

การวิเคราะห์ประสิทธิภาพเชิงนิเวศเศรษฐกิจในอุตสาหกรรมเคมีภัณฑ์: กรณีศึกษา นิคมอุตสาหกรรมมาบตาพุด ประเทศไทย

ECO-EFFICIENCY OF THE CHEMICAL INDUSTRY: EVIDENCE FROM MAP TA PHUT IE, THAILAND

สุภากร ปิยนุชจรินดา*, อุทัย แก้วกลม

Supaporn Pinyochatchinda, Uthai Krawglom*

สาขาวิชาการจัดการ คณะบริหารธุรกิจ มหาวิทยาลัยเทคโนโลยีราชมงคลรัตนโกสินทร์

*Management Program, Faculty of Business Administration, Rajamangala University of Technology
Rattanakosin.*

**Corresponding author, e-mail: supaporn.pin@rmutr.ac.th*

Received: 2 June 2022; **Revised:** 13 December 2022; **Accepted:** 29 December 2022

บทคัดย่อ

การวิเคราะห์ประสิทธิภาพเชิงนิเวศเศรษฐกิจของสถานประกอบการในอุตสาหกรรมเคมีภัณฑ์ ด้วยการศึกษาดัชนีชี้วัดทางเศรษฐกิจและดัชนีชี้วัดทางสิ่งแวดล้อมของสถานประกอบการ ทั้ง 50 แห่ง ในระยะเวลา 3 ปี ประกอบด้วย การใช้ไฟฟ้า การใช้น้ำประปาและการปล่อยน้ำเสีย และดัชนีชี้วัดทางเศรษฐกิจ พบว่ารายได้รวมของแต่ละแห่งมีแนวโน้มเพิ่มขึ้นอย่างต่อเนื่อง รายจ่ายรวมที่เพิ่มขึ้นมากกว่าปีที่หนึ่งและปีที่สอง สำหรับดัชนีชี้วัดทางสิ่งแวดล้อม พบว่าการใช้น้ำประปาและการปล่อยน้ำเสียมีแนวโน้มการเพิ่มขึ้นในอัตราที่เพิ่มขึ้นซึ่งควรมีมาตรการดำเนินงานในด้านของการลดน้ำเสีย สำหรับค่าประสิทธิภาพเชิงนิเวศเศรษฐกิจของการปล่อยน้ำเสียมีค่าที่สูงที่สุด รองลงมาคือ ปริมาณการใช้น้ำประปา และปริมาณการใช้พลังงาน ตามลำดับ หากพิจารณาถึงค่าประสิทธิภาพเชิงนิเวศเศรษฐกิจของปริมาณการใช้น้ำประปา ปริมาณการปล่อยน้ำเสียและปริมาณการใช้พลังงาน มีทิศทางที่เพิ่มขึ้น และเมื่อวิเคราะห์แนวโน้มประสิทธิภาพเชิงนิเวศเศรษฐกิจด้วยกราฟ Snapshot พบว่าการดำเนินงานในทุกตัวชี้วัดในช่วงระยะเวลา 3 ปี มีแนวโน้มในการดำเนินงานที่สะท้อนความยั่งยืน เนื่องมาจากปริมาณรายได้ที่มีการเพิ่มขึ้นอย่างต่อเนื่อง และเมื่อพิจารณาถึงทิศทางของกราฟ พบว่าตัวชี้วัดในปีที่ 2 อยู่ในระดับ Haft Non Eco-Efficiency สำหรับในปีที่ 3 ได้ตกลงอยู่ในระดับ Fully-Non Eco-Efficiency เนื่องจากเป็นตัวชี้วัดนี้สะท้อนการดำเนินงานที่ไม่วางอยู่บนรากฐานของพัฒนาอย่างยั่งยืนสูงสุด และมีปริมาณการเพิ่มขึ้นอย่างต่อเนื่อง โดยผลกระทบที่เกิดขึ้นจากปัญหาที่เกิดขึ้นคือ การมีต้นทุนในการดำเนินงานที่เพิ่มขึ้น สิ้นเปลืองทรัพยากรและปัญหาหลักที่เกิดขึ้นจากน้ำเสีย ด้วยเหตุนี้ผู้วิจัยเห็นว่าการพัฒนาแนวทางในการลดการใช้เป็นอีกหนึ่งทางเลือกที่มีความสำคัญในการลดต้นทุนการดำเนินงานของสถานประกอบการในอุตสาหกรรมเคมีภัณฑ์

คำสำคัญ: การวิเคราะห์ประสิทธิภาพ; นิเวศเศรษฐกิจ; การใช้น้ำประปา; การปล่อยน้ำเสีย; ผู้ประกอบการ
อุตสาหกรรมเคมี

Abstract

An environmental efficiency analysis of chemical industrial enterprises in Thailand was studied by using measurement indicators that reflect the relationship of the economy and the environment. The economic and environmental indicators for 50 enterprises over a 3-year period was monitored which composed of electricity consumption, water consumption, level of wastewater discharge and the measurement of economic indicators. The economic indicators of the total income of each enterprise had a tendency to increase continuously. The third-year total expenses were higher than in the first and second years. With regard to the environmental indicators, which were water consumption and the wastewater discharge increased. These meant a water treatment plant should be applied. The discharged wastewater had the highest score. The second highest level was the water consumption and the third was energy consumption, respectively. It was found that the environmental efficiency of the water consumption level, wastewater discharge, and the energy consumption level had a tendency to increase. When analyzing this tendency in environmental economic efficiency by using a snapshot graph, it has shown every operational indicator in the 3-year period showed signs of sustainability. This is due to the amount of continuously increasing income. When considering key performance's tendencies, all is found to be positioned in the Half Non-Eco-Efficiency in the second year. This changed to Full-Non-Eco-Efficiency in the third year. These showed that development is not based on sustainability. There are issues with the increased operational costs, the expensive resources and problems derived from the wastewater. The recommendation from these results is to provide reducing the high operational costs of chemical industrial enterprises as well.

Keywords: Environmental Efficiency Analysis; Eco-Efficiency; Water Consumption; Wastewater Discharge; Chemical Industrial Enterprises

Introduction

Economic development that concentrates on the manufacture and consumption of goods with eco-friendly services including the health of the members of the community has gained attention due to the environmental and resources crisis which has affected countries around the world. Pollution problems, lack of food and power, degradation of the ecosystem and the over-use natural resources has resulted in the inability of the ecosystem to support the demands of humans and to balance these demands with economic activities. This has led to the concept of developing eco-efficiency in various forms such as the Eco-city, Eco-town and Eco-Industrial Estate which in general refers to an area that has been selected for development and for the use of eco-friendly concepts as well as the instruments and the administration process for the manufacture and the consumption of goods that will be friendly to the environment and create economic diversity. [1]

The concept of an eco-industry has recently been developed due to changes in the manufacturing system and consumers' behavior and it is concerned with increasing efficiency in the design of packaging and the recycling process. [2] This in turn has led to efforts to integrate the industrial system and the ecosystem so that the cycling of materials in a closed system which discharges waste from a plant will be used as an alternative resource. Hence, industrial eco-efficiency promotion is the key factor for green industrial development. [3]

Eco-efficiency is a theoretical concept that has been applied to industrial business organizations to develop the economy with sustainability. It has been officially recognized by the World Business Council for Sustainable Development (WBCSD). [4] At the same time, eco-efficiency may minimize the impact on nature (water consumption, air emissions and dispersion of harmful substances) while maintaining and enhancing the value of the manufactured product. [5]

The chemical industry is a fundamental part of the manufacturing industry of this country at present. A large part of the chemical industry has been replaced by imports. The majority of the enterprises in the chemical industry are large scale enterprises which account for 75 percent of the total industry. The proportion 25 percent are medium and small enterprises that use advanced manufacturing technology. The basic infrastructure of the chemical industry uses materials and requires a high amount of energy, except in some cases such as the production of sodium hydroxide and liquid chlorine which has a material-energy ratio of 45 percent of raw material to 50 percent of energy, plus a workforce of 5 percent. [6]

The structure of the chemical industry requires 3 important types of materials which are oil, natural gas, and agricultural products. Oil and natural gas are the products needed for the refinery processes. These products will be used to produce petrochemical plastics, resin polymer and other types of plastic, plastic products and the minerals that are used as raw materials for inorganic production, organic chemistry, chemical fertilizers, pesticides and the chemical additives in the agricultural industry. Agricultural products are used as raw materials for the production of biological chemicals which has developed as a recent trend in the chemical industry from 2012 onwards. The trend is expected to increase due to additional demands for the consumption of these products. However, since the chemical industry is an industry that creates significant environmental impacts in the form of the international free trading which eventually lead to the non-tariff barriers: NTBs. Many countries around the world are increasingly aware of the importance of environmental management, including considering the ability to manage energy efficiently, especially the clean technology. [7]

Because the chemical industry is an industry that affects the environment as well as being an industry that has high energy costs, [8] the research team was interested in studying and analyzing the eco-efficiency of aspects of the chemical industry. The scope of interest is in studying and analyzing the management of raw materials, energy and the environmental effects of the eco-efficiency of the industry. The information gained from this research will be used in the management of resources and the environment. This will increase eco-efficiency and also require the establishment of guidelines on how to apply the eco-efficiency of the industry and how to establish measurement indicators of eco-efficiency. These indicators will be used to consider the effects on the economy and also the benefits to the environment which will be beneficial to the organization of the chemical industry in the future.

Objectives

1. To study the eco-efficiency of chemical industrial enterprises in Thailand by using measurement indicators that reflect the relationship of the economy and the environment.
2. To study the trends in the eco-efficiency of chemical industrial enterprises in Thailand.

Methods

The information gathered in this research includes data about electricity consumption, water consumption, wastewater discharge and the measurement of economic indicators such as the total amounts of sales and profits. which is showed in Fig. 1.

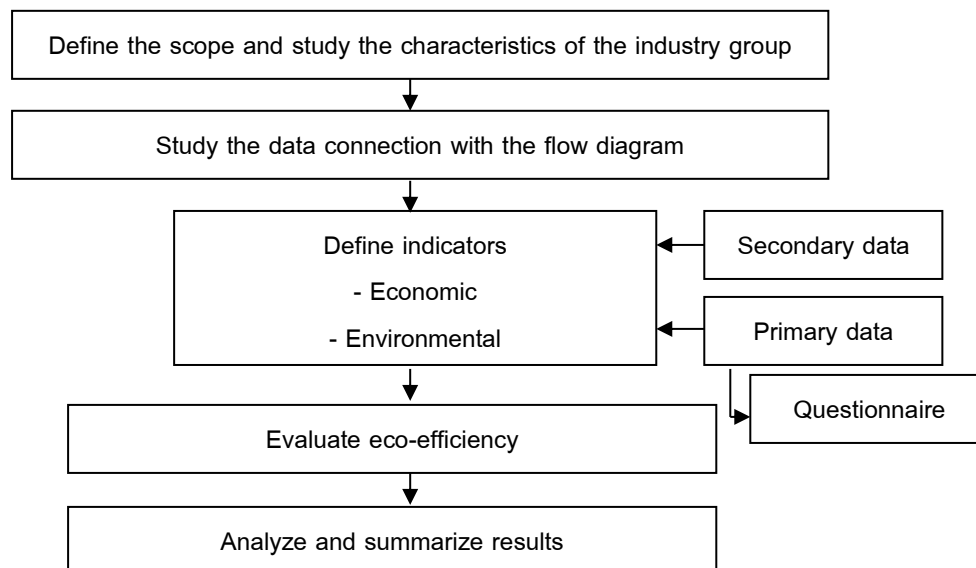


Figure 1. A framework for the research methods.

The evaluation of the eco-efficiency of the group of industrial enterprises in this research is based on the evaluation methodology of The World Business Council for Sustainable Development (WBCSD, 2000). The information was obtained from a comparison of the value of the products and services with the impact on the environment caused by the consumption of resources and the emission of pollutants which is expressed in the equation below: [4]

$$E/En = \frac{EV}{\sum Enm}$$

When: E/En: Eco-efficiency value of the sample n assessed

EV: The economic value generated from the product or service in the research which is the total sales volume and gross profit in Baht.

Enm: Impact on the environment and a direct function of various environmental indicators which is data about electricity consumption, water consumption, level of wastewater discharge. The “m” was determined by the assessment of the eco-efficiency value, the EV value will be evaluated against the Enm value separately, according to each indicator m.

Results

The results of the research on eco-efficiency were obtained from indicators of the chemical industrial enterprises which show the relationship between the economy and the environment. An analysis of the indicators of 50 chemical industrial enterprises on which research was conducted over a 3 year period following a flooding crisis

found that the economic indicators of each enterprise were likely to increase continuously. The average total profit (or loss) is 1,734,309,137.91 Baht. The average of the second year increased while the third-year average decreased by almost 7 percent. The average was 95,539,719.36 Baht. Although the total expenditure of the second year decreased, the decrease accounts for less than 1 percent while in the third year the total expenditure increased more than in the first and second years. The average was equal to 1,685,920,334.06 Baht

The results of the measurement indicators for the environment reveal that all 3 indicators, which showed water consumption, the amount of wastewater discharged and electricity consumption over the 3 year period increased continuously. An in-depth analysis revealed that the water consumption and the wastewater discharge level increased while the electricity consumption also increased but at a lower rate. The average wastewater discharge level was 114,896.43 cubic litres and the average water consumption level was 143,750.45 cubic litres while the average electricity consumption was 1,915,869.17 cubic litres, respectively

The evaluation of the eco-efficiency of 50 chemical industrial enterprises studied over a 3 year period is based on the economic results of the measurement indicators, such as the total income compared to the environmental indicator measurements which were water consumption, wastewater discharge and energy consumption. It was found that the highest eco-efficiency of the indicators was the wastewater discharge level. The second highest was water consumption and then energy consumption, respectively. However, if we consider the rate of increase and the reduction in eco-efficiency, then the eco-efficiency of the water consumption, water discharge and the energy consumption increased, as shown in Figures 2-4.

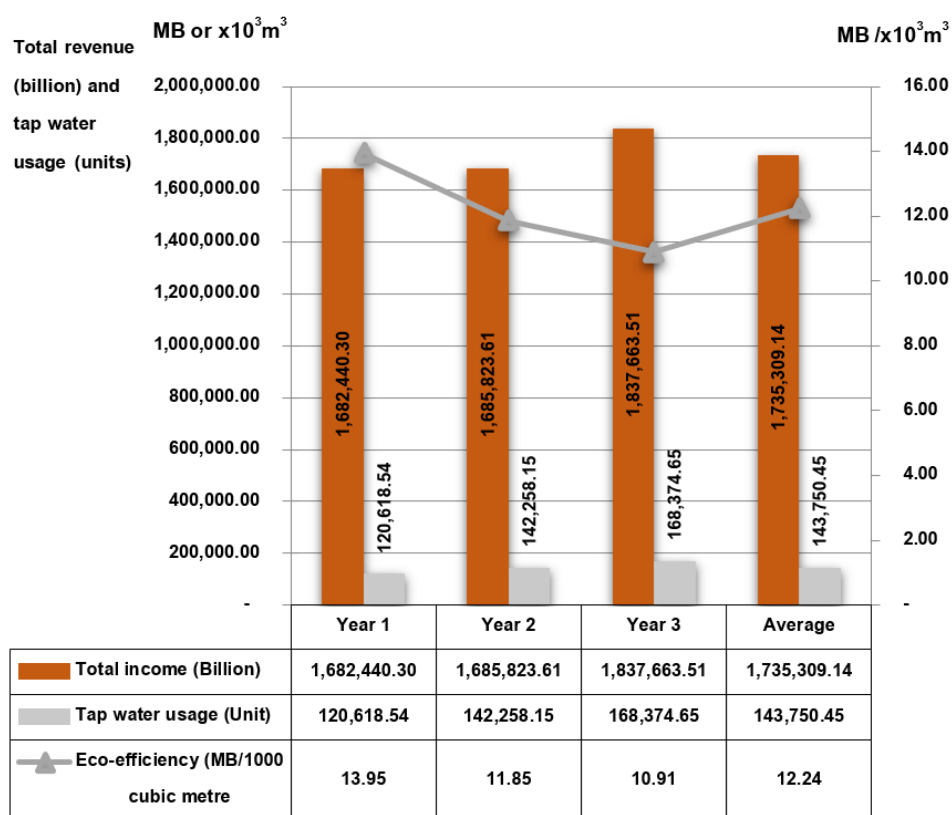


Figure 2. The eco-efficiency assessment of economic indicators, total income compared to environmental indicators and the amount of tap water usage of 50 chemical industry enterprises over a period of 3 years.

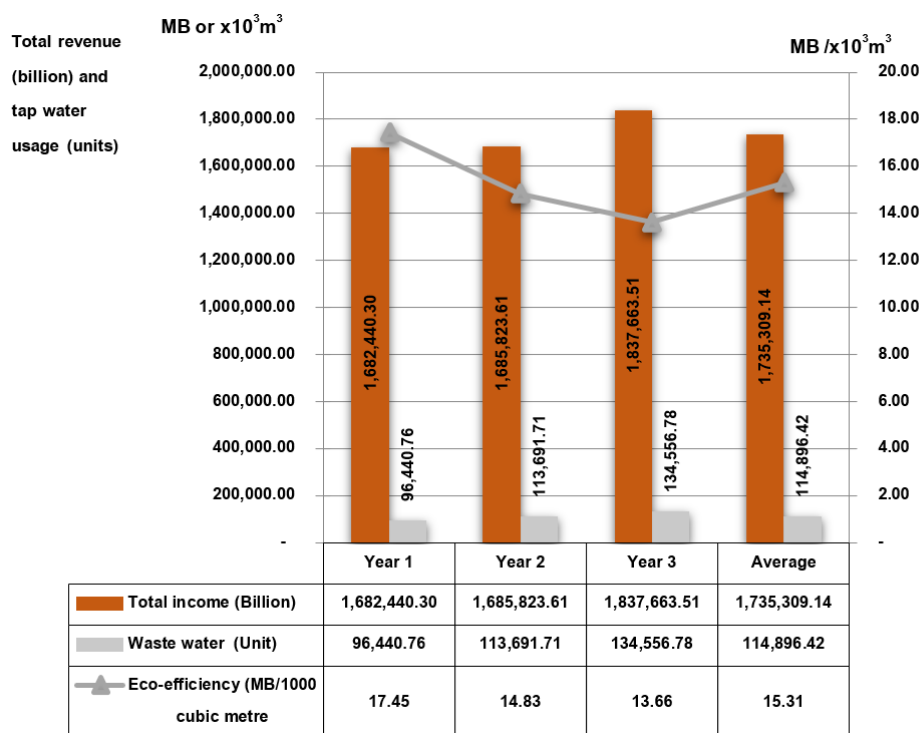


Figure 3. The eco-efficiency assessment of economic indicators, total income compared with environmental indicators and the amount of waste water released by 50 chemical industry enterprises over a period of 3 years.

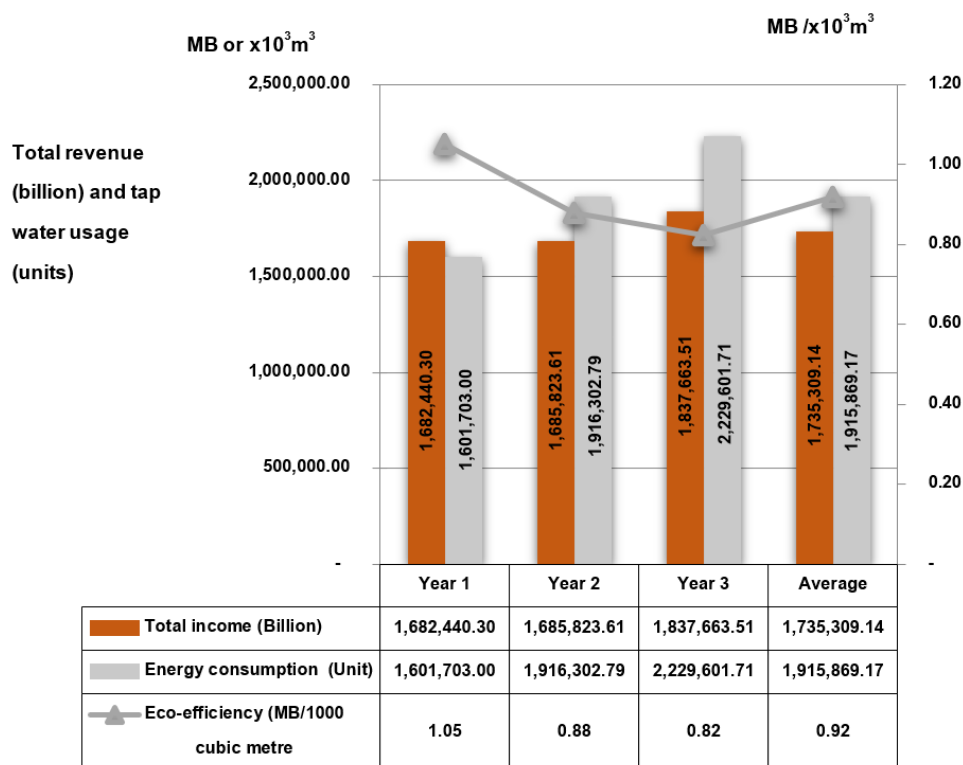


Figure 4. The eco-efficiency assessment of economic indicators, total income compared with environmental indicators and energy consumption by 50 chemical industry enterprises over a period of 3 years.

The results of the indicators of eco-efficiency of the chemical industrial enterprises

After the eco-efficiency was evaluated, the results of the environmental measurement indicators of the chemical industrial enterprises and the measurement indicators of income were used to analyze the amount of eco-efficiency by using a Snapshot graph. The results of the study found that the indicators showed sustainability within the 3 years period due to the continuously increasing income as shown in Figure 4.

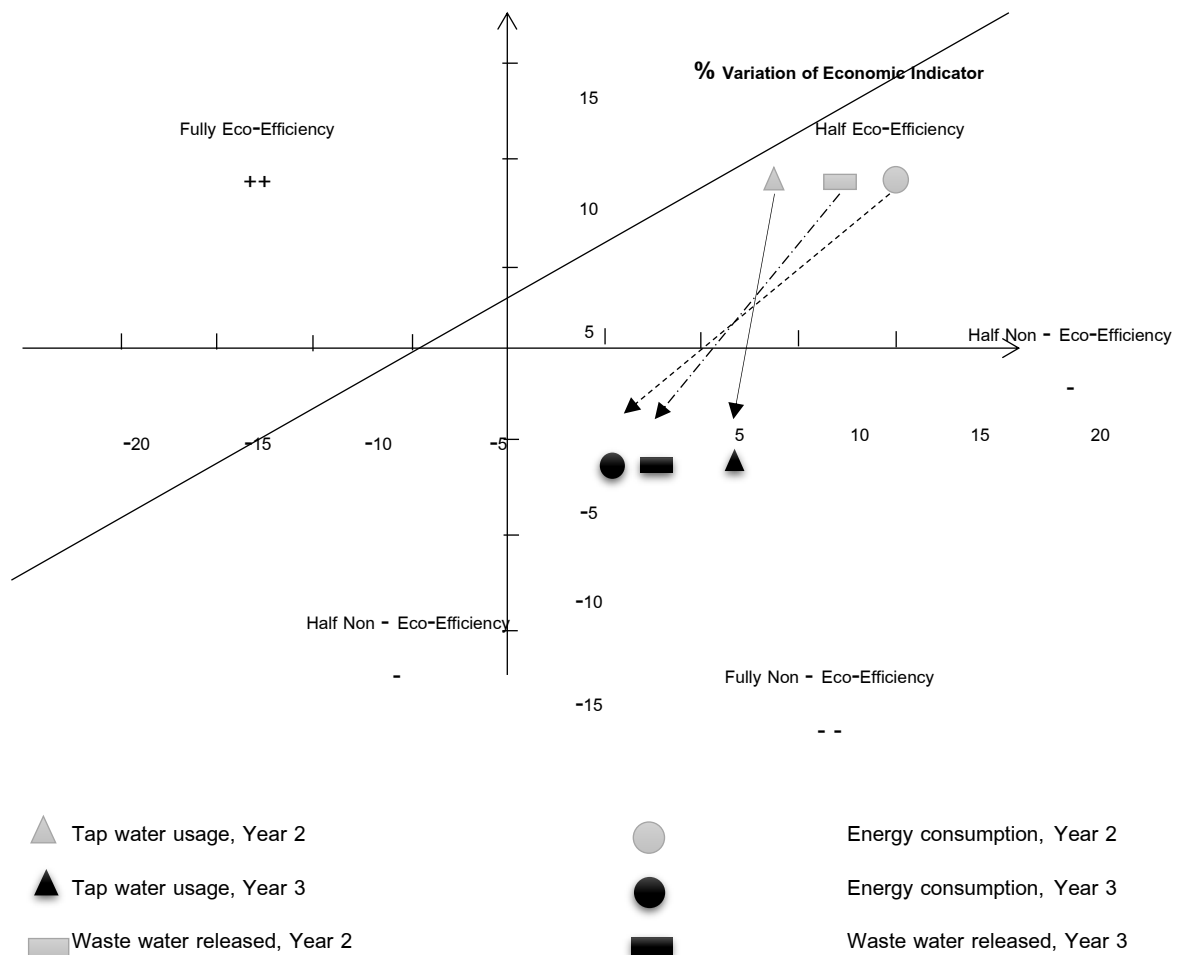


Figure 4. Eco-efficiency trends in the chemical industry.

The study found that there was a trend towards to go in the same direction as the evaluation of the eco-efficiency. The trends indicating eco-efficiency were plotted on the snapshot graph and can be categorized into 4 levels (Jamorndusit et al., 2008)

1. Full Eco-Efficiency level which is the level at which economic changes increased along with changes that will reduce the impact on the environment.
2. Half Eco-Efficiency which is the level to which economic changes increased or the level at which the changes that affect the environment are reduced. This trend is likely to lead to Full Eco-Efficiency.
3. Half Non-Eco-Efficiency which is the level at which economic changes increase or the changes affecting the environment are reduced. This is characteristic of Full Non-Eco-Efficiency.

4. Full Non-Eco-Efficiency is the level at which the economic changes are reduced and the changes affecting the environment are increased.

After investigating the economic changes revealed by each indicator, it was found that the water consumption, water discharge and the energy consumption in the second year should be categorized as Half Non-Eco-Efficiency. In the third year, however, this was reduced to Full Non Eco-Efficiency which is the level at which economic changes are reduced while the changes that affect the environment are increased. This reflects that the operations are not based on sustainability as the direction of the graph was developed in the Y-axis direction. Thus, economic factors play an important role in changing the eco-efficiency of the economy. When we consider the trends towards the eco-efficiency of the chemical industrial enterprises, it is clear that all of the 3 indicators are important. This is due to the fact that the measurement indicators show that the operations are non-sustainable. When considering the data which was collected, it was found that the water consumption, wastewater discharge and the energy consumption were increased continuously. Thus, more resources were being consumed. Furthermore, there was a problem with the smell of the wastewater which was polluted. The researcher of this project, therefore, developed some guidelines to help reduce the consumption levels as a way of reducing the costs of the chemical industry enterprises.

Conclusions and Discussion

The analysis of the eco-efficiency of the chemical industrial enterprises based on the economic indicators and the environmental measurement indicators of the chemical industrial enterprises was conducted for 50 enterprises over a 3 years period. It was found that the economic indicators, which measured the total income of each enterprise, increased continuously. In terms of the net profit (or loss) it was found that the net profit (or loss) in the second year increased while its value in the third year was reduced by almost 7 percent in the second year. When considering that the total expenditure in the second year was reduced, it should be noted that the reduction accounted for less than 1 percent while the total expenditure for the third year was more than the first and the second year combined, respectively. The environmental indicators revealed a continuous increase for all of its 3 indicators, which were for water consumption, wastewater discharge, and energy consumption, respectively. An in-depth analysis found that the water consumption and the wastewater discharge increased. Therefore, there should be counter-measures to reduce the amount of wastewater discharge. The higher the water consumption, the more waste water will be discharged and a water treatment process using chemicals is required for treating the wastewater. This will increase the costs. For this reason a system for reusing water has been implemented so that the water can be used to clean the machines. In addition, the re-used water will be used to clean other instruments and other machines before they are cleaned again with clean water. This will reduce the total amount of water required which is in line with the research of Rattanaphan et al., (2013) who studied how to improve strategies for developing a sustainable pig farm based on the development of eco-efficiency. They found that the water consumption indicator reflected the problems of the farm that were needed to improve its eco-efficiency. [9] This could be done by cleaning the pigs' excrement first before the water was used to clean the stalls. In the drainage area, a grated trap was installed from which the residual sewage was scooped up in sieves and then dried in the yard. This resulted in an increased income from the sale of pig manure.

The results of the evaluation of the chemical industrial enterprises found that the eco-efficiency of the wastewater discharge was the highest followed by the water consumption and the energy consumption, respectively. However, when considering the increases shown by the indicators and the reduction in eco-efficiency, it was seen that the eco-efficiency of water consumption, wastewater discharge level and the energy consumption were likely to increase. After the evaluation of the eco-efficiency, the environmental indicators of the activities of the chemical industrial enterprises and the indicator for the amount of income, an evaluation of the trends in their eco-efficiency which used a Snapshot graph, showed that all the indicators for the chemical industrial enterprises over the 3 years period were likely to reflect greater sustainability in the future. This is because the income increased continuously and when the trends in the graph were taken into account, it was found that the economic factors played a significant role in changing the level of eco-efficiency. All the 3 types of indicators were important. Even the indicators which were not based on sustainability increased continuously as well. Some serious problems were also identified which were the impact of increased operational costs and the greater consumption of water resources which resulted in pollutants in the discharged wastewater and caused a bad smell.

Consequently, after evaluating the eco-efficiency of the chemical enterprises and the application of mathematical models for the management of greenhouse gases in cement plants, the researcher believes that developing guidelines for reducing the levels of consumption is an important alternative to reducing the operational costs. These guidelines will be very useful for the business sector as they will assist enterprises in generating more profits at the same time as they reduce the consumption of resources. [10] The concept of eco-efficiency when applied to the use of raw materials and energy, and including the reduction of waste emissions into the environment is an effective tool in business as well as an indicator of the economic and environmental relationships that can help to guide the direction and support of government policies. And research of Therdkiatikul & et al. (2016) study to water reduction for Dyeing Process in Carpet Production Industry Using Clean Technology Approach the result showed that in the case study plant, water consumption of 93.09 liter per day was found, based on Ishikawa diagram to evaluate loss, 3 potential alternatives including 1) improving bath washing process by box installation 2) utilizing condensed steam loss, and 3) reusing water for scouring process were chosen. [11]

Accordingly, WBCSD, (2000) [12] has established seven guidelines that will help business operations achieve greater ecological success. [4] These guidelines are geared towards more sustainable development as the overall goal of the country in the long term with respect to the economic, social and environmental factors that support the model Sustainability of Engineered processes. [13] Based on the results of Eco-Efficiency Assessment, the condition of the industry's operation in various period of time, both trough and peak, could be seen. To enable the industry to find differences of operation, it could be used for comparing on management competency with other similar organizations or business sectors (Benchmarking) that would lead to improvement of production efficiency of the organization or business section. In addition, these results obtained from Eco-Efficiency Assessment could be applied to improve their own products to be more efficient while reducing production costs on consumption of energy and resources.

Acknowledgement

This study was supported by a research grant from Rajamangala University of Technology Rattanakosin. The researcher most gratefully acknowledges for all worthy support providing to this research.

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