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บทความวิจัย

กระบวนการสนับสนุนการตัดสินใจในการประเมินศักยภาพและเลือกแนวทางการใช้ประโยชน์จากกากของเสียอุตสาหกรรม: กรณีศึกษา อุตสาหกรรมผลิตชิ้นส่วนอุปกรณ์อิเล็กทรอนิกส์

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บทคัดย่อ

งานวิจัยนี้มีวัตถุประสงค์เพื่อนำเสนอกระบวนการสนับสนุนการตัดสินใจในการประเมินศักยภาพและเลือกแนวทางการใช้ประโยชน์กากของเสียอุตสาหกรรมจากอุตสาหกรรมผลิตชิ้นส่วนอุปกรณ์อิเล็กทรอนิกส์ ที่ยังคงต้องนำไปทำการจัดการด้วยการฝังกลบและเผาในเตาปูนซีเมนต์ โดยกระบวนการสนับสนุนการตัดสินใจที่ได้พัฒนาขึ้นนี้จะเริ่มจากการศึกษาปริมาณของเสียที่มีการฝังกลบในเขตพื้นที่กรณีศึกษา หลังจากนั้นจึงทำการประเมินศักยภาพและเลือกแนวทางการนำกลับมาใช้ประโยชน์จากความเป็นไปได้เชิงเทคโนโลยีในการรีไซเคิล ความพร้อมทางด้านเศรษฐศาสตร์ ผลกระทบต่อสิ่งแวดล้อม และกฎระเบียบต่างๆ ที่เกี่ยวข้องทั้งทางด้านเชิงปริมาณและเชิงคุณภาพด้วยกระบวนการลำดับชั้นเชิงวิเคราะห์ ที่สามารถช่วยสนับสนุนตัดสินใจแบบกลุ่มและลดความลำเอียงในการตัดสินใจได้อย่างมีประสิทธิภาพ โดยผลที่ได้จากทดสอบการตัดสินใจของกรณีศึกษา โรงงานผลิตวงจรรวมและตัวเก็บประจุ พบว่ากลุ่มผู้เชี่ยวชาญให้ความสำคัญกับเกณฑ์ด้านเทคโนโลยีมากที่สุดเท่ากับ 39.9% รองลงมาเป็นด้านเศรษฐศาสตร์ 20.8% ด้านสิ่งแวดล้อม 20.6% และด้านกฎระเบียบ 18.7% ตามลำดับ โดยความสำคัญของทางเลือก ในกรณีศึกษาที่ 1 พบว่าเลือกแนวทางการใช้ประโยชน์จากกากของเสียอุตสาหกรรมให้เป็นผลิตภัณฑ์คอนกรีตบล็อกไม่รับน้ำหนักมีความสำคัญมากที่สุดเท่ากับ 54.1% รองลงมาเป็นกระถางต้นไม้ 27.3% และแผ่นพื้นโต๊ะ 18.6% ตามลำดับ ส่วนกรณีศึกษาที่ 2 พบว่าความสำคัญของทางเลือก แผ่นป้ายมีความสำคัญมากที่สุดเท่ากับ 37.0% รองลงมาเป็นกรอบกระจก 32.4% และของที่ระลึก 30.5% ตามลำดับ

คำสำคัญ: กระบวนการสนับสนุนการตัดสินใจ การรีไซเคิลกากของเสียอุตสาหกรรม กระบวนการลำดับชั้นเชิงวิเคราะห์

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Research Article

A Decision Support Methodology for Potentiality Evaluation and Selection of Industrial Waste Utilization: Case Studies from Electronics Component Manufacturing Industry

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Abstract

The purposes of this research were to provide support methods for selecting and assessing the potentiality utilization of industrial waste of electronic components to be disposed of by landfill and burning in a cement kiln. The process began by estimating the amount of waste that was in the landfill in the study areas. After that, the potential to exploit the technological feasibility of recycling, economic feasibility, availability, environmental impacts, and regulations were assessed qualitatively and quantitatively, using the analytic hierarchy process (AHP) to help with group decision-making and to reduce bias in decision-making effectively. The results of the IC (Integrated Circuit) and capacitor electronic component manufacturing industry case studies revealed that the experts focused on technology the most at 39.9%, followed by economics at 20.8%, the environment at 20.6%, and regulations at 18.7% respectively. Case Study 1 revealed that the most frequently-selected alternative for waste utilization was hollow non-load-bearing concrete blocks at 54.1%, followed by flower pots at 27.3%, and table plates at 18.6%. Case Study 2 revealed that label plates were the most important at 37.0%, followed by glass frames at 32.4% and souvenirs at 30.5%.

Keywords: Decision Support Process, Industrial Waste Recycling, Analytic Hierarchy Process (AHP)

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1. Introduction

According to data from the Department of Industrial Works (DIW) [1] found that the proportion of waste asking permission for disposal by landfill during the year B.E. 2548–2552 had amount up to 7–10 percent of the total grant amount of waste taken out of the factories each year, which this amount of waste is still a very high volume. Therefore, the government agencies and the private sector had to accelerate correspond to manage such problems more [2], particularly with the Industrial Estate Authority of Thailand had appointed the vision to be Eco Industrial Estate [3].

However, as long ago it found that one of the key issues in the management of industrial waste is to decide on the selection of management practices and assessing the possibility to increase the utilization of waste generated [4] since the waste in each category has significant differences in several dimensions, such as the different types of industrial factories, in the volume of waste, type of waste, environmental impact, and the stakeholders, etc. Thus, the decision to choose an approach to manage each time it must proceed with caution and having considered the various factors involved extensively in both quantitative and qualitative. This is the feasibility of the technology to be managed, economic value environmental impact, and legal restrictions; especially, the waste that takes to landfill from industrial electronics manufacturers because a certain type can be reused, recycled for precious material such as gold, silver, copper, etc., in order to return the materials to be suitable for new production. But some types of waste, there is no technology to manage it such as thermosetting plastics, epoxy resin or insulation which continues to be managed by the current landfill.

From the study of research related to the decision process support in selecting management practices and studying the possibility to take advantage of industrial waste such as the research of Khan and Faisal [5] who has developed an evaluation framework of the Municipal Solid Waste Management (MSWM) with techniques of Interpretation Structural Modeling (ISM). Boonkanit and Kengpol [6] designed the development of process support decision making in product design eco-products of air conditioning as environmental friendly. Samah *et al*. [7] have developed the process support decision making in management solid waste of community in Malaysia with the application of AHP and Wibowo and Deng [8] who presented criteria group decision effectively. For evaluating the performance of recycling programs, electronic waste under uncertainty in the organization used the application of fuzzy logic etc. found that in the waste management of the process support decision making to be effective, it is an important issue and is gaining attention from researchers around the world. Since such a decision will have to consider several criteria and is an important part in determining the form of action, including the impact on the other side is going to happen in the future. These decisions often include criteria for decision that is complex both quantitative and qualitative. Especially, the decision on taking the industrial waste into recycling products which must consider the consequences of the future carefully such as the quality of products, the acceptance by the society in the long term, investing to bring new technologies into administration etc.

Therefore, this research aims to develop the process support the decision making in the selection of management practices and to assess the feasibility

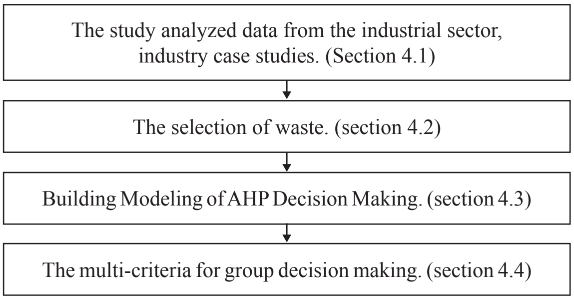


Figure 1 The process support decision making in the selection of management practices and assess the feasibility of the utilization of industrial waste.

of the ability utilization of industrial waste by making application to the study of electronics component waste from integrated circuit and capacitor with the process support the decision making that has been developed. Testing process and research results have details as follows.

2. The Process Support Decision Making

The process support decision making in the selection of management practices and assess the feasibility of the utilization of industrial waste will start from the study DIW report of waste quantity and the flow pattern of material and waste caused by the electronics industry in the area of case study. Transmission of code to get rid of that report to the Department of Industrial Works (Manifest Report) will be chosen by a code of waste in landfill and incineration codes 071–076, which is the waste that cannot be used as the main advantage as shown in Figure 1.

Then, select the type of the most waste volume to achieve the most cost-effective economic management. In the next process, this methodology will be considered the possibility of managing the wastes with the process to support the development of eco-products from the waste in the manufacturing process. By this stage is focused on building elements or criteria for decision making to consider guidelines that are interested in both quality and quantity. Finally, the group decided to form again with the application fundamental scale as illustrated in Table 1 and calculation method in Analytic Hierarchy Process [9], [10].

Table 1 Fundamental scale in calculating AHP

Verbal Judgment of Preference	Numerical
Rating	
Equal importance	1
Moderate importance	3
Strong importance	5
Very strong importance	7
Extreme importance	9
Intermediate value between the two adjacent judgments	2, 4, 6, 8

It is used to consider criteria for all decisions both qualitative and quantitative with a weight of importance, and the comparison with pairwise comparison from the decision rating of the decision maker. The scoring average of the clustered expert will be used to determine by Geometric mean (*Gm*.) as Equation 1.

$$Gm = \sqrt[n]{N_1 \times N_2 \times N_3 \times N_n} \quad (1)$$

Then, calculation of *Gm* is used to performed in AHP matrix model as illustrated in equation 2–5 [9], [10].

$$A = \begin{bmatrix} a_{11}\, a_{12} \cdots a_{1n} \\ a_{21}\, a_{22} \cdots a_{2n} \\ \vdots \quad \vdots \quad \vdots \quad \vdots \\ a_{1n}\, a_{2n} \cdots a_{nn} \end{bmatrix} \quad (2)$$

By

$$AW = \lambda_{max}\, w$$

Whereas

A is square metric commentators of the decision in terms of the importance of value adjusting to 1 already (Normalized).

w is eigenvector that show weight relative importance of things which are in the same hierarchy. Or of what is under the hierarchy of the above.

λ_{max} is the principal eigenvalue of A where A may no longer be consistent but still reciprocal

$a_{ij} = \frac{1}{a_{ji}} =$ The score of the importance of things that are compared each pair is between 0–1.

And $$w = \lim_{n \to \infty} \frac{A^k e}{e^T A^k e} \quad (3)$$

When k is the calculation of the k times

e is Unit Vector

Then check the reasonableness of the decision by the ratio that is calculated by the Consistency Ratio, CR. If $CR > 0.1$ means that the vital information derived from the comparison of a couple does not make sense so it has to adjust the scores of importance in comparing a new pair before analysis in next hierarchy.

$$CR = \frac{CI}{RI} \quad (4)$$

When CR is Consistency Ratio

CI is the Consistency Index and

RI is Random Inconsistency Index depends on square metric A as referred in Saaty [9], [10].

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (5)$$

When n is the size of square metric

λ_{max} is the Maximum Eigenvalue

Today the calculation of AHP can be calculated much easier by using computer software program such as AHP and ANP of super decisions software, Expert Choice software or application writing programming on Microsoft Excel etc.

3. Research Procedure

The process of research is as follows.

1. Study and analyze DIW waste report at Industrial Estate Authority (IEA) area case studies, such as type of waste, waste volume, how to get rid of waste, and sources to get rid of the waste of the factories in order to analyze the flow. Priority types of waste by volume of the total waste that is generated and analytical method for waste management. Then the processed data in the form of material and waste disposal from 3 main codes (071–076) of the Department of Industry (Waste Possessor: WP) and six main code of waste generators (Waste. Generator: WG) [11] are performed to analyze.

2. Select the type of waste that has the high volume abundant from focused factories according to Pareto chart to achieve possibility recycling technology, economics value of waste disposal cost, environmental reduction impact and waste management regulation.

3. Create decision making model technical Analytic Hierarchy Process (AHP) by this step, it can apply to use computer program to calculate.

4. Multi-Criteria Decision Making in selecting management practices and assess the feasibility of the utilization of industrial waste with the decision is performed by group decision making.

5. Decision, discussion and future planning development are concluded.

4. Results

4.1 The study analyzed data from the industrial sector, industry case studies.

From the study of manifest report or industrial waste data in area of Industrial Estates Authority (IEA) case study which locate in the northern region of Thailand found that there are total of 75 factories in this area with the amount of industrial waste 69,768.38 tons/year that is disposed by landfill and incinerated in an industrial estate with a total of 7,773.40 tons/year (The amount of waste from waste generator in Department of Industrial Work manifested report type Sor Kor. 2 Year 2014). These are classified as waste that is landfill 3,821.20 tons, incinerated 3,927.20 tons and disposed of other ways 25 tons.

Moreover, focused on only landfill and incinerated waste information found that the waste is taken to landfills or incinerated are mainly from electronics component manufacturing industries which volume around 1,340 tons/year as reported from DIW waste code generation number 12 01 05 (plastics waste from gridding, cutting, casting or milling production process).

4.2 The selection of waste

According to the data in section 4.1 depicted that the majority waste caused by the electronic components manufacturing industries. This type of waste which still must deal with the landfill and burned in cement kiln or may also be called a waste that cannot add value to it.

Currently, there are two main types of waste from electronic components manufacturing industries which very difficult to manage by current recycling technology, high cost of disposal and also high environmental impact. First is epoxy resin hardening caused by the casting parts of epoxy resin compounds for molding electronic components from the production of IC (Integrated Circuit) which is amount 800 tons/year and the second one is epoxy resin blue powder from the production of the capacitor with amount 200 tons/year or both waste are around 74.6% from amount 1,340 tons of total electronics industries waste as shown in Figure 2 and 3.

Figure 2 Epoxy resin compounds for molding.

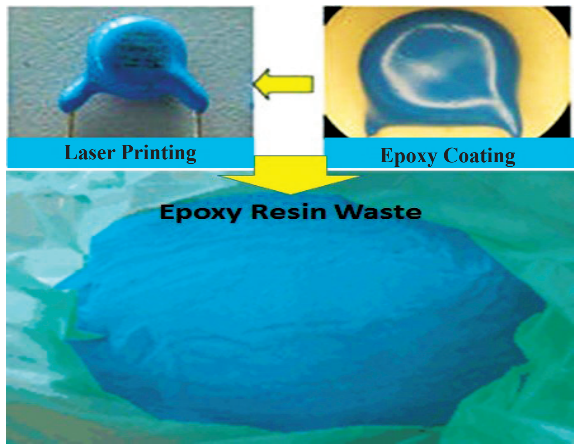


Figure 3 Epoxy resin blue powder.

4.3 Building modeling of AHP decision making

The applications of the modeling decision making AHP to prioritize and select the proper management of waste resulting from the manufacturing process of

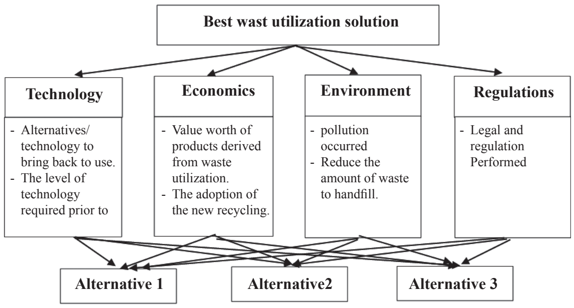


Figure 4 Structure of the decision making in AHP.

the electronics component industry is composed of the main criteria 4 sides as illustrated in Figure 4.

There are technology, economics, environment, and regulations, and the sub-criteria 7 aspects consist of technology exploitation, the necessary technology, return on investment, the adoption of the new recycling, the pollution occurred, reducing landfill, and the implementation of the regulations as AHP model guidelines for the selection of waste from the electronics component manufacturing process used for the electronics industry.

4.4 The multi-criteria for group decision making

The cluster group decision included six persons from representatives of waste administrators of industrial factories three persons, expert in technology recycling one person, environmental impact one person and also representative from the industrial estates one person. The features of various experts are educated to a master degree level. Except expert in recycling technology is Ph.D. level and all of them have experienced of working directly on that field more than 20 years. Totaling six persons who were considered the issues, got more information support from experts in each field and taken into consideration for the geometric mean of the equation 1 and scoring guideline from Table 1, by each side information supports are as follows.

1) Technology found that epoxy resin is solid waste generated by the casting parts from the integrated circuit process and epoxy resin blue powder is waste generated in capacitor coating parts. Recycling technology can be used recycle only technology in the country. However, it requires special expertise in testing for recycling. In recycling technology testing method, this research has been tried out at the SIME laboratory, Rajamangala University of Technology Phra Nakorn with referred to the experiment parameters and method of Pickering [12]. Moreover, epoxy resin blue powder from the production of the capacitor will adopt recycling by chemical high technique as the research of IJI [13]. Nevertheless, the trial will be recycling all the tests and the possibility of exploitation, for example as shown in Figure 5 and 6.

2) Economics found that the value of products derived from waste utilization has increased and it reduces the cost of delivery to get rid of the current (waste treatment cost approximately 2,500 baht/ton or around 2,500,000 baht/year as amount of pilot studies). Moreover, in the other issue such as the image of products resulting from the recycling of the product has also considered. Recycling product from these waste seem quite new in Thai market. Then, all experts consider that the products may not yet be convinced to accept it soon.

3) Environment found that these waste when finished waste recycling process and put to the test leakage of chemical use, the pollution causes mild or no different than the original material [12], [13]. Hence, increasing waste recycling volume, it can be reduced environmental impact from landfill and burned in cement kiln as well.

Figure 5 Epoxy resin mix and test the hardness of casting parts processing IC (Integrated Circuit) to construction materials.

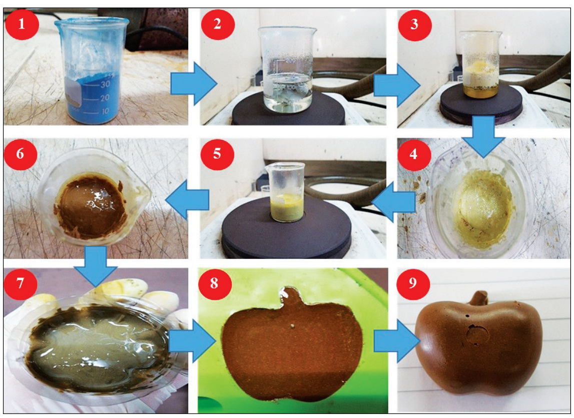


Figure 6 Mixing and forming epoxy resin resulting from the manufacturing process of the capacitor.

4) Regulations found that implementation is quite difficult because industrial factories case studies, both of them which are located in the area of export promotion, which will have a material tax issues involved. It makes real progress, shall be negotiated between the factories. The industrial estates and customs include the recipient of the waste to good use as well.

According to all supported information are depicted, the scores from experts will be calculated on the geometric mean as shown in Equation 1, and then calculated the AHP as shown in Equation 2–5 with application program Expert Choice [14], [15].

4.5 The decision making result of case studies

The results from calculated AHP by the program Expert Choice to select management practices and assess the feasibility of the ability utilization of waste materials, electronic components manufacturing industry case studies found that.

The Case Study 1 the waste of epoxy resin caused by the casting resin components in the production of integrated circuits (IC) as illustrated in Figure 2 and 5. The score was from an expert group who decided to calculate the Gm from Equation (1) for every pair by demonstrations to calculate the Gm between the primary importance of technology and economics and shows an example of comparison for each step of the AHP below.

$$Gm = \sqrt[6]{3\times3\times3\times3\times3\times3}$$
$$= 3.0$$

First level pairwise comparison matrix: criteria to goal by taking Gm value that was put in the matrix in Expert Choice Program to compare between the two primary criteria as shown in Figure 7 and the calculation of the main priorities in the Figure 8.

The expert group was featured on the main criteria with technology the highest 39.9%, followed by 20.8% in economics, environment at 20.6% and regulations 18.7% respectively.

Then calculate the corresponding reason *CR* from

	Technology	Economics	Environment	Regulations
Technology		3.0	2.0	1.25
Economics			1.2	1.5
Environment				1.5
Regulations	Incon: 0.07			

Figure 7 Pairwise comparison matrix: criteria to goal.

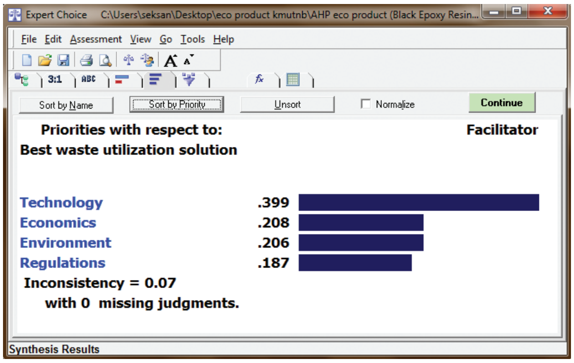


Figure 8 Priorities of four criteria with respect to the goal.

	Alternatives/Recycling technology	The level of technology required prior to use
Alternatives/Recycling technology		1.0
The level of technology required prior to use	Incon: 0.00	

Figure 9 Pairwise comparison matrix: sub-criteria to criteria (Technology).

Equation (2), (3), (4) and (5) the value of *CR* equal 0.07, which is less than 0.1, indicating that the decision was consistent, reasonable.

Second level pairwise comparison matrix: sub-criteria to criteria for example, a comparison of the key pair between the subsidiaries. Alternatives / Recycling technology and the level of technology required prior to use under the technology criterion and calculates the priorities of the small impressions as Figure 9 and Figure 10.

Then calculate the corresponding reason *CR* will be equal to 0.00, indicating that the decision is consistent perfectly reasonable.

Third level pairwise comparison matrix: alternative

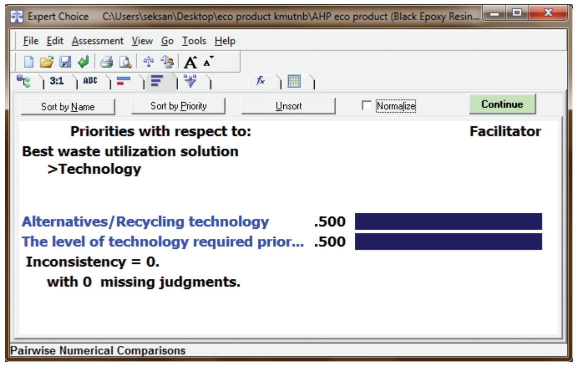


Figure 10 Priorities of sub-criteria to criteria (Technology).

	Concrete block hollow non-load bearing	Table plate	Flower pot
Concrete block hollow non-load bearing		4.0	2.0
Table plate			3.0
Flower pot	Incon: 0.02		

Figure 11 Pairwise comparison matrix: alternative to sub-criteria (The level of technology required prior to use).

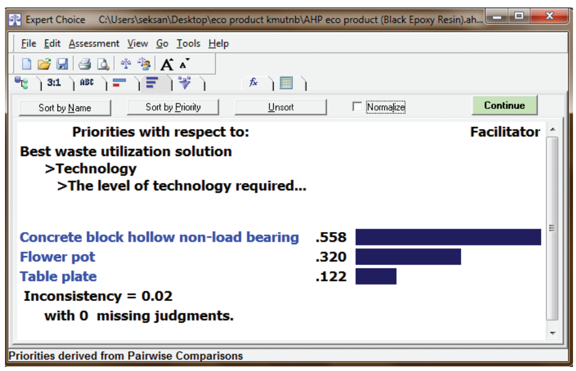


Figure 12 Priorities of alternative to sub-criteria (The level of technology required prior to use).

to sub-criteria for example, the comparison between the two important criteria subsidiary. The level of technology required prior to use and calculate the priorities of the sub-display, as Figure 11 and 12.

Then calculate the corresponding value of reason *CR* equal to 0.02, which is equivalent to less than 0.1, indicating that the decision was consistent and

Alternative	PAIRWISE Technology Alternatives/ Recycling technology (L: .500)	PAIRWISE Technology The level of technology required prior to use (L: .500)	PAIRWISE Economics Value worth of products derived from waste utilization (L: .667)	PAIRWISE Economics The adoption of the new recycling (L: .333)	PAIRWISE Environment Pollution occurred (L: .400)	PAIRWISE Environment Reduce the amount of waste to landfill (L: .600)	PAIRWISE Regulations (L: .187)
Concrete block hollow non-load	1.000	1.000	1.000	1.000	1.000	1.000	.874
Table plate	.119	.218	.237	.149	.215	.164	1.000
Flower pot	.299	.572	.141	.446	.928	.405	.763

Figure 13 Evaluation of alternative to sub-criteria for Case Study 1.

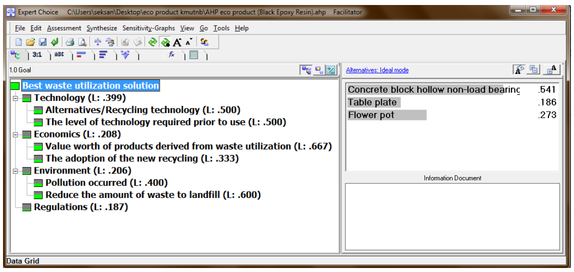


Figure 14 AHP analysis in Case Study 1.

reasonable. When compared the couple importance of the main criteria, sub-criteria, and alternative completely all. The final step is to calculate the priority of choice by putting the weight of each alternative in each sub-criterion multiplied by the weighting of the criteria for a small sum if sort the results of each alternative based on the descending so the alternative with the most points will be the best choice as Figure 13.

The considering their applications, it was found that a recycling guide is divided into three alternatives and total normalized by producing a Concrete block hollow non-load bearing 54.1%, followed by the Flower pot 27.3% and Table plate 18.6% respectively as illustrated in Figure 14.

<u>The Case Study 2</u> Epoxy resin blue powder caused by manufacturing capacitor as illustrated in Figure 3 and 6, the expert group focuses on the weight of the main criteria and sub-criteria are the same as in Case Study 1 Step 1 and 2. For the Third level pairwise

	Souvenir	Mirror frame	Label plate
Souvenir		3.0	4.0
Mirror frame			1.0
Label plate	Incon: 0.01		

Figure 15 Pairwise comparison matrix: alternative to sub-criteria (The adoption of the new recycling).

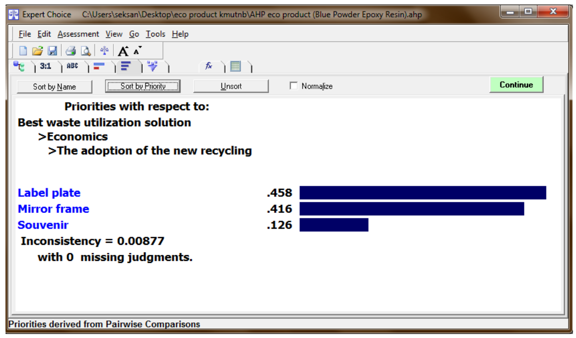
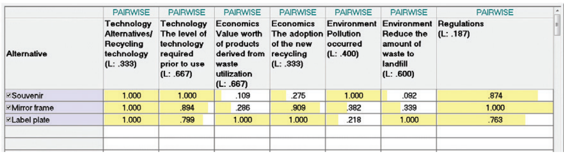


Figure 16 Priorities of alternative to sub-criteria (The adoption of the new recycling).

comparison matrix: alternative to sub-criteria, the example is a comparison between the main criteria and sub-criteria. The adoption of the new recycling and calculate the priorities of the sub-criteria as shown in Figure 15 and Figure 16.

Then calculate the corresponding value of reason *CR* equal to 0.01, which is equivalent to less than 0.1, indicating that the decision was consistent and reasonable.

When compared the couple importance of the main criteria, sub-criteria, and alternative completely all. The final step is to calculate the priority of choice by putting the weight of each alternative in each sub-criterion multiplied by the weighting of the criteria for a small sum if sort the results of each alternative based on the descending so the alternative with the most points will be the best choice as Figure 17.



Alternative	PAIRWISE Technology Alternatives/ Recycling technology (L: .333)	PAIRWISE Technology The level of technology required prior to use (L: .667)	PAIRWISE Economics Value worth of products derived from waste utilization (L: .667)	PAIRWISE Economics The adoption of the new recycling (L: .333)	PAIRWISE Environment Pollution occurred (L: .400)	PAIRWISE Environment Reduce the amount of waste to landfill (L: .600)	PAIRWISE Regulations (L: .187)
Souvenir	1.000	1.000	.109	.275	1.000	.092	.874
Mirror frame	1.000	.894	.286	.909	.382	.339	1.000
Label plate	1.000	.799	1.000	1.000	.218	1.000	.763

Figure 17 Evaluation of alternative to sub-criteria for Case Study 2.

The result of the decision to develop eco-product appropriately of the Case Study 2 epoxy resin blue powder found that recycling guide is divided into three alternatives and total normalized by producing a Label plate that has been selected as the first 37.0%, the second is a Mirror frame 32.4% and Souvenir such as keyring is 30.5% respectively as illustrated in Figure 18. And sum up the relative weight of the main criteria, sub-criteria, and all the alternatives as in Table 2.

Table 2 The relative weight of criteria, sub-criteria & alternative

Criteria/Alternative	Case Study 1	Case Study 2
1. Technology	**39.9%**	**39.9%**
1.1 Alternatives/Recycling technology	50.0%	33.3%
1.2 The level of technology required prior to use	50.0%	66.7%
2. Economics	**20.8%**	**20.8%**
2.1 Value worth of products derived from waste utilization	66.7%	66.7%
2.2 The adoption of the new recycling	33.3%	33.3%
3. Environment	**20.6%**	**20.6%**
3.1 Pollution occurred	40.0%	40.0%
3.2 Reduce the amount of waste to landfill	60.0%	60.0%
4. Regulations	**18.7%**	**18.7%**
Alternative 1	54.1%	37.0%
Alternative 2	27.3%	32.4%
Alternative 3	18.6%	30.5%

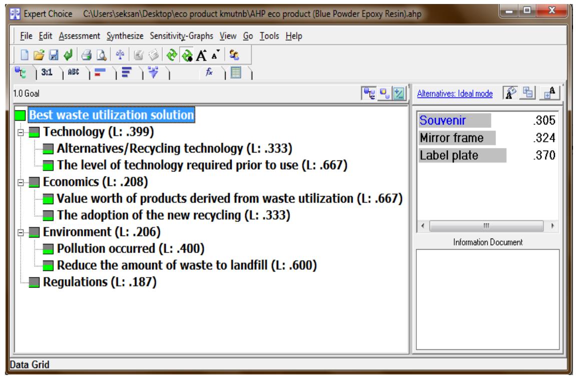


Figure 18 AHP analysis in Case Study 2.

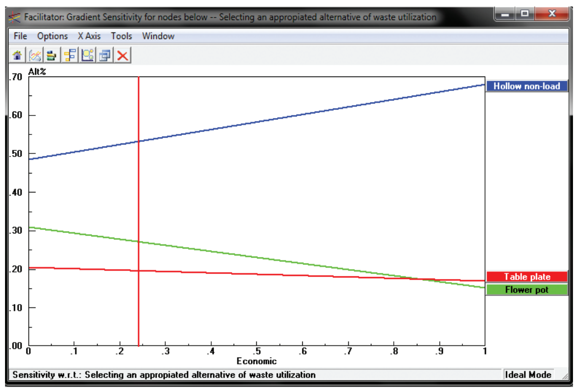


Figure 19 Sensitivity analysis under economics criteria in Case Study 1.

4.6 Sensitivity analysis

The sensitivity analysis on a slope (Gradient sensitivity) of the four main criteria is to determine the priority change of waste if the weights of the criteria have been changed. The results were as follows:

The Case Study 1 found the criteria that are sensitive to changes in the weight are economics and regulations, by the weight of importance of the economics is 20.80% if there is a change of emphasis, over 86% they will change the decision on a Flower pot to a Table plate, located in No. 2 and 3 as shown in graph form in Figure 19.

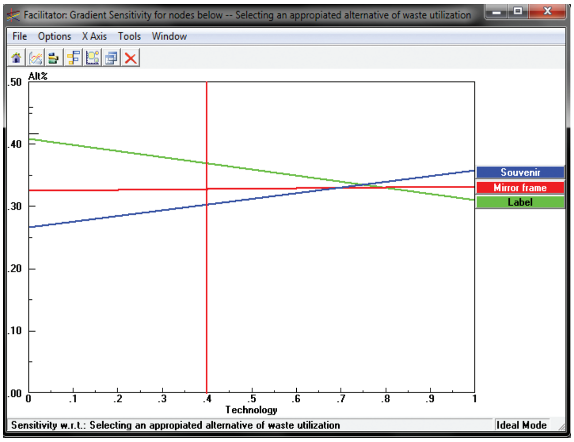


Figure 20 Sensitivity analysis under technology criteria in Case Study 2.

The Case Study 2 found that all of the four criteria are more sensitive to changes in the weight, for example, the technology is worth its weight importance equals 39.90% if there is a change of emphasis, over 70% they will change the decisions on a Mirror frame to a Souvenir, which ranked the second and third, and when the weight is more than 75% they will change the decision on a Label to a Souvenir, which was ranked the first and the second. If the weight of importance is more than 80% they will change the decision on a Label to a Mirror frame, which ranked the second and the third with displays in graph form in Figure 20.

5. Conclusion and Discussion

The results showed that waste of the industrial estates case study is mainly from electronics component manufacturing industry with total volume 7,773.40 tons/year. The analysis of the waste information found that IC and blue powder epoxy resin are waste from the electronics industry still has to deal with the landfill and incineration which cannot be utilized. Therefore, when bring such waste guidelines into consideration deciding on the use of developed methodology found that the first issues of technology to consider are, alternative or recycling technology? And level of technology required prior to use? The second issue is economics found that value worth of products derived from waste utilization? The adoption of the new recycling? Moreover, in term of environment found that the issues of pollution occurred, reduced landfill, and reduction burning in cement kiln are important dimension to the study. Finally, the legal issues were found that it needs to learn that industrial waste from electronic waste is not hazardous or dangerous, illegal transportation, and disposal taxes or not? Because of this, it can be depicted that the decision to bring waste from the production of the electronics industry to take advantage of this approach can be used as a decision support of the factories or other industrial estates in the planning system for waste management that is still a major problem. Furthermore, the recycling industry has utilized judiciously and be worth more in the future.

Results from the study showed that this decision methodology can be applied to solve the problem of multi-criteria decision making models more flexibility, effectively and systematically as follows:

1) Using DIW waste code for analysis of waste volume can support to determine the type and quantity of critical waste management since the origination to waste disposal industry clearly with the capacity to export from manifest report. However, it is possible that another firm totally inexperienced in any waste management analysis, lacking of information and data bases from DIW waste code and profound decision making methods may have difficulty in using this model.

2) The decision support making process can encourage those considering solutions to be able to consider management practices and assess the feasibility of the use of industrial waste has become more systematic. Anyhow, group decision making is important for decision support making process in waste management; therefore, an additional decision making theory is required for a larger group decision making such as applying with the Delphi method.

3) Analytical Hierarchy Process (AHP) can assist determine the factors, checking consistency ratio and analysis the decision making structure that influence the development of industrial waste has covered both the quantity and quality simultaneously.

Furthermore, for further studies, this research could also conduct detailed waste decision making process improvements or 3R recycling technology initiatives, including other program software commercialization variables in the process of Life Cycle Analysis (LCA) particularly in terms of eco-design computer software integration.

6. Acknowledgment

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