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# Life cycle assessment (LCA) of electricity generation from rice husk in Malaysia

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**Abstract**

This paper evaluated the life cycle analysis (LCA) of electricity derived from rice husk combustion in the Malaysia rice mills. Due to environment and security constraint cause by fossil fuel, biomass like rice husk becomes an attractive solution to look at. However, the environment profile of the electricity production from rice husk must be assessed to ensure it environment safety. The unit processes that make up the system are the paddy production, transportation to the rice mill, rice mill processing and combustion of rice husk to generate electricity. This study used functional unit as, 1.5MWh of electricity generating at the energy plant. The result show transportation contributes more to climate change compare to other process. Then, the characterized data from rice husk-derived electricity is compared with coal and natural gas derived electricity. The results indicate the performance of rice husk derived-electricity is better in the aspect of environment impact parameters.



*Keywords:* Electricity Generation; LCA; Rice Husk; Malaysia;

## 1. Introduction

Malaysia has abundant of biomass resources. These make the biomass most promising option, compare to others various source of renewable energy at Malaysia. Government of Malaysia seriously wants to penetrate more renewable energy consumption for electricity generation sectors. By 2015, the estimated potential for electricity from renewable sources such as biomass and biogas is 330MW and 100MW.In 2010, Malaysia electricity generation use gas 59.1% and coal 34% to generate 106291MWh[1]. In fact, government of Malaysia has announced the 5th Fuel Policy that encourages the biomass resources for electricity generation [2]. The increasing amount of paddy production make highly potential in CHP

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technology to convert the paddy husk residue for energy purpose. This paper is focused on rice husk fuel in generating the electricity because it is highly potential in the future. Rice husk is environmentally friendly fuel because the emission of $CO_2$, $SO_X$ and $NO_X$ are less compared to the conventional fuel [3].However the environment prospects for rice husk as bio-energy feedstock into electricity generation have not been assessed in quantitative way in Malaysia. In order to study that, the Life Cycle Assessment (LCA) has been used to evaluate the rice husk, starting from growth until get the electricity power.

## 2. Methodology

### *2.1. Goal and scope definition*

This paper aims to (1) present a full chain energy analysis of rice husk as a fuel in generating electricity at Malaysia starting from paddy farming until electricity produce by rice husk fuel, and (2) compare with conventional fuel electricity mix in the aspect of environment assessment. The functional unit use is 1.5MWh electricity generated from rice husk combustion.

### *2.2. System boundary and data sources*

The system boundary of rice husk life cycle is shown in Figure 1. Major operating units located inside this system are rice production, rice milling and electricity generation. This study covers the entire life cycle including the rice production, rice milling, transportation and energy generation. Table 1 show the main process of life cycle of rice husk and their sources of data.

Table 1.Three processes of the life cycle of rice husk combustion and their data sources

| Process | Subsystem | Sources of data |
|---|---|---|
| 1. Paddy Field | Fertilizer | Measure data from Malaysia rice bowl farm, Literature [4] |
| | Pesticides | Data from[5], Literature data[6] |
| | Mechanical field operations | Data from questionnaire to selected farmer, Literature[7] |
| | Irrigation | Measure data from interview session(Senior Engineer, Irrigation and drainage service, MADA) |
| 2. Rice Mill | Electricity consumption | Data from questionnaire to selected rice mill, Literature[8] |
| | Rice husk combustion | Data from BERNAS rice mill, Literature[8] |
| | transportation | |
| | | Data from questionnaire to selected paddy lorry driver |
| 3. Electricity from rice husk fuel | Rice grain and rice husk | Data from[9], Literature[10] |
| | Water consumption | Interview session(Boiler engineer, selected rice mill) |
| | Electricity generation | Literature[11] |

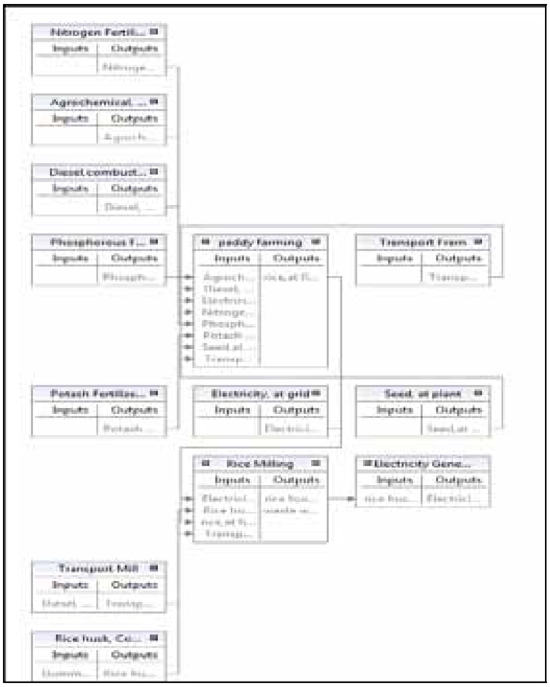


Fig. 1 Flow diagram process for electricity generation from rice husk derived-electricity.

### 2.3. Inventory Analysis

Life Cycle Inventory (LCI) of the LCA methodology is essentially the collection of the data. This involves data collection for inputs and outputs of the product system. The data for paddy fields process, rice mill process were reviewed and collected. Most data are from paddy fields area are located in rice bowl of Malaysia, which is state of Perlis, Kedah, Penang and North of Perak. This is due this area are important rice production at Malaysia, almost 65% of Malaysia rice production are from this area [9]. Some data were taken from literature sources, and it was assumed that these data were the same as the data for the technology chosen for the study. Paper by [12], indicate that there is a chance that not all data required for an LCA study are provided from one particular industry, but often assumptions need to be made to help assess the environment impacts. However, certain data is cited from some international database such as United State Inventory Database, Australia Database and SimaPro software program.

The product system of life cycle stage of rice husk combustion for power generating included in this study is provided in a flow chart (figure 1). Goal of the study is to analyzed 1.5MWh electricity generated from rice husk. Based on [13], about 10 ton of rice husk need to combusted in the boiler. All the input and output data use in the product system is listed in Table 3.

Table 3. LCI material input/output data

| Flow | Unit | Input | Output |
|---|---|---|---|
| 1. Paddy Field | | | |
| Fertilizers | kg/ha | | |
| Nitrogen as N | | 55 | |
| Phosphorous as $P_2O_5$ | | 22 | |
| *Potassium as $K_2O$* | | 15 | |
| Herbicides | | 44 | |
| Diesel used for farm | MJ/ha | 2717.82 | |
| Transportation | kg*km | 33600 | |
| Seed | kg/ha | 140 | |
| Water | $m^3$ | 144000 | |
| Rice grain | kg | | 45600 |
| Rice straw | kg/ha | | 3800 |
| 2. Rice Mill | kg | | |
| Rice grain | | 45600 | |
| Electricity | kWh | 139.98 | |
| Transport | kg*km | 2188800 | |
| 3. Electricity generation | | | |
| Rice husk | | 10032 | |
| Electricity produce | MWh | | 1.5 |

## 3. Results and discussion

### *3.1. Rice husk based electricity generation*

Emission from rice husk combustion is calculated from paddy production until rice husk combustion (figure 1). Table 4 indicated the emissions of gases for 1.5MWh rice husk combustion. Since all the carbon in the paddy field is recycled, rice husk electricity production will contribute to the net $CO_2$ gas emissions only through fossil fuel inputs to paddy farm and transport process.$CO_2$ emission(fossil) are 36400kg, but the carbon, biogenic calculated are 3600000kg. Means, the total emission of $CO_2$ is zero due to consumption of $CO_2$ in paddy fields. Since all the carbon in the rice production is recycle, the contribution of emission is contributed through transportation. Figure 1 shows the transportation contributes more than 60% to the climate change emissions. Input product processes that affect the output of transportation are capacity (lorry) and distance (paddy fields-to-rice mills). Usually, distance between paddy field to the rice mill from 2km until 50 km. Figure 1, show the emission of $CO_2$ and $NO_X$ toward the distance of transportation rice grain (single transportation). After 14km the emission of CO2 during rice husk combustion is higher than emission of coal power plant.

Table 4. Emission from life cycle inventory of rice husk combustion-1.5MWh (base case)

| Emission | NOX | CO | CO2 | N20 |
|---|---|---|---|---|
| Unit(kg) | 12100 | 57.9 | 36400 | 160 |

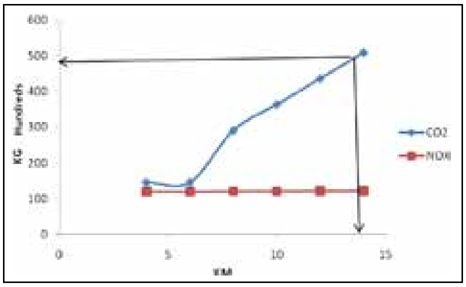

Fig. 1. GHGs emission varying with distance of rice mills

### *3.2. Environmental Impact Based on LCA Methodology*

Table 5 indicated the characterized results for 1.5MWh of electricity using the Eco-Indicator (H, A) life cycle impact assessment (LCIA) method. Figs. 2 show the subdivision of the environmental index by impact category from main process of electricity generated by rice husk with the Eco-Indicator 99(H, A) application.

Table 5.Characterized results for 1.5MWh of electricity

| Result | Unit | Amount |
|---|---|---|
| Greenhouse gas | kg CO2 | 326 |
| Eutrophication & Acification | Kg PO4 | 3743 |
| Eco-toxicity | Kg SO2 | 102 |

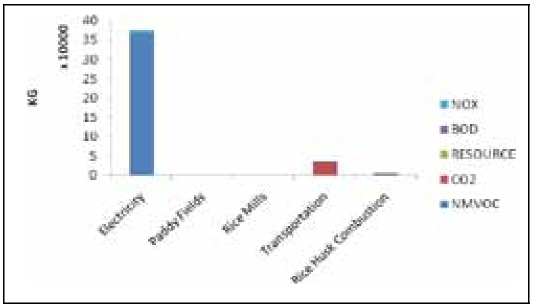

Fig.3 Comparison of Eco-Indicator 99(H, A) scores for the main process

### *3.3. Comparison with electricity with coal and natural gas*

The characterized data of 1.5MWh rice husk-derived electricity have been compared to the coal-derived electricity and natural gas-derived electricity at 1.5MWh electricity produce at plant as shown in Figure 4. Data used for both coal and natural gas-derived electricity are taken from NREL database. Different of geographic location and also methodology apply in this study compare with actual database make this results cannot be the definitive comparison. But comparison the pattern of impact emission between three different fuel types can be seen. The rice husk-derived electricity give the benefit for the component climate-change, fossil fuels resources and eco-toxicity. Study by [14], show that the rate of production of $CO_2$ from coal plant generate electricity in US is about 1022g/kWh. The $CO_2$ emission for rice husk –derived electricity is calculated in this study 217g/kWh. Using rice husk-derived electricity gives 21.2% of $CO_2$ reduction. This value is varies compare to others study [15-17]. Inconsistencies in the assumptions applied like efficiency terms, life –cycle inventory components and system boundaries are the main factors generating the variation in LCA results [18].

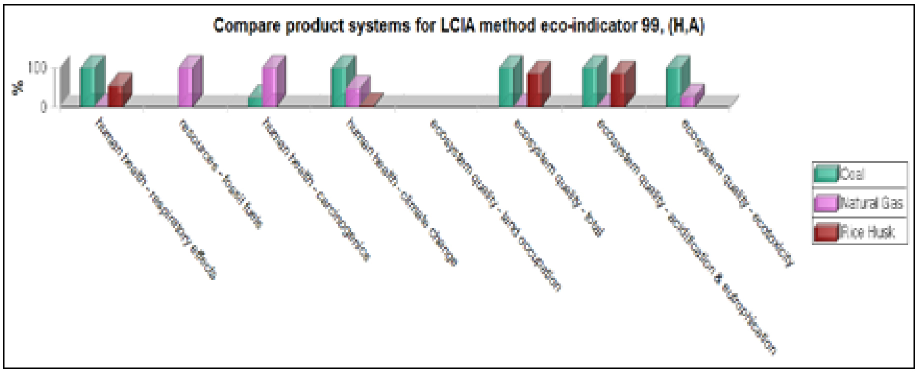


Fig. 4 LCIA results for different type of fuel derived electricity production (1.5MWh of electricity at plant)

## 4. Conclusion

Rice husk-derived electricity is still far to achieve the government target to utilize more sustainable energy in Malaysia energy industries. Transportation and rice mills efficiency need to give extra effort how to reduce the GHGs. Utilization the concept of sustainable management in paddy fields, rice mills and also transportation sector are request to reduce the GHGs emission per kWh electricity generating by rice husk combustion. The $CO_2$ emission from rice husk derived electricity which is 217g/kWh is very high compare to other crop derived electricity. The local criteria like (plant location, crop management, fertilization practices) also need further assessment for reducing the environment impacts. LCA methodology needs to be improving in such way to get the accuracy of the results. Quality database in the local aspect are need to improve to overcome the limitation.

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