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AN ANALYSIS OF ENERGY INTENSITY IN INDONESIAN MANUFACTURING

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Abstract

Many countries utilize their resources at optimal capacity in fostering countries' economic growth without any concern on environmental impact. Even though the importance of environmental issue as one of the important aspects in sustainable development is fully understood, the economic growth still remained as the priority target. In Indonesia, industry is one of the important sectors both in term of its contribution to national output and national energy consumption. Based on Indonesian Statistic Bureau, industry is always at the top list of contributor of national energy consumption since 2000. This paper employs the decomposition analysis to calculate what factors contribute to the change in energy intensity. We also conduct a panel data analysis to investigate the determinants of energy intensity using firm level data. The result suggests that, even though the industrial sector's energy intensity is higher than national level, it varied across sub sectors within the industry. Meanwhile, the econometric analysis suggests that wage, age, capital intensity and share of capital owned by private sector have positive impact on energy intensity, whereas size of firms, labor productivity and technology intensity has negative impact on energy intensity.

Keywords: energy intensity, industry, firm, decomposition, panel data
JEL Code: Q40

I. **INTRODUCTION**

Currently, environment has become one of the major issues in the world, including Indonesia. As one of the biggest carbon emitting countries[1], Indonesia received large concerned on world climate change policy. Some programs have been started in Indonesia, such as Clean Development Mechanism (CDM) and Reducing Emissions from Deforestation and Forest Degradation (REDD). The CDM program is formulated based on The Kyoto Protocol and the results of the United Nations Framework Convention on Climate Change (UNFCCC). Clean Development Mechanism in Indonesia focus on two aspects, namely energy supply side and energy demand side (Napitupulu et.al, 2003). In the supply side, Government of Indonesia (GoI) has developing geothermal project, biomass power generation and switching fossil fuel project with renewable energy. In the demand side, GoI has implementing emission reduction in transportation sector and energy efficiency improvement in industry. The last CDM project is the main focus of this paper.

Industrial sector is the most important sector in terms of both its contribution to national output and final energy consumption. Since 1991, the industrial sector has the largest contribution to national output and the latest statistics suggest that industrial sector accounted about 26.4 percent of Indonesian Gross Domestic Product (BPS, 2010). Indonesian industry grew about 4.38 percent per year in the last four years. In line with the industrial output growth, the consumption of final energy also grew substantially in the last four years with the yearly average growth achieved 10 percent. Interestingly, the growth of final energy consumption by industry was doubled from 11 percent in 2007 to 22 percent in 2008. Meanwhile, in the same period the industry grew slower from 4.67 percent in 2007 to 3.66 percent in 2008. Based on these figure, we should notice that there might be a serious problem in the efficiency of energy use in Indonesian industrial sector.

One of the proxies that we can use to measure energy efficiency is energy intensity (Zhang 2003; Huang 2006; Sandu and Petchey, 2009). Energy intensity is defined as total energy consumption per output. Indonesia has stagnant energy intensity since 2000. Indeed, there was a slight improvement on energy intensity in 2006 but in the next two periods, energy intensity increased continuously[2]. Figure 1 shows that energy intensity in industrial sector was higher than national level. These imply that industry is relatively more inefficient on energy use and become worse in the last three years.

There are only few studies that focus on Indonesian energy intensity. Pambudi (2009) analyze the determinants of energy intensity in Indonesian medium and large industry by using Indonesian Standard Industrial Classification (ISIC) 2 digit definition. The study found irrational energy intensity[3] changes in the period 2000-2005, for instance energy intensity of leather industry increase from 0.002 in 2002 up to 0.15 in 2003 and then decrease to 0.01 in 2004. The problem might be due to number of firms that are not controlled in the construction of panel data. Indonesian industrial statistics are collected from some firms that are chosen as sample. Thus, the construction of panel data by using sub-sectoral basis

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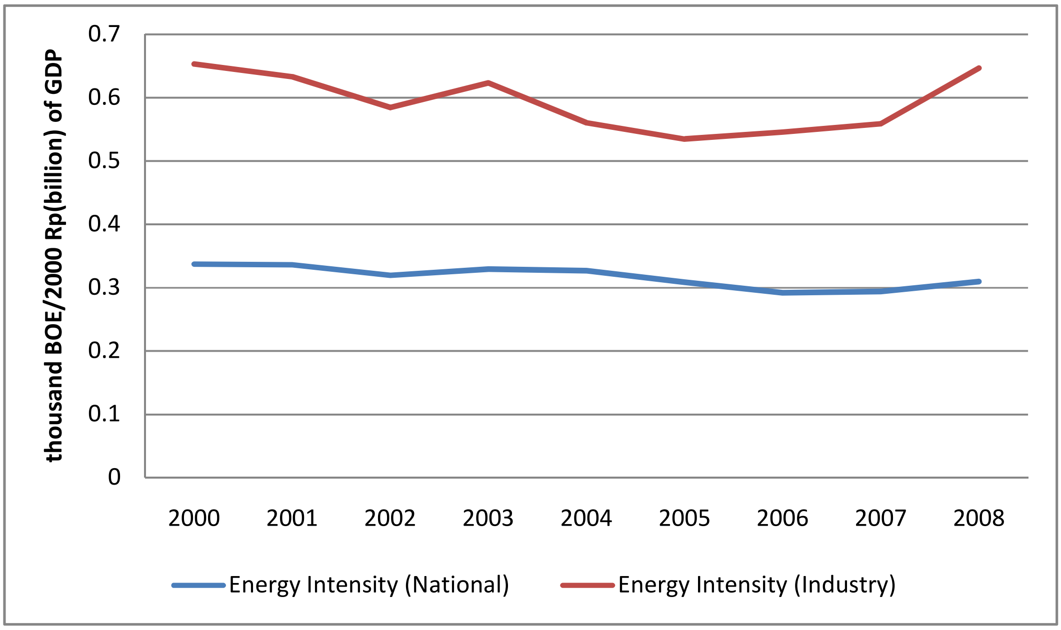
[1] Reuters, 2007 digitally published in http://www.reuters.com/article/idUSJAK26206220070604

[2] Larger energy intensity implies lower energy efficiency

[3] Pambudi (2009) measure energy intensity as total electricity consumption (kwh) per total asset (rupiah)

will be biased since firms that are observed in the industrial statistics could be differ across years. Indra et.al. (2010) analyze the relationship between energy intensity and income per capita in ten Asia Pacific countries including Indonesia by using static and dynamic panel data. The study suggests that the price elasticity of energy consumption and energy intensity is relatively low and negative whereas the income elasticity is positive and decrease over time.



Source: Author calculation based on BPS and Ministry of Energy and Natural Resources data

Figure 1. Energy Intensity of Indonesia's GDP measured in thousand BOE per billion Rupiah of GDP in 2000 prices

In this paper, we analyze the determinants of energy intensity in Indonesian industry by using firm level data in the period 2002 up to 2006. Panel data is constructed in the firm level basis that is derived from 2002-2006 Indonesian Industrial Statistics. Thus, the problem with firm sample has been solved. We employ two approaches in this study. First, we decompose energy intensity in the sub sector level into activity effect and efficiency effect. The aim of this exercise is to analyze whether changes on energy intensity is majorly caused by improvement on efficiency or changes on industrial structure. Second, we conduct econometric analysis by using static panel data approach on firm level data in order to figure out what aspects that contributes to energy intensity changes.

The structure of the paper is organized as follow. Section 1 presents the introduction which explains the background of the study. Section 2 describes the data and methodology. The results are provided in section 3. Finally, the conclusion and policy implication are finally drawn in section 4.

II. DATA AND METHODOLOGY

The analysis in the present study is carried out using firm level panel data in the period 2002-2006. Panel data is constructed from yearly Indonesian Industrial Statistics that are published by Central Bureau of Statistic (BPS). Number of samples for each period is varies and some firms are not continuously taken as sample across year. Therefore, we filter all databases and make sure that firm samples are repeated every year. As a result, we have balance panel that consist of 13743 firms for the period 2002 to 2006. Total numbers of observation that are used in the study are 68715 observations.

As previously mentioned, we employ two approaches in the study. First, decomposition analysis is calculated following Boyd and Roop (2004). Energy intensity is defined as a function of energy efficiency and economic activity components, hence:

$$e_t \equiv \frac{E_t}{Y_t} = \sum_i \left(\frac{E_{it}}{Y_{it}}\right)\left(\frac{Y_{it}}{Y_t}\right) = \sum e_{it} s_{it} \tag{1}$$

Where e_t is energy intensity in year t; E_t is energy intensity in year t; E_{it} is energy intensity of sector i in year t; Y_t is output in year t (measured in GDP); Y_{it} is output of sector i in year t; e_{it} is sector specific energy efficiency in year t; and s_{it} is sectoral activity in year t.

Next, we calculate energy intensity index ($\frac{e_t}{e_0}$) and then decompose the index using Fisher indexes in which energy intensity index is decomposed into efficiency index (F_t^{eff}) and activity index (F_t^{act}), hence:

$$\frac{e_t}{e_0} \equiv I_t = F_t^{eff} F_t^{act} \tag{2}$$

Each of the indexes is calculated using Laspeyres indexes (L_t^{act}; L_t^{eff}) and Paasche indexes (P_t^{act}; P_t^{eff}), hence:

$$F_t^{act} = \sqrt{L_t^{act} P_t^{act}} \tag{3}$$

$$F_t^{eff} = \sqrt{L_t^{eff} P_t^{eff}} \tag{4}$$

$$P_t^{act} = \frac{\sum_i e_{it} s_{it}}{\sum_i e_{it} s_{i0}} \quad ; P_t^{eff} = \frac{\sum_i e_{it} s_{it}}{\sum_i e_{i0} s_{it}} \quad ; L_t^{act} = \frac{\sum_i e_{i0} s_{it}}{\sum_i e_{i0} s_{i0}} \quad ; L_t^{eff} = \frac{\sum_i e_{it} s_{i0}}{\sum_i e_{i0} s_{i0}} \tag{5}$$

Based on the above equations, then we can analyze the changes in energy intensity by using the following equation.

$$\Delta E_t = \Delta E_t \left(\frac{\ln\left(F_t^{act}\right)}{\ln\left(I_t\right)} \right) + \Delta E_t \left(\frac{\ln\left(F_t^{eff}\right)}{\ln\left(I_t\right)} \right) \equiv \Delta E_t^{act} + \Delta E_t^{eff} \tag{6}$$

Where $\Delta E_t = E_t$-$\hat{E}_t$; $\hat{E}_t$ is the energy consumption that would have occurred if we maintain energy intensity as much as its base year level (2002).

In the second approach, we use panel data analysis to estimate factors that determine energy intensity. The model that are used in this study is derived from Kumar (2003) and Martin (2006), hence

$$lenergyintens_{it} = f\left(prod_{it}, loutput_{it}, lwage_{it}, age_{it}, capintens_{it}, tech_{it}, frnown_{it}, prvtown_{it} \right) \tag{7}$$

Where $lenergyintens_{it}$ is natural logarithm of energy intensity (calculated as total energy consumed per output); $prod_{it}$ is labor productivity (measured as total output per labor); $loutput_{it}$ is natural logarithm of total output; $lwage_{it}$ is natural logarithm of total spending on labor wage/incentive; age_{it} is number of years the firm has been operated; $capintens_{it}$ is capital intensity (measured as total capital per output); $tech_{it}$ is technology intensity (measured as total spending on machinery and equipment per output); $frnown_{it}$ is percentage of capital owned by foreign; $prvtown_{it}$ is percentage of capital owned by private.

III. RESULTS

3.1. Decomposition Analysis

As previously mentioned, there are two approaches in this study, namely decomposition of energy intensity and panel data analysis on the determinants of energy efficiency. Decomposition analysis of energy intensity in Indonesian industry during the period 2002-2006 is divided into two parts, namely national level (total industry) and based on the size of the enterprises (medium for firms that have number of employee less than 100 and large for firms that have number of employee equal to or more than 100). Next, we define nine subsectors for each analysis, i.e. (i) food, beverages, and tobacco; (ii) textile, wearing apparel, and leather; (iii) wood, bamboo, rattan, and the like; (iv) paper and plastics paper, printing, and publishing; (v) chemical and goods from chemicals, petroleum, coal, rubber and plastic; (vi) non-metallic mineral products; (vii) basic metal; (Ix) metal products, machinery and equipment; and (ix) other processing.

Table 1 Decomposition Analysis at National Level

Type of Industry	Intensity	Activity	Efficiency
All Industries	0.26	-0.01	0.27
Food, beverages, and tobacco (Food)	-0.08	-0.09	0.01
Textile, wearing apparel, and leather (Textile)	0.82	-0.11	0.92
Wood, bamboo, rattan, and the like (Wood)	0.35	1.06	-0.71

Paper and plastics paper, printing, and publishing (Paper)	1.70	-14.80	16.50
Chemical and goods from chemicals, petroleum, coal, rubber and plastic (Chemical)	1.00	0.51	0.49
Non-metallic mineral products (Non-metallic mineral product)	3.49	1.46	2.03
Basic metal (Basic Metal)	-0.65	12.58	-13.22
Metal products, machinery and equipment (Metal product)	-0.44	-0.29	-0.14
Other processing (Other processing)	-6.48	-1.85	-4.63

Source: author's calculation

Table 1 shows the result of decomposition of energy intensity at the national level both in total and by type of industry. The second column in the table suggests the differences of energy intensity between the years 2006 to 2002 (in percentages). During the period of 2002-2006, the differences on energy intensity, activity and efficiency for the whole industry is respectively 0.26, -0.01, and 0.27. These imply that industry in the national level become more intense on energy use in 2006 relative to 2002 and mostly due to lack of improvement on energy efficiency.

In the subsector level, there are five industries that have higher energy intensity in 2006 relative to 2002. These mean that those five sectors become less efficient on energy use. In term of factors that contributed to the increasing of energy intensity, the analysis can be grouped into three, hence: (i) higher energy intensity due to lack of improvement in energy efficiency and economic activity; (ii) higher energy intensity due to lack of improvement in energy efficiency, even though there are improvements in economic activity; and (iii) higher energy intensity due to lack of improvement in economic activity although the industry experienced improvements in energy efficiency. The similar categorization also can be applied to four sub-sectors that that experienced improvements in energy intensity, i.e. metal product, other processing, basic metals and food. Better energy intensity in metal product and other processing industry is caused by economic activity and improvements in energy efficiency. While for the food, beverages and tobacco industry, improvement in energy intensity is largely due to improvements in economic activity. On the contrary, energy intensity improvement in the basic metals industry is mainly due to improvements in energy efficiency.

Table 2. Decomposition Analysis for Medium Enterprises

Type of Industry	Intensity	Activity	Efficiency
All Industries	0.58	0.12	0.46
Food, beverages, and tobacco (Food)	-0.34	-0.77	0.42
Textile, wearing apparel, and leather (Textile)	-1.24	5.80	-7.04
Wood, bamboo, rattan, and the like (Wood)	-2.87	8.80	-11.67
Paper and plastics paper, printing, and publishing (Paper)	-1.84	-6.29	4.46
Chemical and goods from chemicals, petroleum, coal, rubber and plastic (Chemical)	5.16	0.93	4.23
Non-metallic mineral products (Non-metallic mineral product)	-0.49	-0.53	0.05
Basic metal (Basic Metal)	1.47	0.43	1.04
Metal products, machinery and equipment (Metal product)	-1.43	-0.98	-0.44
Other processing (Other processing)	-1.40	-0.82	-0.57

Source: author's calculation

Table 2 shows the result of decomposition of energy intensity for medium enterprises both in total and by type of industry. Similar with national level data, all medium enterprises in the manufacturing industry experience higher energy intensity in 2006 relative to 2002. The higher energy intensity is mostly due to lack of energy efficiency improvement. In the subsector level, most subsectors have better energy efficiency except for chemical sector and basic metal sector. Better energy intensity in these 7 sectors is contributed either by improvement on energy intensity, improvement on activity or both factors. The result of decomposition on medium enterprises does not reflect the national level condition. These mean that any changes in medium enterprises will not significantly affect industry performance at the national level in terms of energy intensity.

Table 3 Decomposition Analysis for Large Enterprises

Type of Industry	Intensity	Activity	Efficiency
All Industries	0.22	-0.04	0.26
Food, beverages, and tobacco (Food)	-0.07	-0.08	0.01
Textile, wearing apparel, and leather (Textile)	0.93	-0.13	1.06
Wood, bamboo, rattan, and the like (Wood)	0.65	3.42	-2.78
Paper and plastics paper, printing, and publishing (Paper)	2.05	-19.07	21.13
Chemical and goods from chemicals, petroleum, coal, rubber and plastic (Chemical)	0.39	0.28	0.11
Non-metallic mineral products (Non-metallic mineral product)	4.13	1.39	2.73
Basic metal (Basic Metal)	-0.76	2.72	-3.49
Metal products, machinery and equipment (Metal product)	-0.31	-0.22	-0.09
Other processing (Other processing)	-7.37	-1.97	-5.40

Source: author's calculation

Table 3 shows the result of decomposition of energy intensity for large enterprises both in total and by type of industry. Interestingly, sign of changes in intensity, activity and efficiency are completely the same with national level data. There are only some slight differences on the magnitude of changes. These reflect that industrial energy intensity performance by type of subsector at the national level is largely determined by large enterprises in each subsector. Moreover, in the chemical sector and non-metallic mineral sector, both activity and inefficiency aspect give large pressure on energy intensity.

3.2. Econometric Analysis

In this sub chapter, we discuss the determinants of energy efficiency in the firm level based on the results of panel data regression. Based on Hausman test, LM test and diagnostic analysis, we found that robust fixed effect model is preferred than other model. Generally, Table 4 suggests that most independent variables are statistically significant except for percentage of capital owned by foreign and the adjusted R-square is quite high at 0.6969.

Table 4. Firm Level Regression

Independent Variable	Coef.	Std. Error	t-stats	Prob
Ln(wage)***	0.0478	0.0105	4.57	0.000
Ln(output) ***	-0.1450	0.0086	-16.95	0.000
Age***	0.0131	0.0027	4.87	0.000
Technology Intensity***	-5.32×10^{4}	1.52×10^{4}	-3.49	0.000
Capital Intensity**	1.01×10^{5}	4.20×10^{6}	2.41	0.016
Labor Productivity*	-2.53×10^{8}	1.51×10^{8}	-1.67	0.095
Percentage of capital owned by domestic private**	0.0011	0.0004	2.43	0.015
Percentage of capital owned by foreign	2.73×10^{4}	6.71×10^{4}	0.41	0.685
Constant	-2.24E+00	1.37E-01	-16.4	0.000
Adj R-square	0.6969			

Note: *** significant at 1%; ** significant at 5%; * significant at 10%

Wage is expected to have positive impact on energy intensity. In other words, it can be said that higher wage will lead to lower energy efficiency. Theoretically, if price of labor becomes more expensive, firms will switch the labor with other production factors, such as capital. Thus, firm will consume more energy and then increase energy intensity. Wage is usually sticky and cannot easily adjust in the short run (wage rigidity). In Indonesia, labor market is intervened by government regulation that rules the minimum payment/wage for each province (UMP). Each year, UMP is adjusted with inflation rate and other factors through Tripartit Mechanism involving labor union, Apindo (industrialist/corporate management association) and government. As the inflation increase every year, wage will also increase as well even in not the same proportion. Considering wage rigidity theory and the existence of provincial minimum wage in Indonesia, the positive trend of wage in Indonesian labor market is expected will put large pressure to high energy intensity problem.

Proxy of firm size that represented by output has a negative impact on energy intensity. As the size of the firms increase, firms are expected to have better efficiency on energy use. This result supports previous findings by Kumar (2003) on Indian manufacturing and Kleijweg et.al (1990) on Dutch manufacturing. In contrast, Sahu et.al (2009) found positive relationship between size and energy intensity. Based on Indonesian Industrial Statistics, most sub sectors experienced positive growth on its output since 2002. If the trend is continued, Indonesian energy intensity will be better in the future.

The maturity of firms is expected to increase energy intensity. Age of the firm usually reflects age of capital that is owned. Therefore, as the firm grows older, the capital grows older as well and the firm becomes less efficient unless they have new capital that invested in new technology. Consequently, these will raise energy intensity. The positive sign on the coefficient of age also implies that the existing firms will give pressure on energy intensity in the future. Relates to this finding, technology intensity that is measured as total spending on machinery and equipment per output is expected to decrease energy intensity. By having large spending on new machines and equipment, firms could maintain the utilization of the latest technology that is relatively more energy efficient.

In line with previous findings by Kumar (2003) and Sahu et.al (2009), higher capital intensity is expected to increase energy intensity. Firms that are more capital intensive utilize more machines relative to labor in their production processes. Consequently, those firms will consume energy relatively higher than other. Currently, the development of digital technology and robot technology is expected will replace or at least minimize the role of labor in the production process. Therefore, current technology improvement on production will put a large pressure on energy intensity. In contrast, labor productivity is expected to decline energy intensity. Higher labor productivity means that with the same number of labor, we can produce more output. Thus, instead of focus on labor saving technology (more capital intensive) to boost up firm's production level, firm could only increase their productivity of labor without harming their energy intensity.

In terms of ownership, share of capital owned by foreign does not statistically significant affect energy intensity. The result suggests that foreign direct investment does not come along with transfer of technology. We assume that foreign direct investment usually comes from developed countries that have better and more efficient technology. Empirically, there is one success example in terms of CDM program in Indocement-Heidelberg (one of the cement producers in Indonesia) that already applied CDM since 2002. CDM project in Indocement-Heidelberg is implemented through two programs, namely reduction of clinkers content in the cement product and utilization of alternative energy sources. However, these good practices are not followed by other firms. Semen Cibinong-Holcim failed to achieve an agreement with World Bank on the CDM project. Interestingly, share of capital owned by domestic private have positive coefficient which means that as the share of capital owned by domestic private increase, energy intensity is expected to increase as well. Hypothetically, it is expected that private firms have applied better technologies that are more energy efficient. However, the regression result suggests contrast conditions.

IV. CONCLUSSION AND POLICY IMPLICATION

The role of industrial sector is very significant in the Indonesian economy. On average, industrial output grew more than 4 percent per year in the last four years. The impressive growth on industry increases the demand for the input especially on energy which grew much faster than output. Consequently, these economic activities give large pressure on energy intensity. This study aims to analyze the determinant of energy intensity by using decomposition analysis and panel data analysis.

There are some important findings that can be drawn from this study. Generally, during the period 2002-2006, even though level of energy intensity in the industry relatively worse than national level but the condition of energy intensity in Indonesian industry is varies across sub sector. Some sectors experience lower energy intensity and some others have increasing energy intensity. These conditions could be resulted due to pressure from economic activity, level of energy efficiency or both factors. The decomposition analysis by type of enterprises shows that the figure of energy intensity in large enterprises is a mirror of national level data. Meanwhile, we found a completely different figure in medium enterprises. These findings have implications regarding target of energy intensity program. Government should more focus on large enterprises especially on non-metallic mineral product sector that has the highest energy intensity changes.

Based on econometric analysis, we found that wage, age, capital intensity and share of capital owned by private has positive impact on energy intensity which means that if those factors increase, energy intensity will tend to increase as well. Meanwhile, higher size of firms, labor productivity and technology intensity is expected to improve energy intensity. These findings have implication in terms of type of government support on energy intensity improvement program. Government should encourage firms to improve their labor productivity instead of using labor saving technology in order to increase their production level. Moreover, government might also give firms an incentive to adopt new and more efficient technology.

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