JURNAL 7

Komentar untuk karya penelitian : 'Judul Artikel: The potential energy of plastic solid waste as alternative fuel for power plant in Indonesia. Penulis: Muhammad Anshar, Farid Nasir Ani, Ab Saman Kader, Nama Jurnal: Applied Mechanics and Materials, Volume Jurnal: 699, Tahun Terbit Jurnal: 2015, Halaman: 595-600, ISSN: 1662-7482, Penerbit: Trans Tech Publications, DOI: 10.4028/www.scientific.net/AMM.699.595': Agar divirifikasi kemiripan dengan artikel-artikel sebelumnya.

Jawaban:

Mohon maaf Prof kalau ada kemiripan artikel ini No. 7 dengan artikel sebelumnya (No.6) dengan judul "The energy potential of municipal solid waste for power generation in Indonesia" karena kedua artikel ini dilatarbelakangi dengan pemanfaatan energi terbarukan terutama pemanfaatan sampah padat perkotaan atau Municipal solid waste (MSW) sebagai sumber energi (bahan bakar) pada pembangkit listrik (power generation). Jadi beberapa referensi yang saya gunakan sama kedua artikel tersebut. Namun perbedaan mendasar adalah Artikel No.7 ini membahas pemanfaatan sampah plastik sebagai bahan bakar pada pembangkit listrik (power generation). Sedangkan paper No. 6 membahas pemanfaatan sampah padat perkotaan (municipal solid waste) sebagai bahan bakar pada pembangkit listrik (power generation). Namun ada kemiripan karena limbah padat plastik (plastic solid waste) berasal dari limbah padat perkotaan (municipal solid waste) sehingga ada beberapa referensi yang sama. Jadi pada prinsipnya substansi kedua artikel tersebut berbeda, terbukti hasil similarity check hanya 10%.

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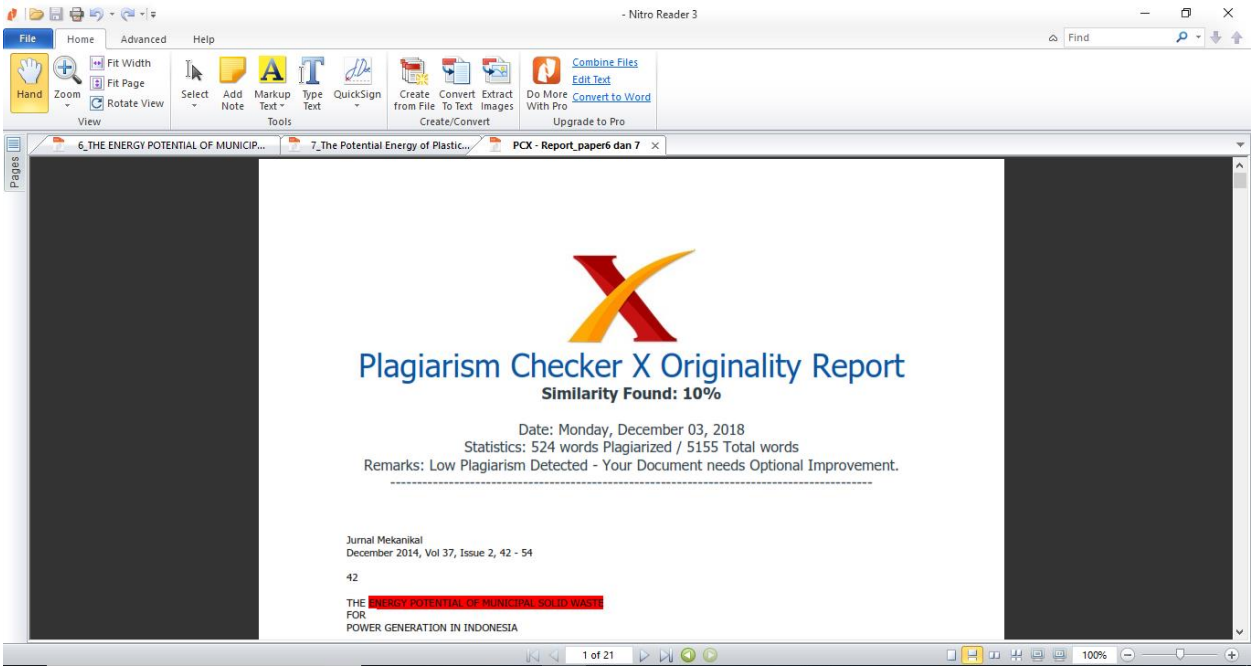

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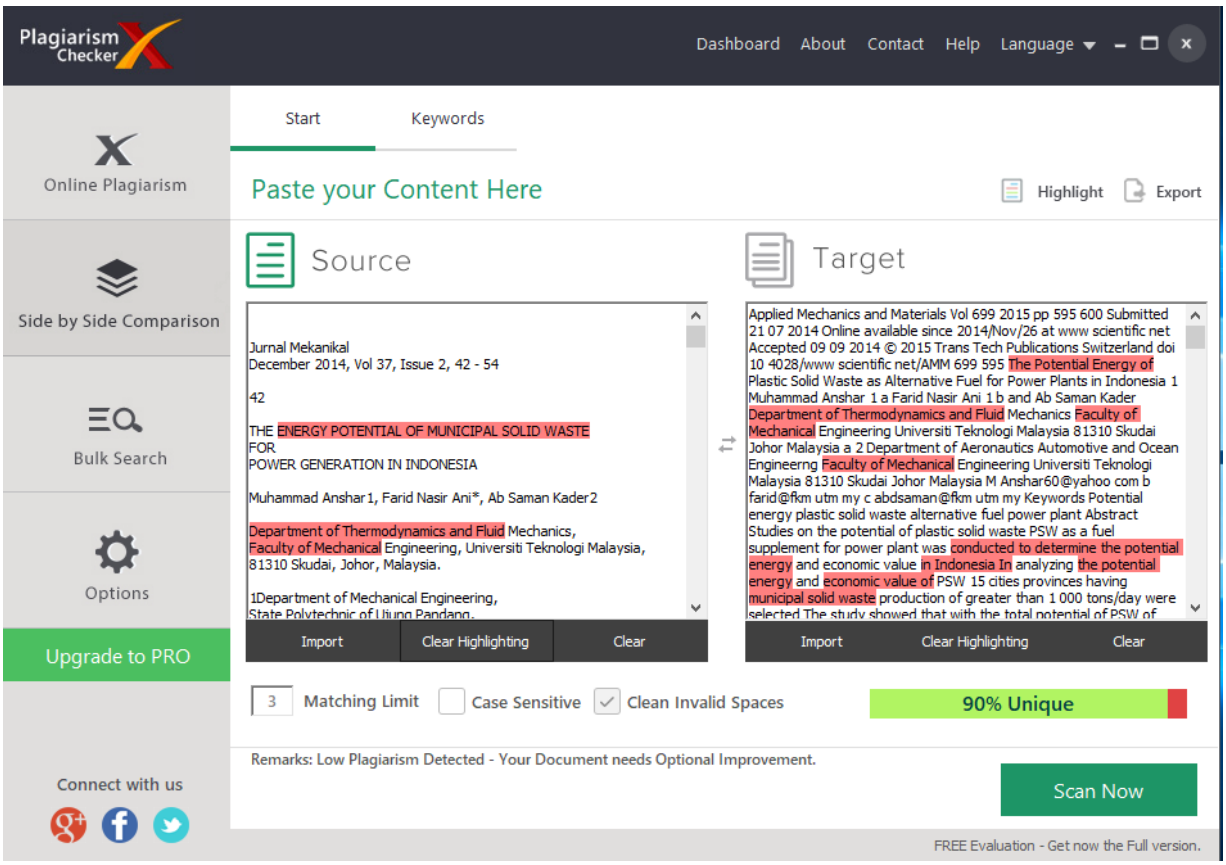

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The Potential Energy of Plastic Solid Waste as an Alternative Fuel for Power Plants in Indonesia

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Keywords: Potential energy, Plastic solid waste, Alternative Fuel, Power plant.

Abstract. Studies on the potential of plastic solid waste (PSW) as a fuel supplement for power plant was conducted to determine the potential energy and economic value in Indonesia. In analyzing the potential energy and economic value of PSW, 15 cities provinces having municipal solid waste production of greater than 1000 tons/day were selected. The study showed that with the total potential of PSW of around 742 tons/day, the electrical energy potential available is around 356.5 MW. The PSW equivalent with coal is approximately 1,143 tons/day, and its equivalent to the oil is approximately 640 ton/day. In conclusion, the PSW is an environmental pollution material but have the energy and economic potential to be used as a fuel supplement for the power plants. Thereby, it can save the use of coal and at the same time overcome the problem of plastic waste in Indonesia.

Introduction

Plastic solid waste is dangerous to the environment because it pollutes the environment and cannot decompose completely in a short time, it takes tens to hundred years to decompose. At the time of degradation, plastic particles will contaminate soil and groundwater. If it is burnt in landfills, incomplete combustion will produce toxic fumes and hazardous to health because the plastic will break down as dioxin. Dioxin compounds are very dangerous, if inhaled by humans could cause cancer, hepatitis, inflammation of the liver and nervous system disorders. At the stage of landfill disposal, plastic wastes emit greenhouse gases if the plastic bags are left on the landfill ground [1]. While the use of plastic bags in Indonesia cannot be avoided and there is no alternative to that can be used by the public for the purposes of day-to-day activities. Although PSW is a source of pollution, but it also have an economic and energy potential that is, it could be used as fuel due to it high calorific value. To overcome these problems, one alternative that needs to be done so that the plastic waste does not contaminate the environment, then the PSW should be optimized in utilization as fuel in power plants. The utilization of PSW can be controlled so as to minimize harmful gases produced during combustion. For PSW combustion in boilers, the exhaust emissions can be minimized by using exhaust emission control system. This study was conducted to obtain an overview of the potential of the PSW in Indonesia and is expected to provide information to policy makers and the competent authorities of exploiting energy potential of plastic bags in Indonesia as a fuel supplement on the power plant. It is expected to be one of the methods to overcome the problems of plastic solid waste (PSW) and reduce the use of coal at the power plant in Indonesia.

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Materials and Methods

The PSW is selected as the study samples are plastic bags of municipal solid waste (MSW) generated each day. Sample locations, selected 15 cities that have larger MSW production of 1,000 tons/day. In this case the selected Jakarta, Surabaya, Bandung, Medan, Semarang, Palembang, Makassar, Padang, Denpasar, Pekanbaru, Samarinda, Manado, Pontianak, Kupang, and Mataram. The city represents the 39 provinces cities in Indonesia. The data used are the statistical data on the average for the year 2008-2010, includes data of MSW production in Indonesia 2008-2010 [2] and PSW calorific value data can be obtained from the results of literatures. The data is analyzed to obtain the PSW potential available in Indonesia.

Result and Discussion

Potential Energy PSW

Energy potential of each fuel is different depending on the calorific value. PSW has the potential energy to be used as a fuel because it has a large heating value. Calorific value of PSW (plastic bags and film) about 41.5 MJ/kg higher than the other fuel, except fuel oil, as presented in Fig. 1. This indicates that the PSW in particular plastic bag has potential as a fuel or fuel supplement on the power plant.

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Define Calorific Value.
Meaning: The amount of energy available from an item of food when digested or fuel when burnt; usually measured in units of energy per unit mass

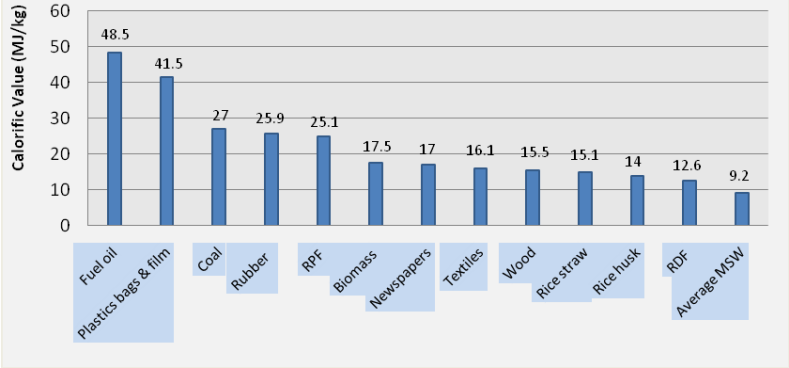

Fig. 1. Calorific values of several types of fuel [3-6].

PSW potential as reflected in the fuel utilization and production PSW generated every day. In general PSW consumption per capita in each country is different and has increased every period. But in Indonesia PSW production tends to fluctuate during the period 2006-2010. In general, the use of plastics in the world increased significantly during the period 1980-2010. Use of plastics since in year 2010 the biggest in the USA is about 150 kg/capita/year, then Western Europe around 120 kg/capita/year and Japan about 100 kg/capita/year [7]. But in Indonesia tend to fluctuate in the period 2006-2010, on average in the 2000 around 22 kg/capita/year. This value is smaller than the plastics world consumption of approximately 38 kg/capita/year as presented in Fig. 2.

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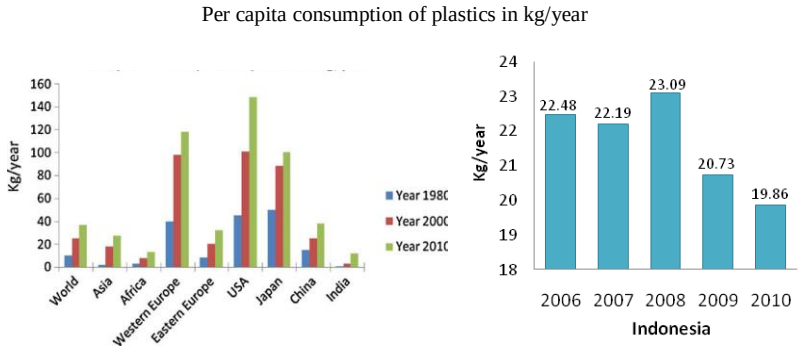

Fig. 2. Comparison of per capita consumption of plastics in Indonesia and several country in the world [7].

The amount of volume PSW (V_{PSW}) produced can be estimated based on the percentage content of PSW (P_P) in the volume of MSW (V_{MSW}), by using the Equation 1:

$$V_{PSW} = P_P \times V_{MSW} \quad (1)$$

The percentage content of PSW in MSW are generally about 8% [8] approximately 10% [3], and can achieve approximately 12.1% [9] of the total MSW generated, as presented in Fig. 3.

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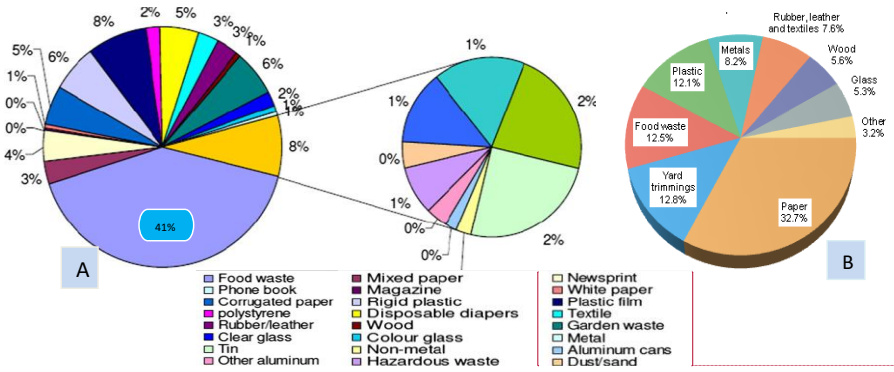

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Fig. 3. Average composition of MSW generated: A) in Malaysia [8] and B) in the United States[9].

Conversion of total volume PSW (V_{PSW}) in m^3 into total mass of PSW (W_{PSW}) in kg, can be determined by using Equation 2:

$$W_{PSW} = \rho_{PSW} \times V_{PSW} \quad (2)$$

where ρ_{PSW} = density of PSW = 112 kg/m^3 (experimental results, 2011). The potential energy PSW (EP_{PSW}) can be determined by using Equation 3:

$$EP_{PSW} = W_{PSW} \times CV_{PSW} \quad (3)$$

where W_{PSW} = amount of mass in kg PSW and CV_{PSW} = calorific value of PSW (plastic back and the film) = 41.5 MJ/kg [3].

The determination of the volume of PSW (V_{PSW}) in 15 cities in Indonesia refers to the value of 8% of V_{MSW} [8]. Thus, the volume PSW of every city can be obtained by using Eq. 1. Meanwhile, the conversion of the volume (m^3) to mass (kg) is calculated using Eq. 2 with a density of PSW (ρ_{PSW}) = 112 kg/m^3 (experiment results), as well as EP_{PSW} obtained by using Eq. 3. The estimation results are presented in Table 1.

Economic Potential of Utilization the PSW as Fuel Supplements

The method of determining the economic value of utilization the PSW as fuel was referred to the method from previous studies. The PSW economic value, when used as fuel in the power plant, can be compared with the energy value of the coal and fuel oil with reference to the calorific value. The value equivalent to coal (Eq_{Coal}) can be determined by using Equation 4:

$$Eq_{Coal} = EP_{PSW} \div CV_{Coal} \quad (4)$$

where CV_{Coal} = calorific value of coal is about 27 MJ/kg [10]. Meanwhile, the value of oil equivalent (Eq_{Oil}) can be determined by using Equation 5:

$$Eq_{Oil} = EP_{PSW} \div CVoil \quad (5)$$

where CV_{Oil} = calorific value of oil around 48.5 MJ/kg [4]. Furthermore Eq_{Coal} and Eq_{Oil} value can be obtained by using Eq. 4 and Eq. 5. The estimated potential energy and economic values of the PSW can be seen in Table 1.

Table 1 Potential energy and economic value of PSW is generated every day in 15 cities in Indonesia.

No	City	Average value from year 2008-2010						
		V_{MSW} (m^3)	V_{PSW} (m^3)	W_{PSW} (ton)	EP_{PSW} (MJ)	EP_{PSW} (MW)	Eq_{Coal} (ton)	Eq_{Oil} (ton)
1	Jakarta	28,464	2,277	273	11,330,000	131.1	420	235
2	Surabaya	8,711	697	84	3,486,000	40.4	129	72
3	Bandung	7,483	599	72	2,988,000	34.6	111	62
4	Medan	5,428	434	52	2,158,000	25.1	80	45
5	Semarang	4,340	347	42	1,743,000	20.2	65	36
6	Makassar	3,758	301	36	1,494,000	17.3	55	31
7	Palembang	3,376	270	32	1,328,000	15.4	49	28
8	Pekanbaru	3,188	255	31	1,287,000	14.9	48	27
9	Padang	2,760	221	27	1,121,000	13.1	42	23
10	Denpasar	2,494	200	24	996,000	11.5	37	21

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There's no data at all on density of PSW?

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11	Manado	1,636	131	16	664,000	7.8	25	14
12	Samarinda	1,604	128	15	623,000	7.2	23	13
13	Pontianak	1,498	120	14	581,000	6.7	22	12
14	Kupang	1,439	115	13	540,000	6.3	20	11
15	Mataram	1,131	91	11	457,000	5.3	17	10
	Total	77,310	6,186	742	30,796,000	356.5	1,143	640

Table 1 presents the potential energy and economic potential of PSW of each of the 15 cities in the analysis. The potential energy of the PSW is the largest in Jakarta, and the smallest in Mataram. In total, the potential production of PSW (W_{PSW}) is approximately 742 tons/day with the potential energy (EP_{PSW}) produced approximately 30,796,000 MJ/day. The potential energy can produce electrical energy around 356.5 MW. Meanwhile, the economic value of PSW is equivalent to coal (Eq_{Coal}) with approximately 1,143 tons/day and equivalent to oil (Eq_{Oil}) approximately 640 tons/day. The potential energy can be used to substitute the use of coal at the power plant with the principle of co-firing with coal for improving the power plant capital costs [11], or can be used as a PSW supplement coal to save the use of coal [12].

As compasison, the economic value of PSW produced in Jakarta is about 273 tons/day, equivalent to 420 tons of coal and 235 tons of oil. This means that if the PSW is used as an alternative fuel for coal, it can save about 420 tons/day of coal and about 235 tons/day of oil. The description concludes that if the PSW is used optimally as a substitute for coal at power plants, it will reduce the power plant operating costs.

Utilization of PSW as fuel in power plants

PSW utilization as fuel in a power plant in Indonesia is still under study. Based on the data obtained as in Table 1, it appears that some areas that have great potential PSW, such as Jakarta, Surabaya, Bandung, Medan, and Semarang that have the electrical energy potential of around 20-131 MW. The potential energy of PSW can be utilized as fuel supplement by co-combustion with coal and biomass at power plants. Similarly, can be used as mono-fuel combustion at power plant in Malaysia which produces 8.9 MW of electricity [13].

Conclusion

The plastic solid waste (PSW) in Indonesia is one of the ingredients of environmental pollution, but it has potential energy that can generate electrical energy. PSW has potential as an alternative fuel because it has a calorific value of about 41.5 MJ/kg greater than the calorific value of other fossil fuels and waste materials except fuel oil. PSW potential available in 15 cities the amount varies depending on the amount of MSW generated. PSW potential analysis results are available in 15 cities is varied, which is about 11-273 tons/day which can generate electrical energy is approximately 5.3-131.1 MW. In total, PSW potential energy obtained is about 742 tons/day, equivalent to coal (Eq_{Coal}) is approximately 1,143 tons/day, equivalent to oil (Eq_{Oil}) is approximately 640 tons/day, and the electrical power available is approximately 356.5 MW. The PSW utilization as fuel in the power plant can be done by co-combustion with coal, co-combustion with biomass, or mono-combustion. In conclusion, though PSW is a hazardous contaminant, but it has the potential energy and economic to be used as alternative fuel in the power plant. Therefore, it can save the use of coal by co-combustion with PSW and at the same time overcome the problem of PSW in Indonesia.

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Acknowledgment

The authors are grateful to the Research University Grant, Universiti Teknologi Malaysia, Vot 05H25 for the financial support to attend ICE-SEAM 2013 in Malacca and Research Management Centre, UTM for the management support.

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