

*Environmental Impact Evaluation Using Cost Benefit Analysis and Multi Criterion  
Analysis: A Case Study of Rayong Province, Thailand*

Nattarin Ueasin, Suthin Wianwiwat

Khon Kaen University, Thailand

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Abstract

Rayong province is a major industrial area in Thailand. For more than 30 years this province has served the demand of Thailand's petro-chemical industries, mainly in the Map Ta Phut industrial zone. However, the industrialization of the area has resulted in many serious environmental and health problems, causing distrust and protests from the local people, and a subsequent delay in the expansion of the capacity of the industrial sector. To solve this problem, the government must find a way to expand the industrial sector that satisfies all stakeholders. Thus, focus stakeholder group meetings and the Delphi technique are utilized to form possible alternatives of investment in expanding factories. Several economic indicators including the net present value provided from a cost benefit analysis were then analyzed via the Multi Criterion Analysis (MCA) technique to indicate the best way to develop the industrial area. This study found that the best alternative is to allow the expansion of industrial capacity without exceeding acceptable levels of pollution, requiring comprehensive town planning, the implementation of existing laws and particular measures, and the consideration of the Eco-industry concept.

**Keyword:** Benefit Transfer, Multi Criterion Analysis, Eco-Industry, Cost Benefit Analysis

## **1. Introduction**

The National Economic and Social Development Plan intends to extend industrial development from Bangkok and nearby areas to the east of the country. Rayong, the province in the Eastern area of Thailand, has high potential to meet the high demand of industry because Rayong is not too far from Bangkok and it is very suitable to build a large seaport to import and export industrial products. One of the most important projects in Rayong is the Petro-Chemical Industry Development Plan (PCIDP), which aims at developing petro-chemical industries to meet the high petro-chemical industry demand of Thailand. This plan is currently in phase 3 (2004 – 2019) in which about 400,000 million baht will be invested in this area. About 100,000 million baht has been already invested. Therefore, a dramatic increase in industry in this area has occurred, and Rayong has become one of most important industrial areas in Thailand and has amongst the highest per capita income in the country. However, with the development of industrialization, many negative impacts have been caused such as high pollution, health problems, labor immigration, insufficient public welfare etc.

Considering the negative impacts, the government announced the Rayong industrial zone as a pollution control area in 2009 (Office of Natural Resources and Environmental Policy and Planning, 2009) and endorsed Rayong's Pollution Reduction and Elimination Plan in 2010 (Office of Natural Resources and Environmental Policy and Planning, 2009). In addition, the heavy pollution areas (for example the Mab Ta Phut industrial zone and vicinity) have taken some specific measures, such as town planning management (approach to mitigate pollution) and the establishment of a protection zone in this area. Moreover, the Industrial Estate Authority of Thailand and the Ministry of Industry launched a policy that is based on the eco-concept named "Eco-Industry or Green Industry" to invite every industrial estate to follow the development policy. Eco-industry focuses on how to increase productivity and competitiveness based on environmental considerations, sanitation, safety and social responsibility in five dimensions (economic, environmental, social, physical and management). Unfortunately, there are still some environmental issues in Rayong industrial zones identified by the National Environmental Board (NEB) at the meeting on July 8, 2010 (Office of Natural Resources and Environmental Policy and Planning, 2009) The important issues are: 1) highly volatile organic compounds in rivers, underground water and air, 2) highly toxic chemicals in seafood, and 3) exploitation of protection zone problems etc. Therefore, this study aims to scrutinize and propose alternatives that are appropriate for industries and other economic development by considering the environmental protection of Rayong province. In this study, there are four parts: introduction, methodology, results of the study and the conclusion.

## **2. Methodology**

This study is being conducted during PCID phase 3 from 2004 – 2018 which has an investment plan of about 400,000 million baht; however, from 2004-2012, about 100,000 baht has already been invested. Therefore, this study assumes there to be new investment which means an increase in investment in the petro-chemical industry of about 300,000 million baht in Rayong province. This study is designed in three stages as follows:

## 1) Set alternatives, review and collect data

First, by considering alternatives in this study to evaluate the optimal alternative from four choices rather than employing the Delphi technique as follows:

- I. Not to allow new investment,
- II. Allow to expand industrial capacity to within 50% of pollution capacity,
- III. Allow to expand industrial capacity without exceeding pollution capacity, requiring comprehensive town planning, and the implementation of existing laws and particular measures,
- IV. Allow to expand industrial capacity without exceeding pollution capacity, requiring comprehensive town planning, the implementation of existing laws, and particular measures while considering the eco-industry concept.

This study employs thirteen indicators which came from the collection of primary and secondary data which have been ranked by the Delphi technique. Secondary data were collected from data bases in both government and non-government agencies. The eight types of secondary data used as indicators in this study are 1) Gross Domestic Product growth (GDP Growth). 2) Gross Provincial Product growth (GPP Growth). 3) inflation rate. 4) tax income. 5) unemployment rate. 6) industrial sector growth rate. 7) agricultural sector growth rate. 8) service sector growth rate. Four types of primary data which were collected from industries, business, and the non-registered population (100 samples each) are 1) the tax income of the non-registered immigrant population, 2) the proportion of local raw materials used in production, 3) the proportion of the local workforce used in production, and 4) the proportion of logistics cost of production.

One of the important indicators is Total Economic Value (TEV). It was calculated by employing the Benefit Transfer technique (BT) and was used in both primary and secondary data. On one hand, the benefits from investment which are based on the current capacity, enactments, measurements and policies of each alternative should be considered. On the other hand, the cost of investment was calculated based on the greenhouse gas effect, the unregistered immigrant effect, and the cost of medical care, which are different for each alternative.

## 2) Weighting analysis of all indicators

After the thirteen indicators were obtained, they were arranged in a Multi-Criterion Table in which the vertical and horizontal axes are the same indicators, which were then ranked by employing the Delphi technique. In order to score the alternatives, the experts need to consider the following

- When the vertical indicator is much more important than the horizontal indicator; the score is 5 marks,
- When the vertical indicator is more important than the horizontal indicator, the score is 4 marks,
- When the vertical indicator is equal to the horizontal indicator, the score is 3 marks,
- When the vertical indicator is not as important as the horizontal indicator, the score is 2 marks,

- When the vertical indicator is less important than horizontal indicator, the score is 1 mark,
- When the vertical and horizontal indicators are the same indicator, the score is 0 marks.

It is then necessary to sum up the compared weight score of each indicator and derive the total compared Weight Score of each indicator in each dimension.

### 3) Assessing the Impact Levels of each alternative

To assess the Impact Levels, the impact of each indicator was rated by comparison with base data, and Impact Levels were obtained from formulas as follows:

$y = a(b - c)/d$ : This formula is applied for every indicator except for inflation rate, unemployment rate, and the proportion of logistics cost of production<sup>1</sup>,

$y = a(c - b)/d$ : This formula is applied (except for three indicators)

When

$y$ : Impact Level of each indicator, every indicator is compared in five ranges as follows:

- 0.00-0.20 means the impact level has the highest negative impact,
- 0.21-0.40 means the impact level has a high negative impact,
- 0.41-0.60 means the impact level has a moderate negative impact,
- 0.61-0.80 means the impact level has a low negative impact,
- 0.81-1.00 means the impact level has the lowest negative impact.

The three excepted indicators are rated as having an impact in five ranges as follows:

- 0.00-0.20 means the impact level has the lowest negative impact,
- 0.21-0.40 means the impact level has a low negative impact,
- 0.41-0.60 means the impact level has a moderate negative impact,
- 0.61-0.80 means the impact level has a high negative impact,
- 0.81-1.00 means the impact level has the highest negative impact.

$a$ : the interval range, in this case is 0.2 and there are five intervals for each indicator.

$b$ : the impact level of each indicator.

$c$ : the impact level of the three excepted indicators.

$d$ : the interval range value in each indicator.

After Weight Score and Impact Levels are calculated, multiply Weight Score with Impact Level of each indicator and sum all thirteen indicator results together; finally, the evaluation result for each alternative is obtained.

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<sup>1</sup> The reason why these three indicators needed to be calculated with another formula is because when they increase, the negative impact will also increase.

#### **4) Evaluating the alternatives**

When the alternative results are obtained, the scores of the alternatives are compared and the best alternative is selected; it is also necessary to add a factor where there is not enough information, or where there are factors that are difficult to quantify, in terms of their positive and negative impact from industrial development in this area to help to provide a more precise evaluation.

### **3. Results Of The Study**

#### **3.1 Results from each indicator**

##### **1) GDP growth**

Thailand's economy in 2004, the initial PCIDP phase 3, had GDP equal to 6,489,476 million baht and this increased to 10,540,134 million baht by 2011 (about a 3.6% annual GDP growth rate). For the proportion of GDP by sector (industry: service: agriculture) it had changed from 43.3%: 46.3%: 10.3% in 2004 to 43.7%: 43.0%: 13.3% respectively in 2011. Comparing the average annual GDP growth rate in Thailand with the average annual GDP growth rate in the world during 2004-2010, the GDP growth rate (3.6%) was higher than the world's GDP growth rate (2.7%). A significant increase in the proportion of agricultural sector income came from an increasing agricultural product demand for agro-industry, food and alternative energy industry products.

##### **2) GPP growth**

The GPP of Rayong province during the study period 2004-2011 was about 364,552 million baht and the largest proportion of GPP by sector was in the industrial sector which was about 87.6% in 2004 and 87.2% in 2011. Therefore, we can conclude that economic development in Rayong depended on the industrial sector, which was 3.8% of the average annual GPP growth rate during 2004-2011 and a little higher than the average annual GDP growth rate of Thailand, which was about 3.6% per year.

##### **3) Headline Inflation Rate**

The headline inflation rate shows the purchasing power of people and how the change in the cost of living relates to the price of goods. During 2004-2011, the average inflation rate in Rayong province was quite high (5.1%) compare with Thailand's average inflation rate (3.2%). Considering the food and beverage price index, the index is significant because it mainly affects people who have low income. Rayong's food and beverage price index (8.7% on average) was higher than Thailand's food and beverage price index (5.9% on average). This situation shows the degree of effect on the cost of living of people with low income in Rayong, where the development of the industrial sector gave rise to such changes.

##### **4) Tax income**

In this study, two types of tax income were identified as Revenue Department Tax (RT) and Excise Department Tax (ET). Bangkok RT, in 2004, collected about 772,316 million baht or 65.9% of the whole country, followed by Chonburi with about 5.7%, and Rayong with about 3.9%. In 2011, the sequence of tax income was the

same: Bangkok, Chonburi, and Rayong provinces had percentage income from tax of about 65.3%, 7.9% and 5.0% respectively.

For ET, the most income, in 2004, was Bangkok with about 20.6% and Rayong province with about 15.5%. Almost all of Rayong ET was collected from petro-chemical products. In 2011, the sequence of ET income was the same: Bangkok followed by Rayong province with about 19% and 13.5% respectively from all of the ET income in the whole country.

#### **5) Unemployment rate**

In 2004, Rayong province had about a 1.6% unemployment rate and had a labor force of 309,980. In 2011, the unemployment rate was lower than before because an increase in economic growth.

#### **6) Industrial sector growth**

In 2004, the Value Added of the industrial sector of Rayong province was about 276,939 million baht or about 9.8% of the whole country. Unfortunately, because of the world economic crisis in 2009 and a big flood in central Thailand in the fourth quarter of 2011, the industrial sector of the whole country was seriously affected. However, the industrial sector in the whole country remained about 4% per year and it was higher than Rayong province, where it was about 2.8% during 2004-2011.

#### **7) Agricultural sector growth**

In 2004, the Value Added of the Rayong agricultural sector was about 11,359 million baht or about 1.7% of the whole country. In 2004, the Rayong agricultural sector was affected by drought and Bird Flu. However, during 2004 – 2011, the Rayong agricultural sector maintained about a 1.3% increase per year, at the same time, the Thai agricultural sector as a whole, increased 1.2% per year.

#### **8) Service sector growth**

In 2004, the Value Added of the Rayong service sector was about 34,218 million baht or about 1.1% of the whole country. Because a tsunami hit the southern part of Thailand, it encouraged tourists to change destination from the southern to the eastern part of the country, including Rayong province. For this reason, during 2004-2005, the service sector growth rate was dramatically high. Therefore, the Rayong service sector growth rate during 2004-2011 was about 7.3% per year, a little bit higher than usual.

#### **9) Total Economic Value (TEV)**

On one hand, in general, if the alternative with TEV in NPV is a positive number, it is counted as an alternative; on the other hand, if TEV in NPV is a negative number, it is not counted as an alternative. The net present value (NPV) of TEV in the first, second, third, and fourth alternatives are zero, 65,677 million baht, 61,955 million baht, and 66,416 million baht respectively. For the first alternative, the NPV is equal to zero because there is no cost or benefit; however, this case is used as a base case to compare with other cases.

For the second alternative (allowing the expansion of industrial capacity without exceeding 50% of the pollution capacity), the alternative is assumed as a new investment which is 50% of capital accumulation (about 300,000 million baht). This

number is based on the capital accumulation of the petro-chemical industry investment from the beginning of PCIDP phase 1 to phase 3 (1982-2011) and the total capital accumulation was about 630,000 million baht. This alternative assumes that the PCIDP phase 3 investment will be continued for 7 years (2012-2018) until the end of plan in 2018 and 10 years of the factory operating (2019-2029) and after 2029 everything will stop operation. The benefits from new investment are equal to 605,002 million baht and the cost of new investment is equal to 300,000 million baht, 14,699 million baht from greenhouse emission controls, 116,912 million baht from non-registered immigration population affecting cost, and 10,706 million baht from medical care.

For the third alternative (allowing the expansion of industrial capacity without exceeding the pollution capacity, requiring comprehensive town planning, and the implementation of existing laws and particular measures), the alternative assumes that new investment is about 400,000 million baht, and about 100,000 has already been invested. Therefore, 300,000 million baht is assumed to be the new investment in the petro-chemical industry for 7 years continuously (2012-2018), and 10 years of the factory operating (2019-2029) and after that everything will stop operation. Moreover, this alternative an 80:20 measure<sup>2</sup> is added into social benefit by calculating 6% of the new investment from the economic model. Considering the benefits and costs of investment, the Value Added from industrial development to Rayong's economy is equal to 573,673 million baht and the social benefit from specific measures is about 3,600 million baht. On the other hand, the cost of new investment is equal to 270,000 million baht ( $300,000 - (300,000 * 6)$ ), 18,000 million baht from greenhouse gas release prevention cost, 109,898 million baht for non-registered immigrant population cost, and 10,064 million baht for medical care.

For the fourth alternative, (allowing the expansion of industrial capacity without exceeding the pollution capacity, requiring comprehensive town planning, the implementation of existing laws and particular measures and considering the eco-industry concept), the alternative assumes that the new investment is about 400,000 million baht, and about 100,000 has already been invested. Therefore, 300,000 million baht is assumed to the new investment in the petro-chemical industry for 7 years continuously (2012-2018), and 10 years of the factory operating (2019-2029), and after that, everything will stop operation. In this alternative, it an 80:20 measure is added into social benefit by calculating 6% of the new investment from the economic model. Moreover, considering in eco-concept, every new investment needs to allocate 10% for eco-industry. The cost of medical care is already added into the cost of Eco-industry cost in a social dimension. Considering the benefits and costs of investment, the value added from industrial development in Rayong's economy is equal to 523,533 million baht and the social benefit from specific measures is about 33,240 million baht. On the other hand, because it is necessary to contribute 10% of the total investment to invest in green production and 6% of the new investment to spend in the 80:20 measure, the cost of new investment is equal to 253,800 million baht. The investment cost of eco-industry is equal to 30,000 million baht, the cost for the greenhouse gas release prevention is 16,200 million baht, and the cost for the non-registered immigrant population is 98,908 million baht.

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<sup>2</sup> The 80:20 measure is a particular measure for new investment in pollution control areas like Rayong province, and 80:20 means for every new investment, a factory must reduce pollution releases by 20% of the new capacity and 80% is allowed to be released.

### **10) Income tax from the non-registered immigrant population**

In this study, 100 samples of non-registered immigrants were collected to identify expense behavior and tax expenses because these data can be used to evaluate how much benefit Rayong province can gain from immigrants. The results show that one immigrant received about 185,491 baht in income, expended about 106,214 baht, paid income tax of about 4,330 baht, and paid VAT of about 3,710 baht in 2011. From the data of the Office of the National Economic and Social Development Board (NESDB), about 524,221 persons are non-registered immigrants (NESDB, 2009); moreover, the data of the National Statistics Office shows that about 69.6% of the Rayong population was over the age of 20 (the National Statistics Office, 2009). Therefore, about 1,580 million baht ( $4,330 \times 524,221 \times 0.696$ ) or about 25.8% of total income tax of Rayong province derives from immigrant labour. From survey data, the average annual expenditure of people over 20 years old is equal to 106,214 baht and about 38,753 million baht ( $106,214 \times 524,221 \times 0.696$ ) is the total annual expenditure of the non-registered immigrant population. From the estimated percentage of VAT that is RT, about 5.5% is income from VAT. Therefore, about 2,130 million baht ( $38,753 \times 0.055$ ) is the total VAT income or 4% of the total income from the VAT the Rayong province has collected.

### **11) The proportion of local raw materials used in production**

The proportion of local raw materials used in production was collected from 100 samples in the agricultural, industrial, and service sectors in Rayong province. The agricultural sector imported 14.60% of its raw materials from foreign countries about and therefore used about 85.40% of local materials in production. Similarly, the service sector greatly depends on local materials at about 88.6% of total materials used in production. The industrial sector, on the one hand, greatly depends on foreign raw materials in the production process (69.30%), and about 30.70% of the raw materials used in production are local.

### **12) The proportion of local workforce used in production**

In this study, we collected data about the proportion of local labor in production from agricultural, service and industrial firms (100 samples in each sector). The results from the survey data shows that for every 100 baht of agricultural firm labor cost, about 11.8 baht is paid to local labor and about 88.2 baht is paid to immigrant labor. For the service sector, for every 100 baht of total labor cost, about 57.5 baht is paid to local labor. For the industrial sector, for every 100 baht of total labor cost, about 16.6 baht is paid to local labor. These data show that labor in the agricultural and industrial sectors represent a small proportion of the Rayong population because most Rayong people have their own businesses. After weighting all of economic sectors, each sector uses about 25% of local labor in their production and 75% is immigrant labor.

### **13) The proportion of logistics cost of production**

Because the data could not be collected directly, we calculated Rayong's logistics cost of production by comparisons with the logistic and inventory costs of the whole country from the Input-Output table of Aat Pisanwanich's study (Aat Pisanwanich, 2010) and the Office of the National Economic and Social Development Board (NESDB, 2010). Because of structural changes in Thailand's industrial cost of production, it made industries consider other products that had lower logistics costs; however, the industries in Rayong still produce the same products as in the past. The



results show that Rayong's logistics cost is about 252,418 million baht or 12.6% of production cost and is a little higher than the whole country, where it is 11.9% of production cost.

### 3.2 The results from MCA

After the thirteen indicators were obtained they were then ranked by employing the Delphi Technique. The results of the ranking table are shown in the table below:

**Table 1: Results from MCA**

Indicators	1. Gross Domestic Product growth rate (GDP Growth)	2. Gross Provincial Production growth rate (GPP Growth)	3. Inflation rate	4. Tax income	5. Unemployment rate	6. Industrial sector growth rate	7. Agricultural sector growth rate	8. Service sector growth rate	9. Total Economic Value (TEV)	10. Tax income of non-registered	11. Proportion of local raw materials used in	12. Proportion of local workforce used in	13. Proportion of logistics cost of
1. Gross Domestic Product growth (G P Growth)	0	3	4	4	4	3	3	3	5	4	4	4	4
2. Gross Provincial Production growth (GPP Growth)	3	0	3	2	3	2	2	2	4	2	3	3	3
3. Inflation rate	2	3	0	2	3	2	2	2	4	2	3	3	3
4. Tax income	2	4	4	0	4	4	4	4	5	2	4	4	4
5. Unemployment rate	2	3	3	2	0	3	3	3	4	2	3	4	3
6. Industrial sector growth rate	3	4	4	2	3	0	2	3	4	2	3	3	2
7. Agricultural sector growth rate	3	4	4	2	3	4	0	4	4	2	4	3	4
8. Service sector growth rate	3	4	4	2	3	3	2	0	4	2	4	4	4
9. Total Economic Value (TEV)	1	2	2	1	2	2	2	2	0	1	2	2	2
10. Tax income collected from the non-registered immigrant population	2	4	4	4	4	4	4	4	5	0	4	4	4
11. Proportion of local raw materials used in production	2	3	3	2	3	3	2	2	4	2	0	4	2
12. Proportion of local workforce used in production	2	3	3	2	2	3	3	2	4	2	2	0	2

13. Proportion of logistics cost of production	2	3	3	2	3	4	2	2	4	2	4	4	0
Total compared Weighted Score of each indicator	<b>27</b>	<b>40</b>	<b>41</b>	<b>27</b>	<b>37</b>	<b>37</b>	<b>31</b>	<b>33</b>	<b>51</b>	<b>25</b>	<b>40</b>	<b>42</b>	<b>37</b>
Weighted score = 100	5.7 7 <sup>3</sup>	8.5 5	8.7 6	5.7 7	7.9 1	7.9 1	6.6 2	7.0 5		10.9	5.3 4	8.5 5	7.9 8

After specialists gave many reasons for the importance of each indicator, important reasons are provided by grouping Weighted Score of group indicators. The highest Weighted Score is the TEV indicator (51) because this indicator not only be used to calculate the market value but can also be used to calculate the non-market value of environmental impact, health impact, and social impact. The proportion of local workforce used in production, the inflation rate, the GPP Growth, and the proportion of local raw materials used in production are high Weighted Score indicators at 42, 41, 40, and 40 respectively. The main reasons that indicate these four indicators have high Weighted Scores are the significant impact on Rayong people’s standard of living, the main cost of every sector in Rayong province, and the wide impact on Rayong’s economy. The unemployment rate, the industrial sector growth rate, the proportion of logistics cost of product have moderate Weighted Score indicators because the unemployment rate is low, the industrial sector is the main sector in the province’s economy, and the logistics cost is the main cost of the business. The service sector growth rate and the agricultural sector growth rate are have low Weighted Score indicators because of main reasons. Although they are the main sector in Rayong’s economy, they have low impact on the local economy. Furthermore, GDP Growth and Tax income collected from the non-registered immigrant population have the lowest Weighted Score indicators because GDP reflects only the impact on the whole country and the tax income has a low impact on Rayong’s economy. The results of the assessment of the economic impact of each alternative are shown in the table below:

<sup>3</sup>Total compared Weight Score of each indicator, GDP growth = 27  
 Total compared Weight Score of all indicators = 27+40+41+27+37+37+31+33+51+25+40+42+37 = 468  
 Score weight of GDP growth = (27/468) x 100 = 5.77

**Table 2: Assessment of the Economic Impact of Each Alternative**

Indicators	Weight Score	Alternative 1		Alternative 2		Alternative 3		Alternative 4	
		Impact Level	Impact Score	Impact Level	Impact Score	Impact Level	Impact Score	Impact Level	Impact Score
1. Gross Domestic Product growth (GDP Growth)	5.77	0.67	3.87 <sup>4</sup>	0.75	4.33	0.74	4.27	0.74	4.27
2. Gross Provincial Product growth (GPP Growth)	8.55	0.53	4.53	0.74	6.32	0.73	6.24	0.71	6.07
3. Inflation rate	8.76	0.59	5.17	0.44	3.85	0.45	3.94	0.47	4.12
4. Tax income	5.77	0.82	4.73	0.96	5.54	0.95	5.48	0.94	5.42
5. Unemployment rate	7.91	0.72	5.69	0.87	6.88	0.87	6.88	0.85	6.72
6. Industrial sector growth rate	7.91	0.35	2.77	0.58	4.59	0.57	4.51	0.55	4.35
7. Agricultural sector growth rate	6.62	0.54	3.58	0.48	3.18	0.48	3.18	0.54	3.58
8. Service sector growth rate	7.05	0.62	4.37	0.77	5.43	0.76	5.36	0.82	5.78
9. Total Economic Value (TEV)	10.9	0.50	5.45	0.94	10.24	0.91	9.92	0.94	10.24
10. Tax income collected from the non-registered population	5.34	0.50	2.67	0.94	5.02	0.92	4.91	0.87	4.65

<sup>4</sup>Score weight x Impact level = Impact score of each indicator

Alternative 1 impact score of gross domestic productivity (GDP Growth) = 5.77 X 0.67 = 3.87

11. Proportion of local raw materials used in production	8.55	0.55	4.70	0.48	4.10	0.49	4.19	0.49	4.19
12. Proportion of local workforce used in production	8.97	0.41	3.68	0.34	3.05	0.34	3.05	0.35	3.14
13. Proportion of logistics cost of production	7.91	0.54	4.27	0.42	3.32	0.43	3.40	0.43	3.40
Total Impact Score	<b>100.0</b>		<b>55.47</b>		<b>65.86</b>		<b>65.32</b>		<b>65.93</b>

According to the summary of all indicators for each alternative, the total Impact Scores are equal to 55.47, 65.86, 65.32, and 65.93 marks for alternatives 1, 2, 3 and 4 respectively.

### 3.3 The evaluation of the alternatives and the impacts from development

After the results of each alternative were obtained, it can be concluded that the fourth alternative is the best way to cope with industrial development demand of the country and the environmental consideration in Rayong province. However, after the total Impact scores of alternatives 2,3 and 4 were compared, they were found to be close to each other; therefore, it cannot be strongly concluded that the fourth alternative is the best alternative in this study.

## 4. Conclusions And Remarks

Rayong province has a high capacity for industrial development; however, some areas especially industrial estates such as Mab Ta Put industrial estate have excessive limitations of environmental capacity. To cope with the environmental problems, four alternatives were provided. Finally, the best solution was obtained, which is to allow the expansion of industrial capacity without exceeding the pollution capacity, requiring comprehensive town planning, the implementation of existing laws and particular measures, and the consideration of the eco-industry concept. However, the total Impact Score of alternatives are close to each other; therefore, future study needs to determine find more alternatives, indicators, and techniques that can calculate the best alternative without any questions.

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