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**Eco - Efficiency of the Automotive Industry: Evidence from an Industrial Park in Thailand**

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**Abstract:** Sustainable development has become an important issue for the industrial sector. In particular, the need to create an efficient level of balance between environment and the economy has been highlighted. This is the heart of the eco-efficiency concept. This paper investigates, from a managerial perspective, the physical and environmental eco-efficiency data of the automotive industry in Thailand, which accounted for 11% of national GDP in 2013. The focus is on the Rojana Automotive Industrial Park in central Thailand. It is shown that there is a tendency towards more energy reduction and efficient management of resources. This has had an impact on the relationship between industry and nearby communities. Since industry is extracting more value from existing resources, local communities are able to achieve a good quality of life while industry obtains economic growth with social development. These results are used to establish eco-efficiency indicators for the automotive industry in terms of policy planning and resource allocation. Consequently, an eco-industry assessment has been conducted and the prospects for sustainable development conducted.

**Keywords:** Eco-efficiency, Automotive Industry, Industrial Park, Eco industry, Rojana Automotive Industrial Park, Sustainable development

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### 1. Introduction

Nowadays, sustainable development has become an important issue for Thailand's industrial sector because sustainable development of industrial sector currently refers to building the economic balance without causing any burden to the world, i.e., creating free competition in the world market along with environmental protection leading to good quality of life of humans in today world and future. This concept is presented concretely and called Eco-Efficiency that is the integrated guideline of development generating holistic integration between economic and environmental dimensions (Kitikorn Jamorndusit, et al. , 2007) in order to support higher demands of people and future sustainability.

Sustainable development means development that meets the needs of the present without compromising the ability of future generations to meet their own needs. In addition, it could be said that industry sector is currently affected (Ministry of Industry, 2011). Nowadays, EID-Eco-Industrial Development is invented in order to improve the efficiency of worthwhile materials and energy consumption through cautious planning and building cooperation network among industrial factories. Improvement of efficiency is not only helping to reduce environmental effects and pollution caused by production process (Department of Industrial Works, 2010), it also helps to reduce cost while increasing profit and competitiveness of business sector referring to industrial society and service business that helps to improve environmental and economic potential through the cooperation on energy and environmental management contributing higher level of common interests. As a result, Eco-Industrial Parks are a different case from general industrial estates (Industrial Estate Authority of Thailand, 2012).

Eco industry has been developed based on the principles of Industrial Ecology due to the transformation from industrial production process to consumption process emphasizing on improvement of the efficiency of product design and recycling (Industrial Estate Authority of Thailand, 2013) leading to an effort in connecting industrial system with natural eco system. Besides being the theory and principle that can be applied for achieving sustainable development of industrial sector, eco efficiency can also be applied as a tool for evaluating and indicating the tendency of organizations (Ayres, 1989).

When mentioning the major industry that is important for Thailand's economic expansion, it can be said that automotive industry is one of major industries. As a result, it is defined by Thai government as one of target industries because it has been considered that development of this industry would give several advantages. Since investment in automotive industry has been emphasized by Thai government, it is necessary to establish the policy on Foreign Investment

Support. However, it is currently impossible to operate business aiming to the ultimate benefits without considering on social impact (Kriangsak & Chareonwongsak, 2007). On the other hand, it is necessary to have the principles of business operation emphasizing on freedom, equality, fairness, and generosity, in order to develop community and improve the living standard sustainably (Pearce, 2003).

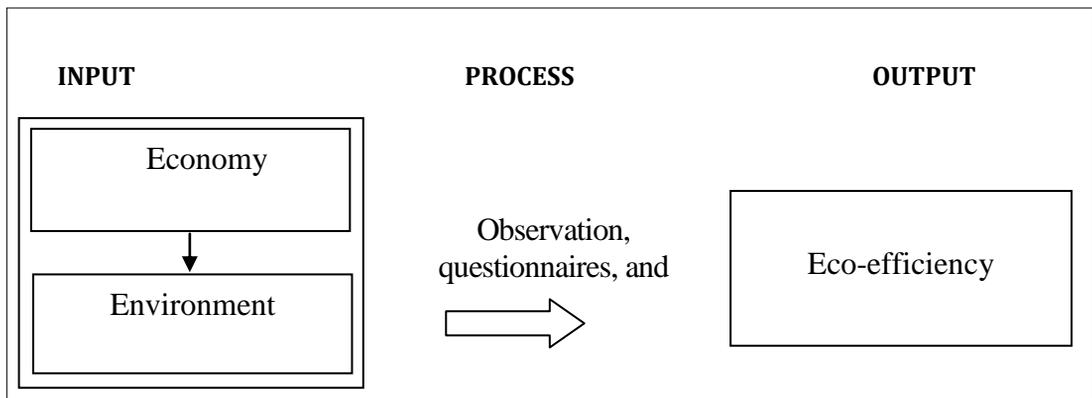
From the above phenomenon, the researchers were interested in analyzing the eco efficiency of automotive industry: evidence from Rojana Automotive Industrial Park in Ayutthaya in order to study on the relationship of eco efficiency among automotive industry leading to higher efficiency of the guidelines for improving eco efficiency.

**1.1 Objectives**

1. To study eco efficiency based on starting materials and resources consumption and utilization of energy for production that is determined s the indicator of relationship between economy and environment of automotive industry: evidence from Rojana Automotive Industrial Park in Ayutthaya.
2. To compare eco efficiency on economy and environment of industry sector of automotive industry: evidence from Rojana Industrial Park in Ayutthaya.

**1.2 Conceptual framework**

**Figure 1: Conceptual framework**



**2. Related Concepts and Theories**

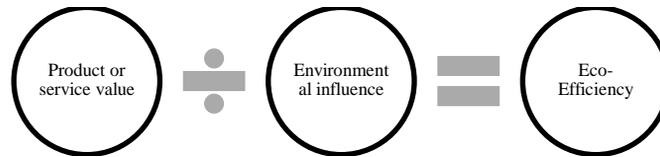
**2.1 Eco Efficiency**

Eco efficiency is a principle applied for develop economy along with sustainable development and such principle is able to be used as a tool for managing business sector to gain economic competitiveness among themselves along with taking responsibility on possible environmental impact (Kitikorn Jamorndusit, 2008).

**Operational Procedures for Improving Eco Efficiency**

To assess eco-efficiency of industry sector, it is normally the calculation for finding the proportion between product or service value and environmental impact. For environmental impact, it emphasizes on consumption of energy, materials, and water as well as Greenhouse Gas or CO2. The World Business Council for Sustainable Development has determined a method for calculating the eco efficiency as shown in Figure 2.

Figure 2: Illustration of Eco Efficiency Calculation (WBCSD, 2000)

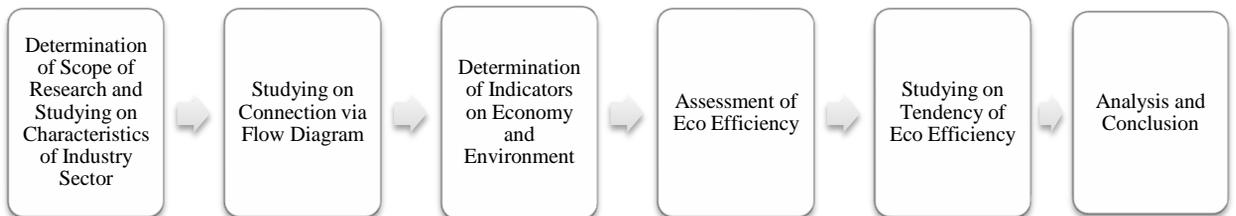


There are several methods for calculating eco efficiency with the above equation because both product or service value and environmental impact is consisted of several indicators that are unable to be combined as one number, for example, the value of environmental impact data that can be calculated by using several dimensions of indicator including data value obtained from indicator of environmental impact on energy or water resource. As a result, to calculate the eco efficiency based on such equation, it is necessary to select data from indicator that is suitable with each type of business. The results of calculation obtained from such indicator must be communicated easily leading to decision making in adopting these results in practical operation of executives and other persons in the organization as well as general outsiders directly or indirectly related to the business.

**3. Methodology**

The scope of this research is focusing on the eco efficiency of 30 factories of electronics industry located in Rojana Automotive Industrial Park, Ayutthaya. After determining the scope of research, the next procedure is collecting data on consumption of resources or starting materials as well as consumption of energy and pollution caused by production through data collection, observation, survey, and in-depth interview (Supang Chantawanitch, 2010). Such data was used for supporting classification of automotive industry and companies in Rojana Automotive Industrial Park (Kitikorn Jamorndusit, 2008). The guideline of this research’s methodology is able to be illustrated as shown in Figure 3.

Figure 3: Methodological Framework



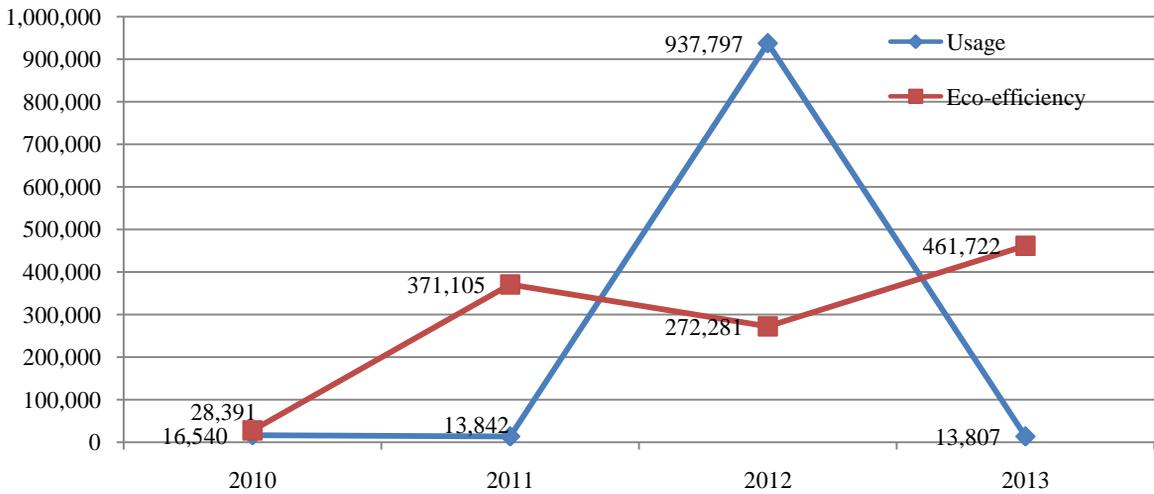
To select indicators as referred in the manual for assessing eco efficiency provided by the World Business Council for Sustainable Development (WBCSD, 2000), general indicators were selected and they were suitable with assessment of eco efficiency conducted in this research. Indicators selection was conducted by collecting primary data upon indicators determined by companies located in the sample industrial estate for assessing eco efficiency. Data collection of this research was divided upon the type of data used in assessing eco efficiency including primary data and secondary data. The second data was collected from related data sources including data recorded and stored in the Office of Rojana Automotive Industrial Park and Industrial Estate Authority of Thailand, report on assessment of environmental impact of each company, Annual Statement Report of each company submitted to Ministry of Commerce, and published Annual Report of each company. On the other hand, the primary data was collected by using some questionnaires specifically developed for this research and responded by companies located in the target industrial park (G. P. Kharel and K. Charmondusit, 2007)

**3.1 Results**

The results of analysis on eco efficiency based on indicators indicating the economic and environment relationship on electric power consumption and comparison of eco efficiency by averaging were considered as show in Table 1-3.

**Table 1:** Conclusion of Analysis on Overall Eco Efficiency

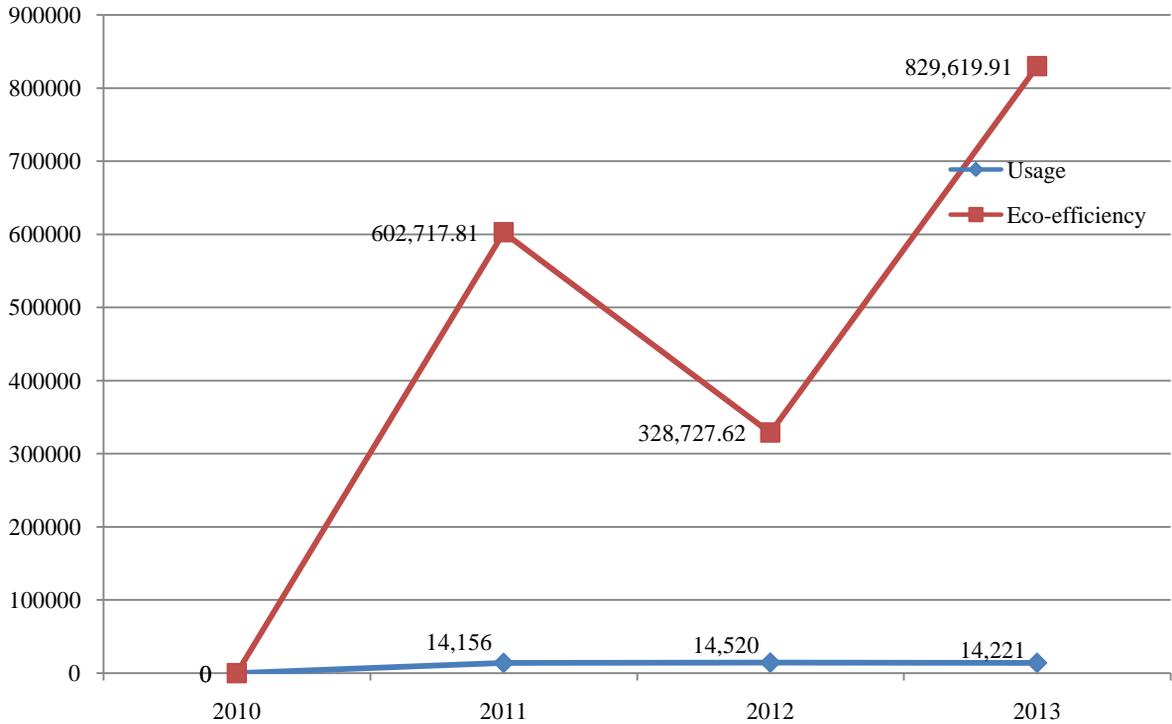
electric power	Eco Efficiency				Summary of Trends
	2010	2011	2012	2013	
Usage (kw)	16,540	13,842	937,797	13,807	lower
Eco-efficiency	28,391	371,105	272,281	461,722	higher



Based on Table 1 for the results of studying on economic and environmental indicators of 30 studied factories from 2010-2012 by averaging, in order to find eco efficiency value, it was found that the rate of eco efficiency’s reduction and increasing was uncertain. When utilizing the obtained data for finding the tendency of eco efficiency in 2013, it was found that eco efficiency value tended to be higher due to reduction of energy consumption which causes from increasing of eco efficiency that assessed by total income per quantity of energy consumption.

**Table 2:** Conclusion of Analysis on Eco Efficiency of Companies with Tendency of Higher Eco Efficiency

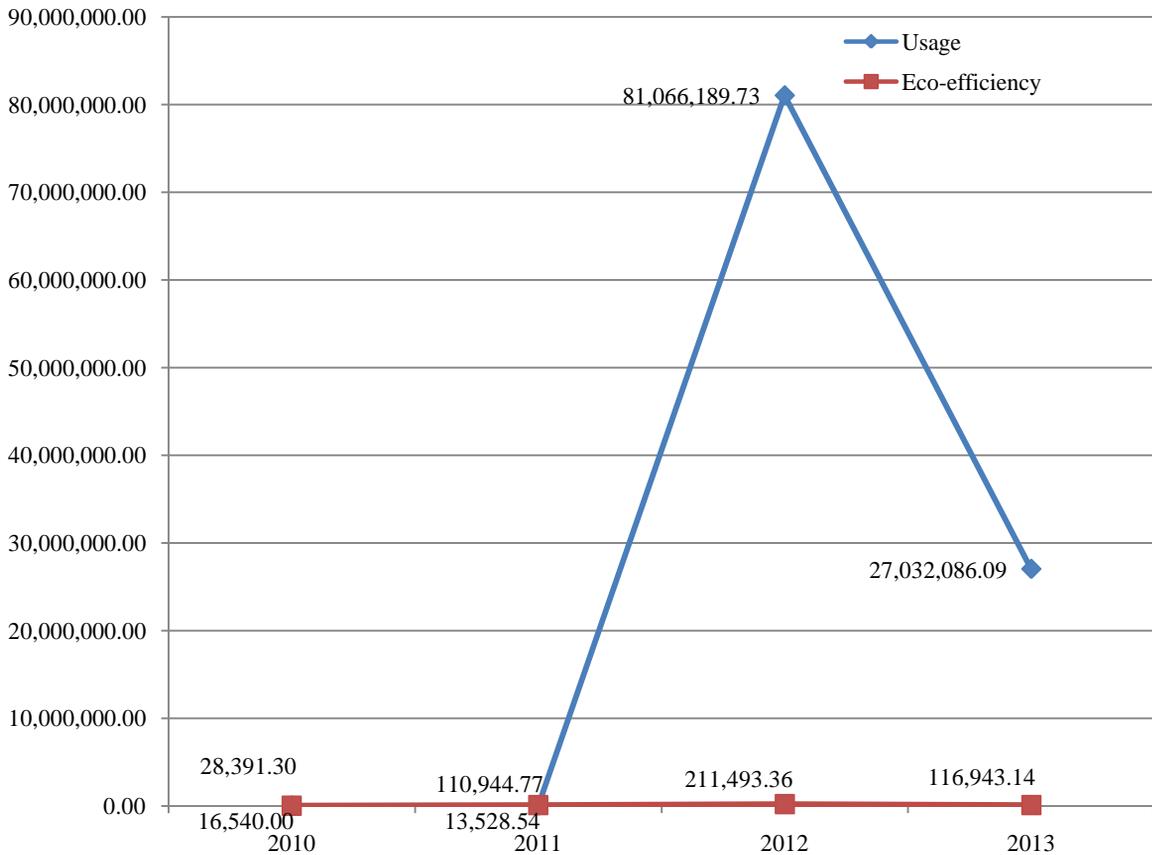
electric power	Eco Efficiency				Summary of Trends
	2010	2011	2012	2013	
Usage (kw)	N/A	14,156	14,520	14,221	lower
Eco-efficiency	N/A	602,717.81	328,727.62	829,619.91	higher



Based on Table 2 for the results of analysis on eco sufficiency among companies with tendency of higher eco efficiency calculated to be 48.28% of all companies from 2010-2012 by averaging, in order to find eco efficiency, it was found that the rate of eco efficiency's reduction and increasing was uncertain. When utilizing the obtained data for finding the tendency of eco efficiency in 2013, it was found that eco efficiency value tended to be higher due to reduction of energy consumption which causes from increasing of eco efficiency that assessed by total income per quantity of energy consumption.

**Table 3:** Conclusion of Analysis on Eco Efficiency of Companies with Tendency of Lower Eco Efficiency

electric power	Eco Efficiency				Summary of Trends
	2010	2011	2012	2013	
Usage (kw)	16,540.00	13,528.54	81,066,189.73	27,032,086.09	lower
Eco-efficiency	28,391.30	110,944.77	211,493.36	116,943.14	lower



Based on Table 3 for the results of analysis on eco sufficiency among companies with tendency of lower eco efficiency calculated to be 51.72% of all companies from 2010-2012 by averaging, in order to find eco efficiency, it was found that the rate of eco efficiency's reduction and increasing was uncertain. When utilizing the obtained data for finding the tendency of eco efficiency in 2013, it was found that eco efficiency value tended to be lower although the tendency of energy consumption was also lower. However, it could be noticed that the rate of energy consumption was not quite lower. When compared with 2011, it was found that the higher quantity of electric power consumption for twice from 2011. Nevertheless, it was not compared with 2012 because it was the year of factories restoration due to 2011 flood. As a result, the reduction of electric power consumption did not affect to eco efficiency due to small reduction of electric power consumption.

From concluding the data obtained from these 3 tables, it indicated that environmental indicator on energy consumption was another important variable that could increase or reduce eco efficiency. As a result, industrial factories with a goal on improving eco efficiency should emphasize on reduction of energy consumption.

**4. Discussion**

From studying and comparing eco efficiency on economy and environment of industry sector of automotive industry: evidence from Rojana Automotive Industrial Park in Ayutthaya, it could be analyzed as follows:

1. From the results of studying on transformation of economic and environmental indicators on electric power consumption of 30 factories studied from 2010 – 2012, it could be seen that the rate of reduction and increasing was uncertain as same as the results of eco efficiency assessment.

2. When considering on tendency, it was found that eco efficiency tended to be higher due to reduction of consumption of environmental indicator on electric power consumption. As a result, eco efficiency that assessed from economic indicator per consumption of environmental indicator was higher.

3. For promoting factories to be under international and national management system, there were at least 10% of all factories that have been certified by ISO 14001 ISO 50001 or TIS/OHSAS 18001. In addition, it was also found that the companies set the Participatory Environmental Quality Monitoring System as defined by Rojana Automotive Industrial Park as well as held some meetings to develop potential of management team regularly in order to ensure that their management system would be efficient that was consistent with the study of Rilker W.S, (1983) Feigenbaum, (1991) stated that all company's personnel must participate in quality control and cooperation of all organization's personnel, whatever their positions are, will lead to actual success. Moreover, this result was also consistent with the research of Burritt and Saka (2006) who studied on Application of Environmental Management Accounting (EMA) and Eco Efficiency in Japan. The results informed that such research would be useful and needed further support and promotion though application of EMA supported Japanese business on production and production consumption for achieving sustainable development.

4. From the results indicating that environmental indicator on energy consumption was another important variable reducing or increasing eco efficiency, industrial factories with the goal on improving eco efficiency should emphasize on reducing electric power consumption. However, based on the results, it was unable to conclude that increasing of eco efficiency was caused by any certain part of management. Consequently, it was important to conduct some in-depth study on management or operational guidelines for improving eco efficiency that was consistent with the study of Somchai Muichin (2014) stated that eco industrial estate development required the guidelines of development for quality management on reduction of environmental impact and building the economic and social connection.

## 5. Suggestion

Suggestion obtained from this research

Analysis on eco efficiency was able to be utilized as a tool in managing industry sector to be more potential on production and management. Moreover, if industry sector adapted the principles of eco industry to industry sector, the operation would be more efficient.

Suggestion on Implementing Obtained Results in Policy Planning

There should be the policy on adapting the principles of eco industry to industry sector more concretely. Nonetheless, industry sector should establish the explicit policy on adapting the principles of eco industry to industry sector.

Suggestion on Practical Implementation of Obtained Results

The principles of eco industry should be promoted to be applied to industry sector more extensively by regularly publishing news and information on knowledge and understanding on the principles of eco industry. In addition, key evidences of application should be provided through understanding on the principles of eco industry and passing such understanding and knowledge to practitioners in the same direction.

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