Development of Sustainable Performance Measurement System for Electronic and Plastics Industrial Cluster Based Industrial Symbiosis Scenario in the Industrial Estate

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***Abstract*— Industrial sustainability currently becomes a very important issue, in line with the long term industrial development goal to build industry according to sustainable development concept. This research aims to design a sustainability performance measurement system of electronics and plastics industrial cluster with the approach of Sustainability Balanced Scorecard and Labuschagne model, and it determines the scenarios of industrial symbiosis application as a strategy for improving the sustainability performance, as well as measuring and evaluating the sustainability performance of the industry using Objective Matrix (OMAX) and Traffic Light System methods. Based on the strategic objectives and needs of the industries, 69 KPIs (Key Performance Indicators) and sub KPIs are determined, which covered the economic, environmental, and social perspective. The initial results obtained from measurement and assessment of sustainability performance by using 3 samples of the industry; the value of each industry A 4.28 (good), B 5.26 (good), and C 4.14 (good). Results of scenario I, II and III of industrial symbiosis application deliver improved sustainability performance on average respectively 52%, 75% and 87%. Thus, it needs the policy for encouraging the application of industrial symbiosis systems in order to improve the sustainability performance of the industry in the industrial estate.**

Keywords*— *Industrial Symbiosis, Sustainability Performance, Industrial Estate, OMAX.

I. INTRODUCTION

Industrial sustainability currently becomes a very important issue, it is in line with the long term industrial development goal to build industry according to sustainable development concept, namely economic development to meet the needs of the present generation without compromising the ability of future generations to meet economy needs [1], thus the industrial sustainability performance should be improved and enhanced continuously, that is by using the application of industrial symbiosis.

Industrial symbiosis is a form of collaboration among different industries which have mutual benefit, that is by the utilization of by-products and wastes as raw materials, and energy for other industries. Utilization of waste intended as an effort to reduce the exploitation of limited natural resources, moreover the substitution of imported raw materials are still quite large and the effort to reduce the impact of pollution on the environment in accordance with the concept of cradle to cradle cycle pattern instead of applying cradle to grave which has linear pattern. Labuschagne, et al. [2] states that companies that want to compete globally must compile and report sustainability performance of the overall operations. Bansal, et al. [3] reported that industrial symbiosis which is a sub field of industrial ecology, is essential to the achievement of sustainability, not only because of the waste management aspect, but also about the social and economic aspects. Mubin [4] also reported that the application of industrial symbiosis concept can improve the efficiency and performance of economic, social, and environmental industries.

Based on the description above, it is very important to do a study on the strategy for improving the sustainability performance of electronics and plastics cluster industries through industrial symbiosis scenario in the industrial estate. Scenario of industrial symbiosis is a collaboration between industry in the utilization of resources including raw materials, water, energy, by-products and waste, in order to improve economic, social and environmental performances, and also to improve the sustainability performance of the industry that is expected to enhance industrial competitiveness and sustainability performance of national industry.

This research aims to design a sustainability performance measurement system of electronics and plastics industrial cluster by applying the approach of Sustainability Balanced Scorecard and Labuschagne model, and it determines the scenarios of industrial symbiosis application as a strategy for improving the sustainability performance, and also measuring and evaluating the sustainability performance of the industry using Objective Matrix (OMAX) [22] and Traffic Light System methods [12].

II. Literature Review

A. Industrial Symbiosis

The concept of industrial symbiosis, according Chertow, et al. [5] is a sub-field of industrial ecology, which is principally related to the management of resources flow through the business network using ecological sustainability approach as an industrial activity. Industrial symbiosis is engaging separate industries traditionally in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and by-products. The keys to industrial symbiosis are collaboration and the synergistic possibilities offered by geographic proximity. Some effective characteristics of industrial symbiosis according to Chertow [6] are: (1) industry of symbiosis members placed in one area and has manufacturing different, (2) the distance between the industry should be close to each other in order to increase the materials transportation efficiency, (3) each industry makes a collective agreement with the economic principle that is mutually beneficial, (4) each industry must be able to communicate well, and (5) each industry takes responsibility on environmental safety in the region.

Industrial symbiosis program that has been success and famous is one of industrial symbiosis is in Kalundborg, Denmark. Kalundborg industrial symbiosis, which consists of six industries namely the Asnaer power plants, Statoil oil refining industry, the biotechnology company Novo Nordisk, the plywood industry Gyproc, bioengineering Jordrens soil remediation company, and the residential city of Kalundborg. The results obtained from Kalundborg industrial symbiosis, are: (1) The cost efficiency, (2) decrease the pollution of air, water and soil, (3) production wastes such as fly ash, sulfur, sludge, and gypsum can be processed become raw material for production as additional value, (4) the environmental impact is greatly reduced through the reduction of SO_2 and CO_2 emissions, and it also can improve the quality of waste water (5) efficiency of energy and water use, and (6) Kalundborg city as the cleanest industrial city [7]. Industrial symbiosis program that has been shown to provide benefits and to improve economic, social, and environment performance, it is the result of the national industrial symbiosis program (NISP) in the United Kingdom, during the month of April 2005 - June 2006, namely: diverted from landfill 1.483.648 tons of waste, saving 1.827.756 tons of raw materials, saving 386.775.000 liters of drinking water, etc. [8].

Fujita, et al. [9] reported the results of his research in the industrial estate of Kawasaki Eco-town, Japan, that the region has been implemented good industrial symbiosis. Moreover, in other study, Zhu, et al. [10] reported on industrial symbiosis strategy implemented in the Guitang group company, can increase revenues, reduce waste emissions, and reduce costs, and simultaneously improve the quality of sugar products. Research on industrial symbiosis in Kwinana industrial estate, Western Australia, that has been reported by Harris [11] that the utilization of the resources is originally discarded, and it is used as an alternative input by other companies which can help to improve business performance and sustainability performance for the company. Mubin [12] proposed that the importance of industrial symbiosis policy to encourage improvements in economic, social, environmental and sustainability performance of industry. Similarly, Termsinvanich, et al. [13] reported the results of his research in the industrial estate of Mab Ta-Phut Thailand, that the policy, the initiator, the information (about the generation of waste), and an effective financial mechanism is a factor affecting the implementation of industrial symbiosis.

Planning of national industrial symbiosis program implementations in Indonesia strongly supported the government's policy in the form of release of Government Regulation (PP) No. 24 year 2009 on industrial estate which stipulates that in accordance with Article 7 paragraph (1), starting on March 3, 2009 every company that runs industrial activities should located in the industrial estate [14].

B. Sustainability Performance Measurement System of Industry

Performance measurement is a management tool used to improve the quality of decision making and accountability. Performance measurement is also used to assess the achievement of goals and objectives [15]. Neely, et al. [16] defines performance measurement as the process of quantifying the efficiency and effectiveness of action, and performance measurement system as the set of metrics used to quantify the efficiency and effectiveness of an action. Sustainability becomes a mainstay of organizational operations, a strategic pre-requisite for long term competitive advantages and business excellence [23].

In other study, Deloitte and Touche in Labuschagne, et al. [2] define business sustainability as adopting business strategies and activities that meet the needs of the enterprise and its stakeholders today while protecting, sustaining and enhancing the human and natural resources that will be needed in the future. Business sustainability needs to adjust with the objective of sustainable development, i.e. social equity, economic efficiency and environmental performance, in operational practice of the company. Dimensions of sustainability involve three aspects: economic, environmental and social [2].

Model of Sustainability Balanced Scorecard (SBSC) (Figure 1) is the result of the concept development of Balanced Scorecard (BSC) [17]. Understanding of the environmental and social strategies that are consistent and in accordance with the company is a prerequisite to compose SBSC [18], [19], [20]. Yan, et.al [24] proposed that the sustainability performance evaluation of machining process refers to a consistent set of economic, environmental, and social impacts.

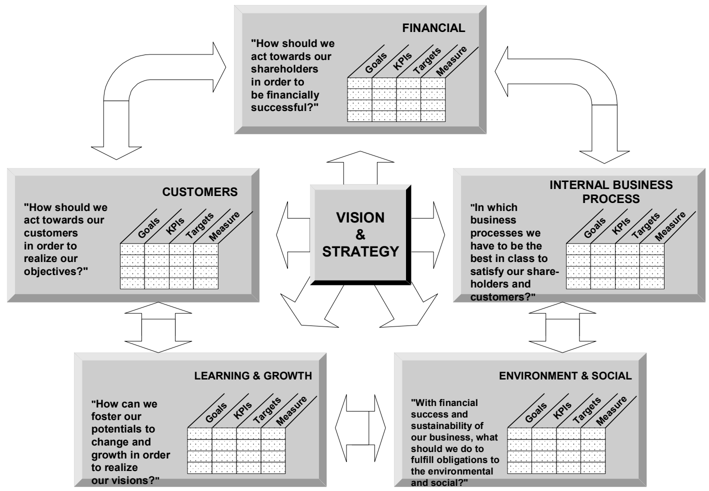

Fig. 1. Framework of SBSC [16], [17].

Furthermore, in the planning of the sustainability performance measurement system, every perspective and criterion revealed to be the strategic objective and key performance indicators (KPI). Weighting perspectives and KPIs used Analytical Hierarchy Process (AHP) [21], and the measurement and evaluation of sustainability performance used Objective Matrix (OMAX) [22] and Traffic Light System (TLS) methods [12].

AHP is a method that is very popular for decisions making and it can be used as a tool to do the weighting of criteria and sub-criteria [21]. AHP uses the concept of pairwise comparisons were used to compare the criteria of the other criteria. The concept of preference confirmed there are three kinds of possibilities, that the criteria is same, and it is larger or smaller than the other criteria.

OMAX method is a method of scoring system that were attentive to the measurement metrics of existing KPI by consolidating the metrics into a single measure that is often referred to current performance. Application of this method was originally used in the measurement of productivity with the size of specific performance indicators. However in its development, it is very helpful to consolidate the existing performance indicators, it is also applied to the performance measurement system [15]. This method combine quantitative and qualitative approaches, it can be used to measure all aspects of performance that are considered in a work unit, and the performance indicators for each input and output are clearly defined, moreover incorporate consideration of the management in scoring in order to make it more flexible. Performance Score of body Objective Matrix ranges on a scale of 0 - 10, means that there are 11 levels of achievement for each indicator [22].

III. Research Methods

Framework for solving the problem in this study is divided into five phases, that are: (1) The preliminary research phase; (2) the phase of designing sustainability performance measurement system using SBSC-L models; (3) the phase of determining scenario of industrial symbiosis application as a strategy for improving the sustainability performance of the industry, (4) the phase of measurement and evaluation of sustainability performance using AHP, OMAX and TLS methods; (5) the phase of analysis; and (6) the phase of making the conclusion.

Industrial sustainability performance measurement using a combination of AHP, OMAX and TLS methods. AHP method is used to determine the weight of perspectives and KPIs with the principle of paired comparisons, and OMAX method used to determine the score of KPI performance achievement, in which the score is 0-10. Performance value for each KPI is obtained by multiplying the weight with a score of performance, and perspective performance value is obtained by summing the overall performance value in each perspectives. While TLS methods used to evaluate the results of the performance appraisal using three colors indicators namely red, yellow and green. Red for a score of 0-3 (poor), yellow for scores 4-7 (good), and green colors for score 8-10 (excellent).

The study was conducted in three industries of electronics and plastics clusters in industrial estate X. Designing sustainability performance measurement system of industry using a model approach of Sustainability Balanced Scorecard - Labuschagne (SBSC-L). Measurement and evaluation of sustainability performance of industry in accordance scenarios of industrial symbiosis applications in industrial estate using Analytical Hierarchy Process (AHP), Objective Matrix (OMAX) and Traffic Light System (TLS) methods. Performance value is equal to the weight multiplied by the score, and sustainability performance value is the cumulative performance value of the economic, environmental and social performance value.

IV. Results and Discussion

A. Results Analysis of Designing Sustainability Performance Measurement System of Industry

Designing Sustainability performance measurement system can be done by model approach of Sustainability Balanced Scorecard - Labuschagne (SBSC-L) which consists of three aspects: economic, environmental, and social. The case studies conducted in three industries of plastic and electronics clusters, with the stages include: determining measurement architecture, setting strategic objective, determining KPI (Key Performance Indicators), and weighting perspectives and KPIs. KPI determination was done through interviews, discussions and by searching internal documents that describe the company's system.

Results of designing sustainability performance measurement system of industry gained 69 KPIs and sub KPIs, includes 5 KPIs of economic perspectives, 54 KPIs and sub KPIs of environmental perspectives, and 10 KPIs of social perspective. Weighting is done by using Analytical Hierarchy Process (AHP). AHP results showed inconsistency ratio (IR) of 0.01 or 1%, also feasible and acceptable (IR <10%). Based on the achievement of KPI performance, and weight of each KPI of industries surveyed, subsequent measurement of sustainability performance by using OMAX and TLS.

B. Results Analysis of Sustainability Performance Measurement and Evaluation of Industry

Results of measurement and assessment of sustainability performance which use OMAX and TLS methods for Scenarios 0 or without industrial symbiosis in three industries (Industry A, B, C) surveyed, shows that the value of each perspective performances (Figure 2). The overall sustainability performance values of each industry are presented in Figure 3. Figure 3 shows that the industry B and has an overall sustainability performance values that is relatively higher than other industries in the amount of 5.26 (yellow or good). The average value of overall sustainability performance in three industries surveyed in the amount of 4.56 (yellow or good). All industries have sustainability performance score above 3 (red or poor), but it still below from the target value which is 10 (green or excellent).

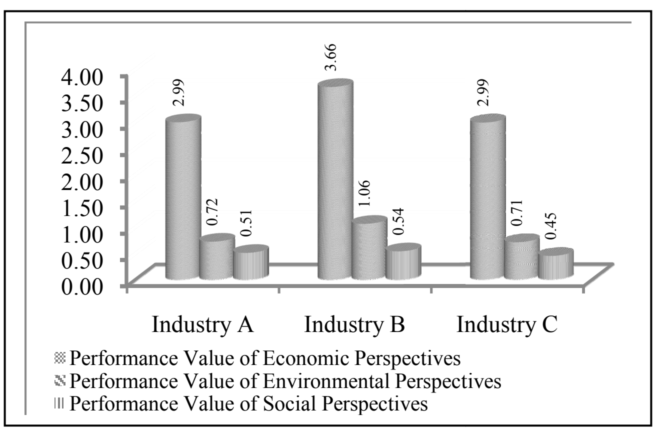

Fig. 2. Value of economic, environment an social perspective (Skenario 0)

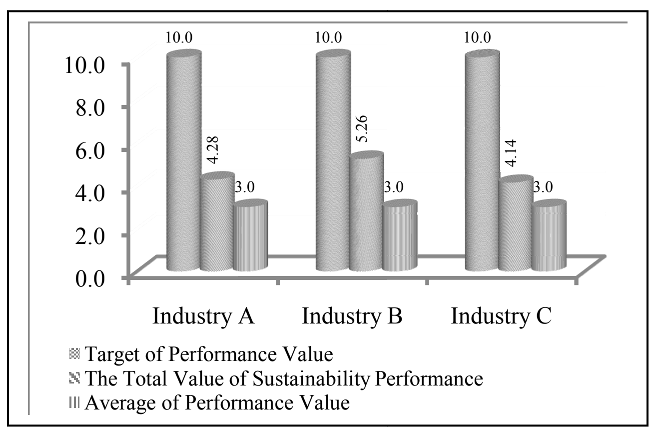

Fig. 3. Value of overall sustainability performance of industries (Skenario 0)

In scenario I, II and III, using the provisions of scenario I (application of industrial symbiosis in the aspect of raw materials, utilization of by-products and waste), scenario II (the application of industrial symbiosis in the aspect of raw materials, water use, the use of by-products and waste), and scenario III (application of industrial symbiosis in the aspect of raw materials, water use, energy use, utilization of by-products and waste). Results of the overall sustainability performance calculations of each industry are presented in Figure 4, 5 and 6.

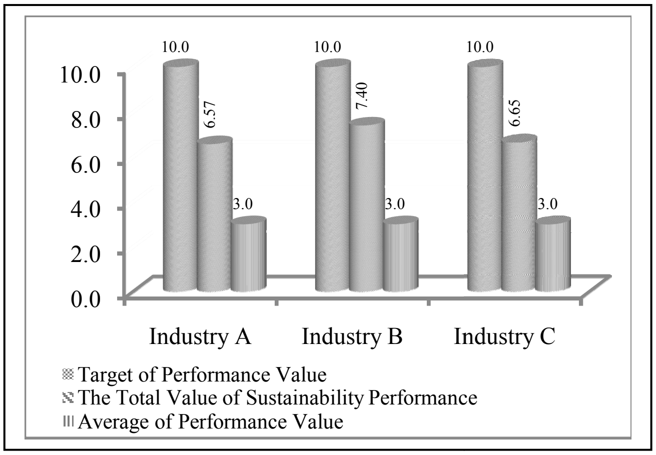

Fig. 4. Value of overall sustainability performance of industries (Scenario I)

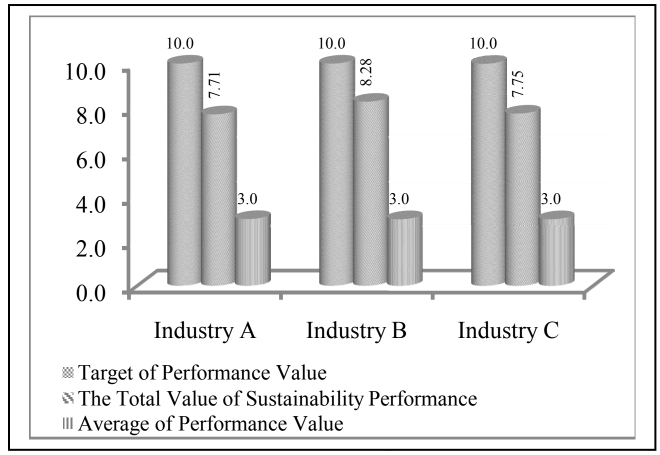

Fig. 5. Value of overall sustainability performance of industries (Scenario II)

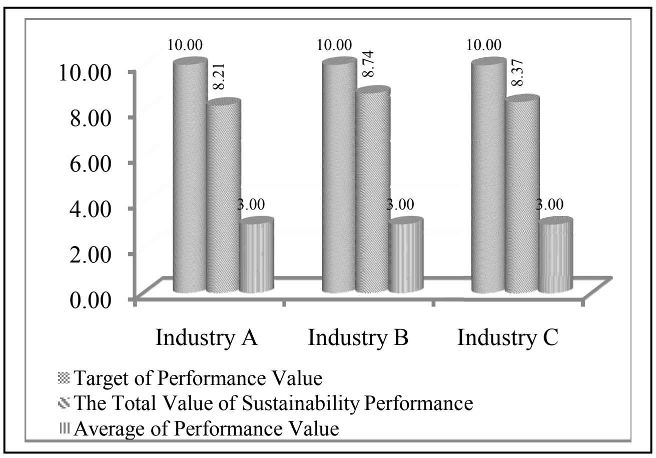

Fig. 6. Value of overall sustainability performance of industries (Scenario III)

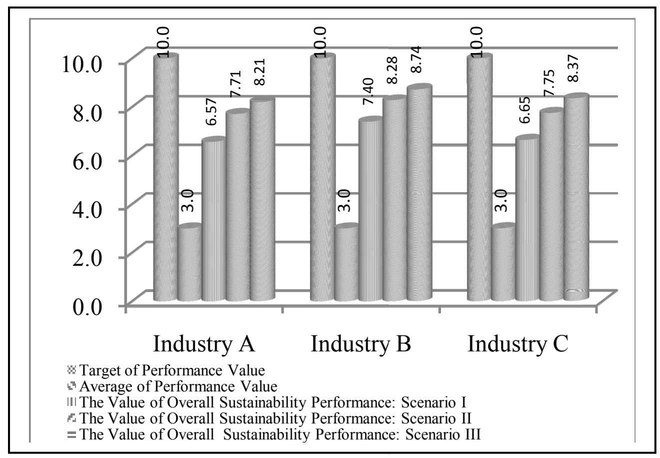

Fig. 7. The combined value of overall sustainability performance of industry (Scenario I-III)

Figure 4 shows that in the first scenario, the average of overall sustainability performance is 6.87 (maximum score 10), increased by 52% compared to the prior of industrial symbiosis applications (scenario 0). Figure 5 shows that in scenario II, the average value of overall sustainability performance is 7.92, an increase of 75% compared to the scenario 0. Figure 6 shows that in scenario III, the average value of overall sustainability performance is 8.44, an increase of 87% than scenario 0. The combined value of overall sustainability performance of industry (scenario I - III) can be seen in Figure 7.

V. CONCLUSION

Results of designing sustainability performance measurement system of industries in electronics and plastics clusters, obtained 69 KPIs (Key Performance Indicators) and sub KPIs, includes 5 KPIs of economic perspectives, 54 KPIs and sub KPIs of environmental perspectives, and 10 KPIs of social perspective.

Provisions Scenario I: application of industrial symbiosis in the aspect of raw materials, utilization of by-products and waste, Scenario II: application of industrial symbiosis in the aspect of raw materials, water use, utilization of by-products and waste, and Scenario III: the application of industrial symbiosis in the aspect of material raw, water use, energy use, utilization of by-products and waste.

Results of measurement and evaluation of the overall sustainability performance value of industry in scenario 0 is 4.28 (yellow) which means good or satisfactory, industry B is 5.26 (yellow) which means good or satisfactory, and industry C is 4.14 (yellow) are means good or satisfactory, but the industry B has the highest sustainability performance value. The application of industrial symbiosis scenario provides improved sustainability performance on average in scenario I by 52%, scenario II by 75%, and scenario III by 87% compared to scenario 0. Thus it is necessary for policies that encourage the application of industrial symbiosis systems, and also to improve the sustainability performance of the industry in the industrial estate.

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