

# Using Fuzzy Analytic Hierarchy Process to Construct Green Suppliers Assessment Criteria and Inspection Exemption Guidelines

Chauchen Torng\* and Kuan-Wei Tseng

Institute of Industrial Engineering and Management,  
National Yunlin University of Science and Technology, 123 University Road, sec.3,  
Touliu, Yunlin, Taiwan  
{torngcc, g9821213}@yuntech.edu.tw

**Abstract.** Since the announcement of Restriction of Hazardous Substances Directive (RoHS) in 2003, manufacturers of electrical and electronic equipments are restricted of containing any harmful substances such as: Pb, Cd, Hg, Cr6+, PBB and PBDE, in their products importing to European market, starting from July 1, 2006. How to avoid the use of materials containing hazardous substances has become a major issue in the electrical and electronic industry. The purpose of this research is to establish green supplier's assessment criteria through a modified Delphi method, and to determine the weights of criteria by the Fuzzy Analytic Hierarchy Process. A sequential sampling plan is proposed as inspection exemption guideline based on the MIL-STD-1916 procedure. This could save 12.13% in material inspecting time for the case company.

**Keywords:** Delphi method, Fuzzy analytical hierarchy process (FAHP), Green supplier, Inspection exemption.

## 1 Introduction

Since the announcement of Restriction of Hazardous Substances Directive (RoHS) in 2003, manufacturers of electrical and electronic equipments are restricted of containing any harmful substances such as: Pb, Cd, Hg, Cr6+, PBB and PBDE, in their products importing to European market, starting from July 1, 2006. How to avoid the use of materials containing hazardous substances has become a major issue in the electrical and electronic industry. Many companies had set up management systems such as IECQ QC 080000 management system to effectively control hazardous substance. IECQ QC 080000 requires identification of hazardous substances in the beginning of development and design stage of the raw materials. [3]

To assist the domestic industry in response to environmental protection directives of the European Union, Ministry of economic in Taiwan has developed the green product

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\* Corresponding author.

management system-hazardous substances process management requirements (GPMS-HSPM). This system uses the same terms as IECQ system and is more suitable for small and medium companies in Taiwan.

The purpose of this research is to establish green supplier's assessment criteria through a modified Delphi method, and to determine the weights of criteria by the Fuzzy Analytic Hierarchy Process. To reduce the inspecting time and cost, a sequential sampling plan is proposed as inspection exemption guideline based on the MIL-STD-1916 procedure.

## 2 Green Supplier Assessment Criteria

A decision of supplier selection criteria is required before supplier assessment can be performed. Manufacturers normally develop their supplier assessment form according to ISO 9000, ISO 14000, IECQ QC 080000 and other related regulations and special requirements. The case company in this study adopts the supplier assessment form from its clients such as DATAFAB, 3M, Wistron, ASUS, and Compal to build up its own criteria.

In the criteria development stage, the Delphi method was used. A panel of experts answers questionnaires in two or more rounds to decide which important criteria needs to be considered. Once the statistics reach the pre-defined stop criterion, the process was stop and the mean or median scores of the final rounds determine the results. Through this process four assessment aspects and sixteen assessment criteria were determined.

## 3 Fuzzy Analytic Hierarchy Process (FAHP)

The second stage is based on FAHP, and consults experts of various fields to find out the importance of various criteria, in order to obtain the weights for the selected criteria in the previous section. The linguistic scale of traditional AHP method could express the fuzzy uncertainty when a decision maker is making a decision. Laarhoven and Pedrycz [5] proposed the FAHP in 1983, which was an application of the combination of Analytic Hierarchy Process (AHP) and Fuzzy Theory. FAHP converts the opinions of experts from previous definite values to fuzzy numbers and membership functions to achieve more reasonable assessment criteria.[2][6]

The FAHP steps proposed by Kreng, *et al.* [4] were adopted as follows:

1. Determine problems: To ensure future analyses correct, this study discussed the "assessment criteria for green suppliers".
2. Set up hierarchy architecture: This study screened the important factors conforming to target problems through Delphi method investigating experts' opinions, to set up the hierarchy architecture.
3. Set up fuzzy paired comparison matrices after the definite values are converted to fuzzy numbers.
4. Calculate fuzzy weight value: This study uses the "Column Vector Geometric Mean Method" proposed by Buckley [1].

5. Hierarchy series connection.
6. Defuzzification: Convert fuzzy numbers to easy-comprehended definite values, this study adopts the center of gravity method to solve fuzzy numbers.
7. Sequencing: Sequence defuzzified criteria.

## 4 Case Study

The case company was established in 1983 and specializes in the field of Memory Card connectors. Table 1 shows the weights of green supplier assessment obtained by FAHP. Furthermore, application of the inspection exemption guideline based on the MIL-STD-1916 procedure, eight of the suppliers are certificated as inspection exemption suppliers. According to the inspection records of years 2009 and 2010, a reduction of 12.13% in material inspecting time for the case company can be saved.

**Table 1.** Weights of aspects and criteria for green suppliers assessment

Aspect	Aspect weight	Criteria	Criteria weight	Global priority	Ranking
Quality management	0.309	Raw material inspection report	0.119	0.037	14
		Promise of not using hazardous substance	0.137	0.042	12
		Management system verification	0.165	0.051	10
		Regulation restriction and customer request	0.315	0.097	2
		Quality system audit	0.264	0.082	3
Resource management	0.155	Raw material management	0.196	0.030	15
		Equipment environment	0.128	0.020	16
		Equipment procurement management	0.243	0.038	13
		Training	0.434	0.067	7
Design and Development management	0.280	Product innovation	0.169	0.047	11
		Green procurement	0.566	0.158	1
		Cleaning cost	0.265	0.074	5
Process management	0.257	Control of production process	0.241	0.062	8
		Control of nonconforming product	0.289	0.074	4
		Shipping management	0.269	0.069	6
		Product preservation	0.201	0.052	9

## 5 Conclusion

This research proposes a green suppliers assessment methodology through a modified Delphi method, and a Fuzzy Analytic Hierarchy Process. The top five assessment criteria determined are Green procurement, Regulation restriction and customer request, Quality system audit, Control of nonconforming product and Cleaning cost. After implementing these criteria to the material suppliers of the case company, eight of the suppliers are certificated as inspection exemption suppliers. A reduction of 12.13% in material inspecting time can be saved.

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