, 98.64 million tons, 103.58 million tons, 106.31 million tons in 2009, 2010, 2011, 2012, and 2013, respectively.

RS in Indonesia is used as raw material for industry (RSi) of about 7%, animal feed (RSa) of about 31%, and about 62% just burnt as waste[1]. Utilization of RS in Indonesia is targeted to increase approximately 40% for animal feed (RSa), approximately 30% for small industries (RSi), and approximately 25% for fuel (RSf). Thus RS as waste (SRw) is only about 5%. The potential of RS to be used as fuel, which is RS surplus is not used for

industry and animal feed.

Surplus of RS is wasted in the fields, generally burned to clear the land that will be used the next planting. Burning of RS should be avoided because it can damage the soil nutrients, reduce soil fertility, and produces air pollution. Burning of RS in the field can emit gases CO, CH₄, NO_x, and SO₂ into the atmosphere due to uncontrolled combustion processes [2].

This study was conducted to obtain the potential surplus of RS as an alternative source of energy for rural communities in Indonesia. The results of the study are expected to contribute to the policy makers and investors in order to develop the potential of RS to overcome the shortage of electric energy in rural areas.

Materials and Method In determining the potential surplus of RS available in Indonesia each year, rice production (RP) data was analyzed for 5 years (2009 - 2013). As for determining the availability of potential surplus of RS in each province, performed data analysis of RP in 2013 [3]. Determination of RS available potential can be determined by using the value of Straw-to-Grain Ratio (SGR) of 1.5

[2, 4-5] and the amount of RP every year, using the equation. $RS = SGR \times RP$ (1)

Determination of the potential surplus of RS can be used as fuel (RSf) in rural areas, can be determined by the equation: $RSf = RSt - (RSi + RSa + RSw)$ (2) where RSt = rice straw produced overall rice production obtained by (Eq.1), RSi = rice straw as raw material for small industries, RSa= rice straw for animal feed, RSw = rice straw as waste.

Determination of potential energy of RH surplus can be done based on previous study [6-7], by the equation: $EPRS = WRS \times CVRS$ (3) where WRS = number of RS, and CVRS = calorific value of RS. Results and Discussion Analysis of the potential of rice straw surplus The potential of RS produced from RP in Indonesia in 2009 - 2013, can be analyzed using Eq.

(1). While the potential surplus of RH can be determined by using Eq. (2) Analysis of the potential surplus of RS refers to the utilization of RS for animal feed (RSa) of about 40%, RS as raw material for industry (RSi) of about 30%, the RS surplus for fuel (RSf) of approximately 25%, and RS as waste (SRw) is about 5%.

The analysis results of the potential surplus of RS are presented in Table 1. Table 1. Potential surplus of rice straw in Indonesia in 2009 - 2013. No _Year _RP (106ton) _RSt (106ton) _RSa (106ton) _RSi (106 ton) _RSw (106ton) _RSf (106ton) _ _1 _2009 _64.40 _96.60 _38.64 _28.98 _4.83 _24.15 _ _2 _2010 _66.47 _99.71 _39.88 _29.91 _4.99 _24.93 _

_3_2011_65.76_98.64_39.46_29.59_4.93_24.66__4_2012_69.05_103.58_41.43_31.07_5.18_25.90__5_2013_70.87_106.31_42.52_31.89_5.32_26.58__ Table 1 shows the development of RP, RSt, RSa, RSi, RSw, and RSf, increased significantly every year for 5 years.

In 2009, the potential of RS in total obtained approximately 96.60 million tons, increasing to approximately 106.31 million tons in 2013. In this case an increase of approximately 10% for 5 years, or an average increase of approximately 2% per year, as shown in Fig. 1. / ___ / / / / ___ Fig. 1. The development of the potential surplus of RS in 2009 - 2013. Fig.

1 shows a potential surplus of RS in Indonesia has good prospects as a future energy source of electricity in rural areas. Continuity of supply potential of RS will be assured will not be reduced and even be increased each year in Indonesia as one of producer and exporter of rice in the world. The main consideration for the smooth operating power plant is the availability and continuity of fuel supply [8-9].

The Potential surplus of rice straw in each province in Indonesia Analysis of the potential surplus of RS in each province can be obtained by using Eq. (1), Eq. (2) and Eq. (3) with a calorific value of RS from the experimental results obtained approximately 12.56 MJ/kg. The availability of the potential surplus of RS, are presented in Table 2. Table 2. Availability the potential surplus of RS in each province in Indonesia in 2013.

No	Province	RP (103ton)	RSt (103ton)	RSa (103ton)	RSi (103ton)	RSw (103ton)	RSf (103 ton)	EPRSf (TJ)
1	East Java	12,199	18,299	7,320	5,490	915	4,575	57,462
2	West Java	11,272	16,908	6,763	5,072	845	4,227	53,091
3	Central Java	10,233	15,350	6,140	4,605	768	3,838	48,205
4	South Sulawesi	5,008	7,512	3,005	2,254	376	1,878	23,588
5	North Sumatra	3,716	5,574	2,230	1,672	279	1,394	17,509
6	South Sumatra	3,295	4,943	1,977	1,483	247	1,236	15,524
7	Lampung	3,093	4,640	1,856	1,392	232	1,160	14,570
8	West Sumatra	2,368	3,552	1,421	1,066	178	888	11,153
9	West Nusatenggara	2,114	3,171	1,268	951	159	793	9,960
10	South Kalimantan	2,086	3,129	1,252	939	157	782	9,822
11	Banten	1,866	2,799	1,120	840	140	700	8,792
12	Aceh	1,789	2,684	1,074	805	134	671	8,428
13	West Kalimantan	1,300	1,950	780	585	98	488	6,129
14	Central Sulawesi	1,024	1,536	614	461	77	384	4,823
15	Jogyakarta	946	1,419	568	426	71	355	4,459
16	Bali	866	1,299	520	390	65	325	4,082
17	Central Kalimantan	756	1,134	454	340	57	284	3,567
18	East Nusatenggara	699	1,049	420	315	53	262	3,291
19	Jambi	625	938	375	281	47	235	2,952
20	North Sulawesi	615	923	369	277	46	231	2,901
21	Bengkulu	582	873	349	262	44	218	2,738
22	East Kalimantan	553	830	332	249	42	208	

2,613 23 Southeast Sulawesi 516 774 310 232 39 194 2,437 24 Riau 512 768 307 230 38
 192 2,412 25 West Sulawesi 413 620 248 186 31 155 1,947 26 Gorontalo 245 368 147
 110 18 92 1,156 27 Papua 138 207 83 62 10 52 653 28 Maluku 84 126 50 38 6 32 402 29
 North Maluku 66 99 40 30 5 25 314 30 West Papua 30 45 18 14 2 11 138 31 Bangka
 Belitung 23 35 14 11 2 9 113 32 Jakarta 11 17 7 5 1 4 50 33 Riau Islands 1 2 1 1 0 1 13
 Total 69,044 103,566 41,426 31,070 5,178 25,892 325,204

__ Table 2 shows the potential surplus of RS and the potential energy for each province is vary in number. In total, potential surplus of RS for fuel (RSf) obtained approximately 25.892 million tons with the energy potential of around 325,204 TJ.

Conclusion The potential surplus of RS is one source of energy that can be used to supply electrical energy to rural communities in Indonesia. Rural communities need a source of energy to meet the electrical energy needs and small industries. The potential of RS produced, is used for animal feed, for small industries raw materials, and for use as fuel.

The analysis shows the potential of RS increased each of about 10% for 5 years, or an average increase of approximately 2% per year. The potential surplus of RS in each province various in number, where the largest and smallest was East Java and Riau Islands, respectively. The study is expected to be one of the alternative sources of energy to meet the electrical energy requirement and energy needs of small industries in rural areas in Indonesia.

Acknowledgment The authors are grateful to the Ministry of Higher Education Malaysia for the RU Grant, Vot 05H25 and Research Management Centre, UTM for the financial and management support. References Martawidjaja, M., Utilization of rice straw as a substitute for grass small ruminant, Wartazoa, Livestock Research Center, 13 (2003) 119. Gadde, B., et al.,

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