Application of Analytical Hierarchy Process in Supplier Assessment from Environmental Perspective
A survey Study in Pan Nordic Logistics AB

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ABSTRACT

Nowadays the importance of environmental logistics is increasing while organizations are trying to pay more attention to their transport activities. Since PNL is a famous logistics company in Nordic countries and transport activities are done by sub contractors they intend to make sound environmental choices by assessing their suppliers from environmental performance in order to identify the best suppliers which is comply with the PNL environmental policy.

In this project the survey study and questionnaire has been made in order to evaluate the supplier performance from environmental perspective. At first the investigation has been made for improving the previous questionnaire which was made by PNL. Some parts were revised according to researchers’ knowledge, reliable references and suggestion of environmental consultant. Lots of study has been made in order to find the most importing effects that can affect environmentalism. Obtained results from questionnaire were analyzed and appropriate suggestions were given in order to enlighten the significant importance of environmental issues.

Due to complexity of decision making environment, the applicable and reliable method should be applied to cope with complexity and the factors that can affect the objective while simplifying the process. Analytical Hierarchy process has been applied for this project in order to change the qualitative situation into quantitative manner to rate the suppliers based on their performance.

The first step in AHP process is constructing hierarchy in two or more level for evaluating the alternatives. The goal of the project is environmental performance. Second level is criteria which has been made according to literature and the importance of them while the suggestions of consultant has been applied as well. Third level is sub criteria which are questions of questionnaire and finally the forth level include alternative which is suppliers.

Next step in AHP process is weighting criteria and sub criteria and making pair wise comparison between them. Procedure of weighting is done by researchers and managers from PNL in order to decrease the subjectivity of decision making process. The result from suppliers has been investigated and points were given to them according to their performance and ability regarding environmental logistics.

Sensitivity analysis was made for analyzing the result from AHP in order to investigate the responsiveness of the result.

Key words: Logistics, Environmentalism, AHP Method, Supplier Assessment, Survey Study.
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## List of Abbreviations

- **PNL**  Pan Nordic Logistics AB  
- **AHP**  Analytical Hierarchy Process  
- **SCM**  Supply Chain Management  
- **JIT**  Just in Time  
- **HFC**  Hydro fluorocarbon  
- **PFC**  Per fluorocarbon  
- **UNEP**  United Nations Environmental Programme  
- **WMO**  World Meteorological Organisation  
- **EMS**  Environmental Management System  
- **ISO**  International Standard Organisation  
- **EMAS**  Eco Management and Audit Scheme
1 INTRODUCTION

Logistic activities, especially transportation, are large source of several environmental problems. However, logistical decision making can also be applied to reduce or eliminate most of these problems. Companies have a hard struggle in their environmental performance, especially when it comes to the greening of transports (Björklund, 2005). Waste and emissions caused by the supply chain have become main source of serious environmental problems (Min, H. and Galle, 1997). In this project the aim is to assess and select the suppliers according to their environmental performance.

Selection can be defined as the combination of processes that lead to the choice of one or more candidates over others for one or more jobs or roles. Assessment is the application of systematic processes to understand the performance of individuals or groups, either currently or in a predictive sense (Edenborough, Robert, 2005). The survey study method and questionnaire is used as the tool to evaluate suppliers in this project.

In today’s competitive market proper management of the supply chain is the key to success of every company. Selection of the appropriate supplier is a major requirement for an effective supply chain. Thus, the subject has been the focus of numerous studies both theoretical and empirical (Sharon M, Ordoobadi 2009).

Survey research involves the collection of primary data from all or part of a population in order to determine incidence, distribution, and interrelationships of certain variables within the population. It encompasses a variety of data collection techniques for example questionnaires (print or electronic), interviews (face to face or telephone), and observation techniques (Williamson, 2002). The analysis of the input data from the questionnaire is important to reach to the right results. To achieve this Analytical Hierarchy Process (AHP) is used.

The use of qualitative judgments in multi-factor decision models is receiving increasing attention and a variety of approaches have been developed which cover a wide range of techniques. One method which has received increasing attention in the literature is the relatively recently developed AHP. This method has been widely documented in variety of problem area (Partovi, Burton and Banerjee 1990). The AHP is a decision-aided method which each level is composed a complex multi-factor problem into a hierarchy, in which each level is composed of specific elements. The overall objective of the decision lies at the top of the hierarchy, and the criteria, sub criteria and decision alternatives are on each descending level of this hierarchy (Partovi, Burton and Banerjee 1990).
1.1 SPECIFICATION OF PROBLEM

This project is carried out in Pan Nordic Logistics AB (PNL) in order to perform efficient method for evaluating suppliers from environmental perspective. Nowadays environmental approaches have essential role in the world. The organisations and the industry should manage their activities while maintaining the environment. Therefore, PNL wants to make sound environmental choices while at the same time being able to contract out transport services. Because of this reason they want to evaluate their suppliers’ environmental performance. The questionnaire that is previously prepared by the company should be improved in order to cover all environmental aspects to make an accurate evaluation of the subcontractors’ performance while it should be easy to evaluate. The questionnaire should not be complex in order not to confuse the suppliers which might lead to wrong answers and wrong results. An appropriate method should be applied in order to evaluate the company’s subcontractors. The method should change the complex qualitative situation into simpler quantitative form to rate and compare the subcontractors while being reliable.

1.2 PURPOSE AND GOALS

The main goal of this thesis work is, forming an efficient questionnaire that is easy to understand and easy to evaluate while giving accurate results and covering the necessary criteria, building a tool that is able to assess and compare the subcontractors of PNL Company.

The application of a suitable method and evaluating the suppliers accordingly will help to choose the best suppliers among the others and increase the PNL Company’s environmental performance. Hence, this research study will suggest and investigate the way to evaluate and rate the suppliers about the environmental aspect.

1.3 RESEARCH QUESTION

In order to fulfil this study, following questions should be investigated:

- What are the environmental effects of the services of the PNL’s suppliers?
- How these effects can be evaluated?
- Can AHP be accepted as an appropriate method to rate and compare the subcontractors regarding environmentalism?

1.4 LIMITATIONS

The study focuses on the effects of the Pan Nordic Logistics’ suppliers on environment since, Pan Nordic Logistics’ most acute impact on the environment is connected with the vehicles that transport its goods and those vehicles are obtained from the suppliers. The company’s other operations have a minimal impact on the environment and are easier to address compared with the transport services. This study is only about the Pan Nordic Logistics’ transport service suppliers. The negative effects of the transport services of the suppliers on environment are considered in this study. The study focuses on PNL’s suppliers that transport PNL goods, other sources of environmental impacts have not been considered. Although the quality of the services provided and the financial outcomes of the services have vital importance for PNL while evaluating and choosing the suppliers, the study has been limited to focus only on the environmental aspect.
1.5 OUTLINE

This thesis consists of eight main chapters. Theoretical background regarding supply chain, logistics, environmentalism and AHP is presented in chapter two. The methodology part which is in third chapter includes the methods such as survey study and data collection method which is used to carry out the thesis. Chapter four presents the background of PNL regarding environmentalism and their policy regarding supplier assessment. Chapter five includes the design of the questionnaire, the questions included and the reason why those questions were chosen. Chapter six is the part where the results of the survey study are demonstrated, also application of analytical hierarchy process for supplier assessment for this study explained. In Chapter seven the analysis on the results survey study and AHP is made according to the results obtained from the survey. Chapter eight includes the discussion and the conclusion section, the importance finding of the thesis is pointed out also the suggestion for future research has been made in this part. The Chapter nine includes the references used in the study.
2 THEORETICAL BACKGROUND

2.1 SUPPLY CHAIN

A supply chain is a complex network, which consists of all stages (e.g. order processing, purchasing, inventory control, manufacturing, and distribution) involved in producing and delivering a final product or service. The entire chain connects customers, manufacturers and suppliers, beginning with the creation of raw material or component parts by suppliers, and ending with consumption of the product by customers (Danny I. Cho, Shin-Chan Ting, 2008).

In reality, organizations do not work in isolation, but each one acts as a customer when it buys materials to its own suppliers, and then it acts as supplier when it delivers materials to its own customers (Waters, 2003).

The simplest view of a supply chain has a single product moving through a series of organization, each of which somehow adds value to the product. Taking one organization’s point of view, activities in front of it- moving materials inwards- are called upstream; those after the organization-moving outwards- are called downstream (Waters, 2003).

Supply chain management (SCM) represents a significant change in how most organizations view themselves. Traditionally, firm view themselves as having customers and suppliers. Historically, a firm did not consider the potential for either its supplier or its customer to become a partner. In many industries each firm was very competitive with its suppliers and customers, fearing that they would be taken advantage of by them (Lawrence D, Fredendall Ed Hill, 2001).

Supply chain exists to overcome the gaps created when suppliers are some distance away from customers. They allow for operations that are best done- or can only be done- at locations that are distant from customers or sources of materials (Waters, 2003).

The power of supply chain management is its potential to include the customer as a partner in supplying the goods or services provided by a supply chain (Lawrence D, Fredendall Ed Hill, 2001).

Supply chains are formed to achieve a sustainable competitive advantage for all parties involved. The social and political concerns on environmental issues have encouraged manufacturing firms to “green” their supply chains (Jao-Hong Cheng, Chung-Hsing, 2008).

2.2 LOGISTICS

Logistics is the functions responsible for the flow of materials from suppliers into an organization, through operations within the organization, and then out to customers (Waters, 2003). Logistics activities include locating facilities, transporting material, storing inventory, communicating, and the handling associated with these (Fredendall and Hill, 2001). Manufacturers build factories that collect raw materials from suppliers and deliver finished goods to customers; retail shops have regular deliveries from wholesalers, etc. Logistics is the function that is responsible for this movement. It is responsible for the transport and storage of materials on their journey between suppliers and customers (Waters, 2003). It includes the process of planning, implementing and controlling the efficient, cost-effective flow and storage of raw materials, in-process inventory, finished goods and related information from point of origin to point of consumption for the purpose of conforming the customer requirements (Waters, 2003). The planning and coordination of the physical movement aspects of a firm’s operations such that a flow of raw materials, parts, and finished goods is achieved in a manner that minimizes total costs for the levels of service desired (Fredendall and Hill, 2001). According to Saunders (1997) the main logistics considerations from a user point of view, involve:

- Identification of the range of logistics service required
- Choice of transport media
- Choice of logistics operator
- Choice of supply chain/distribution channel structure
- Assessment of materials handling and packaging implications
A supply chain consists of series of activities and organizations that materials move through on their journey from initial suppliers to final customers (Waters, 2003). Along the journey of materials, materials may move through raw materials suppliers, manufacturers, finishing operations, logistic centres, warehouses, third party operators, transport companies, wholesalers, retailers, and a whole range of other operations (Waters, 2003). The logistics system is concerned not only with the physical placement of the facilities, but also with the levels of inventory and the flow of material through those facilities (Fredendall and Hill, 2001). The following is the list of benefits of well-designed supply chains according to (Waters, 2003):

- Producers locate operations in the best locations, regardless of the locations of their customers.
- By concentrating operations in large facilities, producers can get economics of scale.
- Producers do not keep large stocks of finished goods, as these are held further down the supply chain nearer to customers.
- Wholesalers place large orders, and producers pass on lower unit costs in price discounts.
- Wholesalers keep stocks from many suppliers, giving retailers a choice of goods.
- Wholesalers are near to retailers and have short lead times.
- Retailers carry less stock as wholesalers provide reliable deliveries.
- Retailers can have small operations, giving a responsible service near customers.
- Transport is simpler, with fewer, larger deliveries reducing costs.
- Organizations can develop expertise in specific types of operation.

Moving materials into the organization from suppliers is called inbound or inward logistics, moving materials out to customers is outbound or outward logistics, moving materials within the organization is materials management (Waters, 2003). Concern for SCM and also the introduction of just-in-time (JIT) strategies have heightened the motivation of buyers to become more directly involved in shaping the arrangements for inward logistics. Traditional purchasing approaches often relied on contracts with suppliers that delegated responsibility for making delivery arrangements to the latter (Saunders, 1997). The involvement of buyers can be in different ways. Buyers may place purchase contracts on an ‘ex works’ basis and take over the tasks of organizing transport, using their own firms’ services or those of third-party distribution companies (Saunders, 1997).

Technological change has affected all transport media, thus altering the relative importance of each with regard to the factors such as flexibility of service, versatility, speed, capacity, cost, reliability and safety (Saunders, 1997). Utilization of loads, through the development and use of containers and pallets, has increased the efficiency of materials handling techniques and has opened up opportunities for intermodal transport arrangements (Saunders, 1997).

The role of the third-party distribution companies is growing in the sector. As well as transport firms supplying specific freight services, other companies have developed a more comprehensive range of services that can be provided to customers on a ‘third-party basis’. The range includes collection and delivery, the use of transhipment and consolidation warehouses and the provision of an information service to relay orders and to track the flow of goods (Saunders, 1997). Bulk shipments can be received into a distribution centre from manufacturers and consolidated or mixed loads dispatched out to customer locations. Such services can be bought by large users on a dedicated basis, which means that both certain vehicles and stores may be operated solely for particular clients.

Logistics managers have two aims. The first is to move materials into, through, and out of their own organization as efficiently as possible. The second aim is to contribute to an efficient flow through the whole supply chain. The efficient term includes fast deliveries, low costs, little wastage, quick response, high productivity, low stocks, no damage, few mistakes, high staff morale, and so on (Waters, 2003). Ultimately, the success of every organization depends on customer satisfaction. The overall aim of logistics is to achieve high customer satisfaction. It must provide a high quality service with low – or acceptable – costs (Waters, 2003).
2.3 TRANSPORT SERVICE

Transportation is an important and pervasive element in our society, affecting every person, either directly and indirectly. The goods we consume, our economic livelihood, our mobility, and our entertainment are in some way affected by transportation (Coyle, Bardi, and Novack, 2000). Transport plays an important role in bridging the time and geographical gaps between production and consumption (Björklund, 2005). A transport service can be defined as “change of address”, or as an “inter-local change of position (movement) + local change of position (handling)”, i.e. change of address plus handling (Björklund, 2005). Definition of transport without considering its role in logistics is hard since it is an integral and inseparable part of a company’s logistics system. The transport field is often too complex and diverse to take all aspects and mechanisms into account in one single analysis or design. Traditional divisions make distinctions according to mode of transport (road, air, water and rail) and analyse and design specific subsystems accordingly (Björklund, 2005).

Benson and Whitehead (1975) make a definition of the transport system by the illustration of the system through four components. According to that illustration the components of the transport system are the way, the terminal, the unit of carriage and the unit of propulsion. The way is the medium on or through which the transport unit travels (Benson, Whitehead 1975). Terminal is the interface where the transportation starts and where the transportation ends. The unit of carriage is the interface where the goods are stored and the unit of propulsion is the vehicle or the craft that is used for the transportation.

Activities in the transport system include load carriers moved between production, assembly, storage, etc. by the use of different transport modes, loading, sorting, consolidation, and deconsolidation. The transport of load carriers provides a supply of transport services that are matched with the demand from the logistics operators at a transport market. The demand for goods movements results in a demand for the utilization of the infrastructure in time and space (Björklund, 2005).

2.4 ENVIRONMENTALISM

The awareness on the harmful effects of the industrial and the logistics activities to the environment is increasing. The researches on environmentalism increased during the last decades. These researches increase the attention of the society, governments, and trade bodies and encourage companies to reduce the negative effects on the environment and increase the intentions to improve the efficiency of usage of the resources. Many human activities today are not friendly to the natural environment, our ways of consuming, transporting, etc. Often have a negative impact on the environment. These impacts are often described in a number of environmental threats, according to Björklund (2005) these can be classified as the following:

- The greenhouse effect (change of climate)
- Acidification of land and water
- Utilization of land and water
- Photochemical oxidation (ozone in the ground layer)
- Decrease in biological multiplicity
- Eutrophication of land and water
- Menacing to particularly valuable territories
- Air pollution and noise
- Decrease in the stratospheric ozone layer
- Influence of metals
- Increase in the tropospheric ozone layer
- Waste
- Radiation
2.4.1 The effect of Supply Chain Activities

Waste and emissions caused by the supply chain have become main sources of serious environmental problems (Min and Galle, 1997). The logistical activity of transportation is one of the largest contributors to several environmental threats and problems, such as the greenhouse effect, health problems and energy consumption (European Commission, 2000; European Environment Agency, 2000). Transportation also causes health problems due to noise and unhealthy substances in the emissions (Björklund, 2005).

2.4.2 The effect of Greenhouse Gasses

According to Hensher and Button (2003), the earth’s climate is essentially determined by factors that affect the redistribution of energy within the atmosphere, or between the atmosphere, land, and ocean. There is a strong scientific evidence to suggest that most of the warming observed over the last 50 years is attributable to human activities and is likely to have been due to the increase in greenhouse gasses (GHGs) such as carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF₆) into the atmosphere. International efforts have been made since the early 1970s to try to combat the global warming problem. In 1988, the UN Environmental Programme (UNEP) and the World Meteorological Organization (WMO) established the Intergovernmental Panel on Climate Change and gave this body the task of assessing the current state of knowledge about the world climate system, the environmental, economic, and the social impacts of climate change, and also study possible response strategies. On the second assessment report of the Intergovernmental Panel on Climate Change provided the foundation for the adoption in 1997 of Kyoto Protocol, where industrialized countries committed themselves to achieving quantifiable reductions in the levels of GHG emissions. GHG emissions have many different sources but more than 95% of CO₂ emissions in industrialized countries are from fossil fuel combustion of which the transport sector is responsible for 26% of the total CO₂ emissions.

2.4.3 Transportation Fuel Strategies

The transport sector depends almost totally on the use of petroleum fuels (Hensher, Button, 2003). The main contributor to the negative impacts on the environment from the transport sector is connected to the petroleum fuels consumed and the remainders of them such as the GHG and particulates. There have been many researches to find alternatives and replace the fossil fuels. The substitution of cleaner burning alternative fuels for conventional gasoline and diesel fuels has attracted significant attention during the past two decades. Alternative fuels are more likely to be produced from domestic sources, generally reduce vehicular emissions and some alternative fuels offer the potential to lower fleet operating costs. Some alternative fuels have the potential for significant cost-effective reductions in emissions of CO, HCs and NOₓ but may cause sharp increases in emissions of other toxic pollutants (Hensher, Button, 2003). Therefore, the effects of the alternative fuels should be carefully investigated and evaluated. Transportation fuel strategies should be developed in connection with other options for reducing the environmental impact of transportation, such as fuel efficiency improvement, the development of the exhaust reduction technology, transport management, etc. (Hensher, Button, 2003).

2.4.4 The Regulations on Fuel Emissions:

There are serious regulations set for the trucks to reduce the emission and the harm given to the environment in the European Union, North America, Australia and etc. With the introduction of the Euro emissions criteria within the European Union starting from 1992, the emissions of the harmful gases and particulates have significantly decreased. The euro emissions set a standard for the limit of
exhaust gases for the new vehicles. There are significant reductions achieved with the introduction of EURO I in 1992 till EURO V in 2008. For instance, the amount of CO emitted from the engines of trucks with EURO I decreased starting from 4.5 grams in per kilowatt hour to 1.5 with EURO V, whereas HC dropped from 1.1 g/kWh to 0.46 g/kWh, NO_x dropped from 8.0 g/kWh to 2.0 g/kWh and particulate matter from 0.612 g/kWh to 0.02 g/kWh. For traditional internal combustion engines and fuels substantial technological advances have been made which undoubtedly reduced the level of harmful emissions (TFB, 1990). Following is the table 2.1 about emission limits for the heavy duty vehicles in g/kWh taken from Asian Development Bank website (www.adb.org).

Table 2.1 Emission Limits for the heavy duty vehicles

<table>
<thead>
<tr>
<th>As from</th>
<th>Test cycle</th>
<th>CO</th>
<th>Total HC</th>
<th>Non-Methane HC</th>
<th>NO_x</th>
<th>Particulate Matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Euro 1</td>
<td>1/10/1993</td>
<td>13-mode</td>
<td>4.5</td>
<td>1.10</td>
<td>—</td>
<td>8.0</td>
</tr>
<tr>
<td>Euro 2</td>
<td>1/10/1996</td>
<td>13-mode</td>
<td>4.0</td>
<td>1.10</td>
<td>—</td>
<td>7.0</td>
</tr>
<tr>
<td>Euro 3</td>
<td>1/1/2000</td>
<td>ESC</td>
<td>2.1</td>
<td>0.66</td>
<td>—</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ETC</td>
<td>5.5</td>
<td>0.78</td>
<td>1.6</td>
<td>5.0</td>
</tr>
<tr>
<td>Euro 4</td>
<td>1/10/2005</td>
<td>ESC</td>
<td>1.5</td>
<td>0.46</td>
<td>—</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ETC</td>
<td>4.0</td>
<td>0.55</td>
<td>1.1</td>
<td>3.5</td>
</tr>
<tr>
<td>Euro 5</td>
<td>1/10/2008</td>
<td>ESC</td>
<td>1.5</td>
<td>0.46</td>
<td>—</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ETC</td>
<td>4.0</td>
<td>0.55</td>
<td>1.1</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Note: 'Euro 1 and 2': Directive 91/542/EEC; 'Euro 3, 4 and 5': Council position December 1998 and agreed with the European Parliament
CO = carbon monoxide, HC = hydrocarbons g/kWh= gram per kilowatt hour, NO_x = nitrogen oxides
^a Until 30/1/1998 the particulate limit for engines <700 cc per cylinder and with a rated power speed of more than 3000 rpm was 0.25 g/kWh
^b For engines <750 cc per cylinder and with a rated power speed greater than 3000 rpm
^c Measured on the European Standard Cycle (ESC)
^d Measured on the European Transient Cycle (ETC)

The Swedish Environmental Protection Agency (Kommunkationskommitten, 1997) together with ten other organisations, presented long term environmental goals for the transport sector. One presumption was that the transport sector, as a whole, faces the same CO_2 reduction demand as other sectors in society. The goal for 2050 is a reduction by 60%, using 1990 as a base year. Road transport was then set to reach a reduction by 75%, while the long-term goals for air, sea and rail were set to a 20% reduction. Adjustments within the industry to logistically related trends, such as increased globalization due to open markets, shorter production development cycles, lean and just-in-time production, decreased stock levels, centralization, reverse flows, postponement, and a higher degree of concentration on core activities (by increased outsourcing) will aggravate rather than alleviate these problems (Solem, 1999). Environmental responsibility has therefore become a key issue in logistics management (van Hoek, 1999; Murphy, Poist, and Braunschweig, 1995).

2.4.5 Sustainable Development:

By the rise of the globalization trend and the spread of the free market economy, the challenge on maintaining and improving the share in the market getting fierce for the companies. The results of the decisions taken by the management regarding their operations and the affects of those operations on the environment have to be considered carefully since, they have to be efficient, effective, and productive and meet the demands of the customers. With the increasing trend of environmental
awareness in the society the priority of the results of their choices on the environment is rising for the customers while purchasing services. Therefore the companies tend to be environmental friendly to be competitive in the market while trying to match up with the demands increasing transport intensively. It is desired to avoid environmental and resource degradation in a way not harming but supporting the economical improvements. This intention is named as “sustainable development” in the Bruntland commission and the transport sectors crucial role in the development towards a sustainable society is mentioned. It is indicated that sustainable development “seeks to meet the needs and aspirations of the present without compromising the ability to meet those of the future”. The report states that, increased free trade will result in an increased transport demand, but the technical development together with increased efficiency and effectiveness will be the solutions to attain a sustainable society (World Commission on Environment and Development, 1987). Many of the clearly non-sustainable industrial processes are in the transport sector. While many of the other non-sustainable activities in society, such as general use of energy or materials, tend to grow slower than the economy, the increase of the activity in the transport sectors may grow faster than the economy (Roth, Kabberger, 2002). It is suggested by (Hensher, Button, 2003), the measures to achieve a future transportation system which is less damaging to the environment comprise:

- An investment policy based on cost-benefit analysis in which environmental impacts are evaluated as opportunity costs (derived as shadow prices from the safe minimum constraints).
- A pricing policy based on the polluter pays principle, using prices derived from opportunity costs.
- A regulation policy that aims to meet safe minimum values by importing restrictions on travel behaviour.
- Standards setting for technical processes (e.g. pollution from combustion of engines), to incentivize industry to develop cleaner technology.
- Education and behavioural training to make environmentally friendly behaviour routine, concentrating on areas in which safe minimum standards are often exceed.

2.4.6 The Effect of Logistics Activities

Measuring the external cost of logistics activities can guide companies in choosing among different solutions and estimating the socioeconomic value of decreasing the environmental impact (Björklund, 2005). In assessing the environmental impact of freight movement, it is important to take account of logistical trends and the trade-offs that companies make between transport and other elements in the logistical system (Hensher, Button, 2003).

According to (McKinnon, Woodburn, 1996) decisions affecting the freight transport operations can be divided into four categories:

1. Strategic decisions relating to numbers, locations, and capacity of factories, warehouses, shops, and terminals. These determine the physical “infrastructure” of the business.
2. Commercial decisions on product sourcing, the subcontracting of production process, and distribution of finished products. These establish the pattern of trading links between the company and its suppliers, distributors, and customers.
3. Operational decisions on scheduling of production and distribution that translate the trading links into discrete freight flows.
4. Tactical decisions relating to the management of transport resources. Within the framework defined by decisions at the previous three levels, transport managers still have discretion over the choice, routing, and loading of vehicles.

One of the central paradoxes in the field of green logistics has been that as vehicles have become more fuel-efficient, cleaner and quieter, reducing externalities per kilometre travelled, major business trends, such as globalization, centralization, to a lesser extent, just in time (JIT), have been sharply increasing total vehicle-kilometres. Many of the environmental benefits accruing from improvements in vehicle technology are therefore being sacrificed as logistical systems become ever more transport-intensive (Hensher, Button, 2003). Transport work can be defined as the product of amount of goods and the distance and it is measured in tonne kilometre (tonnekm). Traffic work can be defined as the product of the number of vehicles and distance, and is measured in vehicle kilometre (vkm) (Blinge,
To get a measure on the organisation of transport, the transport efficiency, one can for instance measure the average payload. One common way to calculate the average payload is to calculate the ration between the tonne-kilometres and the vehicle-kilometres. However, it is then important to make sure that all the vehicle kilometres represent unloaded transports (Björklund, 2005).

According to Björklund there are two main approaches to addressing environmental concerns in freight transport, either to improve the technology applied (e.g. using modern engines, catalytic converters and more efficient and/or less environmentally harmful fuels) or to implement changes in logistic-related activities. Implementing different forms of technological innovations often implies a retained service level (e.g. transport time and frequencies) but an increase in transport costs due to large investments. On the other hand, the most efficient and effective way to quickly decrease the environmental impact from transports today is to increase the usage of existing resources, thus increasing the transport work (measured in tonne-kilometres) without increasing the traffic work (measured in vehicle-kilometres) (Björklund, 2005).

2.4.7 The Standardization of Environmental Management

This needs a better utilization of the sources of the logistics companies. The standardization of environmental management and the logistics systems of the companies will also help the companies to reduce the harmful effect to the environment and increase the awareness, the ISO 14001 is a common certificate that companies try to obtain. ISO 14001 deals with environmental management systems and is a management tool enabling an organization of any size or type to identify and control the environmental impact of its activities, products or services, improve its environmental performance continually and to implement a systematic approach to setting environmental objects and targets, to achieving these and to demonstrating that they have been achieved (www.iso.org/iso/iso_14000_essentials). To gain accreditation to ISO 14001 they must install an environmental management system, undertake regular environmental audits and demonstrate a commitment to continually improve their environmental performance (Hensher, Button, 2003).

An environmental management system can support the environment work of a company in many ways. The environmental system provides, for example, guidance regarding how to distribute responsibilities, prioritise, communicate, follow up and continuously improve environmental performance (Björklund, 2005). The implementation of an environmental management system can be presented as a number of stages:

1. Environmental Investigation: An investigation of how the company affects the environment.
2. Environmental Policy: The policy is a written document that describes the company’s environmental ambition and attitude.
3. Environmental Goals: The goals of the company show what the company would like to improve and thereby also the prioritising within the environmental work.
4. Environmental Plan: Plan the actions as well as the organisation regarding who is responsible for different parts of environmental work.
5. Implementation: The environmental performance is conducted.
6. Revision: The follow-up of the environmental performance.
7. Environmental Report: Report and communicate the environmental progress made to both internal and external interested parties.
8. Evaluation: The environmental performance is evaluated and the loop is closed (Björklund, 2005).

2.4.8 Measuring Environmental Impact and Performance:

There are increasing demands from customers, shareholders, investors, and the general public for quantified environmental information. This places a demand on an organisation to quantifiably measure its environmental performance (A measure of commitment, 1992). Many logistics and haulage companies work on a way to improve their environmental performance and searches ways to understand and analyse their contribution on the harm given to the environment, to make the possible changes and developments in the organisation.
It is a complex process to measure the environmental impact and the performance of the company and the subcontractors. The researchers should find a useful tool to quantify the environmental performance of the organisations. The strongest challenges during this process is deciding on what to measure, how to measure it and gathering input data as accurate as possible since in many cases there is a need to make assumptions.

While conducting the survey study to evaluate the environmental performance of the subcontractors one of the most important problems that arises is the decision on what to measure. It is not possible to measure all of the environmental aspects that would be too complex, too time and effort consuming, highly possible for respondents to make mistakes and highly possible to be hard to understand for the staff and the management of the company. On the other hand the selected criteria should well be able to reflect the environmental performance of the suppliers which makes prioritising an important issue. There are some basic principles for the selection of measures. A measure should be consistent with the company’s environmental policy and corporate objectives (Björklund, 2005). By incorporating measurement into the management system, the measures become a part of the company’s management system. There must not be a gap between strategic objectives and actions at the operational level. Managers must understand how the information could be turned into consistent actions (Björklund, 2005).

Another important aspect is regarding how to measure. Due to the way the underlying investigations are conducted, the input data can be very different depending on the extent of the investigations and the methods used to gather investigation (Björklund, 2005). The nature of the data will be different depending on the method used for gathering there is a need for quantifying the qualitative data input to measure the impact. Also, the impact of the activities should be compared and weighted against each other to measure their values.

Some of the data is too hard to measure of its actual value such as the emissions from the vehicles during the transportation activities. There is a need to make assumptions to get the results. In such a case the researchers depend on the accuracy of these assumptions.

2.4.9 The Role of Purchasers

Even though the scope of this research is limited with the assessment of the environmental performance of the suppliers, there is a need to mention the role of the purchasers in greening the activities of the companies. That is because assessment is a crucial part of the purchasing strategies, and the limits, contents and goals of the assessment would be affected by the related purchasing strategy and its stand point regarding environmentalism. Routine job responsibilities for most purchasers focus on daily efforts to secure various commodities at the lowest available price through an efficient, standardised process. The majority do not have the latitude or authority preferentially to procure goods (or the services) at a higher price on the basis of qualitative benefits such as environmental strengths. Nor do they have the time to explore the relative benefits of various products unless specifically requested to do so (Russel, 1998). However, several factors continue to drive change forward in this area. Many large corporations have faced substantial public pressure to accept greater responsibility for the environmental impacts of products and services they produce (Russel, 1998). It is clear that by the increasing awareness of the public and the companies regarding environmentalism, the importance of the subject is improving in the companies’ strategic decisions and purchasing. According to Russel (1998) for the concept of green procurement to progress significantly there is a need for the majority of the suppliers have basic training in the marketing of the environmental benefits of their products and services and also the procurement professionals need to recognise the role they play in improving the environmental performance of their companies.

2.5 SUPPLIER ASSESSMENT

One important activity in the purchasing process is the evaluation of the supplier. The supplier evaluation often take place after the supplier are investigated, but before the negotiation and supplier selection (Björklund, 2005).
Since suppliers seldom meet all the purchasers’ requirement, they have to be valued in relation to each other. Suppliers can be evaluated based on the product, their process, the level of quality and/or on an overall company level, e.g. the organization’s financial situation (van Weel, 1994). The evaluation can be based on more subjective opinions (based on own interpretation), and/or be more objective (Björklund, 2005).

Supplier selection is one of the most critical activities of purchasing management in a supply chain, because of the key role of supplier’s performance on cost, quality, delivery and service in achieving the objectives of a supply chain (A. Amid, C. O’Brien, 2006). The supplier selection criteria play an important role throughout the purchasing process. The criteria are set in the first phase as the needs of the firm are recognized. These criteria are then used as a basis regarding what information to focus on when investigating potential suppliers, what aspects to focus when evaluating different suppliers, and what aspects to monitor in order to ensure that the supplier products and services match the organization’s requirement (Björklund, 2005).

Today important criteria in the selection of supplier, regardless of the type of purchased product, are quality, on-time delivery, and supplier performance history along these criteria. Other common criteria are delivery reliability, technical, capacity, and the financial stability of the supplier (Björklund, 2005). According to Ordoobadi, (2009) the approaches for evaluation and selection of suppliers that were uncovered in the literature follows:

- Categorical method (Timmerman, 1986; Willis and Huston, 1990). Once the list of attributes to use in the evaluation process is established, the suppliers’ performance on each attribute is assessed in categorical terms such as “good”, “fair”, and “poor”. The supplier receiving the most “good” rating is considered the best. This method is easy to use, inexpensive, and requires minimum data. However, it is largely an intuitive process, heavily dependent on personal judgment of the evaluator, and all criteria are assumed to have equal importance.

- Linear weighted average method (Timmerman, 1986). This method assigns relative importance weight to each criterion. The evaluator then rates the performance of suppliers with respect to each criterion. The supplier performance ratings are multiplied by criterion importance weights to calculate a weighted score. These weighted scores are then summed over all the criteria to obtain one aggregate weighted score for each supplier. The supplier with the highest weighted score is the best. Although this method no longer treats the criteria as having equal importance, the subjectivity of the decision maker in assigning weights remains as an issue.

- Cost-ratio method (Timmerman, 1986; Dobler et al., 1990). The total cost related to quality, delivery, and service are calculated and expressed as a proportion of the total firm’s purchase price. The supplier who can provide the lowest cost is the best. This method is more precise compare to the other aforementioned methods. However, it requires a comprehensive cost-accounting system to identify the precise cost data.

- Vendor profile analysis (Thompson, 1990). This is a modified weighted average method in order to reduce the uncertainty involved in the assignment of the ratings. A Monte Carlo simulation technique is used to replace the rating based solely on intuitive judgment. The use of Monte Carlo simulation has two advantages over the weighted average technique. It simplifies the decision maker’s input to the evaluation process and provides output that has considerably more information for the decision maker.

- Dimensional analysis (Willis et al., 1993; Youssef et al., 1996). The evaluation process involves a series of one-on one comparison and can compare only two suppliers at a time. The dimensional analysis ratio can be greater than one, equal to 1, or less than one. The main difficulty is that the process becomes very time consuming if there are a large number of suppliers that should be evaluated.
Vendor rating with analytical hierarchy process (Nydick, 1992; Ghodsypour and O’Brien, 1998; Yaha and Kingsman, 1999; Bhutta and Huq, 2002; Kahraman et al., 2003; Teng and Jaramillo, 2005). One of the major difficulties of the aforementioned methods was the assigning of the weights to the attributes. These weights were assigned purely based on personal judgment and intuition of the decision maker. To overcome these difficulty researchers proposed the use of analytical hierarchy process (AHP). AHP provides a systematic way for determining the attributes weights by a series of pair wise comparisons of all attributes. Once weights of the attributes are determined by AHP they are used to construct a vendor evaluation and selection system.

2.6 ANALYTICAL HIERARCHY PROCESS:

Individual knowledge and experience are inadequate in making decision concerning the welfare and quality of life for a group. Participation and debate are needed both among individuals and between the groups affected (Saaty, 2008).

According to Saaty (2008), decision –making approach should have these characteristics:

- be simple in construct
- be adaptable to both groups and individuals
- be natural to our intuition and general thinking
- encourage compromise and consensus building, and
- Not require inordinate specialization to master and communicate.

In addition, the details of the process leading up to the decision –making process should be easy to review.

Our present complex environment calls for a new logic-a new way to cope with the myriad factors that affect the achievement of goals and the consistency of the judgments we use to draw valid conclusions. This approach should be justifiable and appeal to our wisdom and good sense. It should not be so complex that only the educated can use it, but should serve as a unifying tool for though in general (Saaty, 2008).To the best of our understanding, the world is a complex system of interacting elements (Saaty, 2008). In our complex world system, we are forced to cope with more problems than we have the resources to handle. To deal with unstructured social, economic, and political issues, we need to order our priorities, to agree that one objective outweighs another in the short term, and to make tradeoffs to serve the greatest common interest (Saaty, 2008).so for solving the complexity and better decision making, The AHP method is proposed for this dissertation.

The AHP developed by SAATY is a decision making tool that reduces complex decisions to a series of comparisons and ranking .The results are then combined to give a single result (Lari, 2004).With AHP the process can be used to make trade–offs and determine the priorities among factors and sub factors (Chin and Pun, 2002)

The AHP is a multi-criteria decision making process that helps decision makers set priorities and arrive at the best decisions when the qualitative aspects of vendor selection decision need to be considered. The AHP structures a decision into smaller parts, by proceeding from the goal to objectives to sub-objectives, down to alternative courses of action. Decision makers make pair-wise comparisons throughout the hierarchical structure in order to arrive at overall priorities for a set of alternatives. The AHP makes some calculations to determine the overall weight that the decision makers assign to each criterion: this weight is between zero and one, and the total weight adds up to one (Ha and Krishnan, 2008).

The AHP is a general theory of measurement .It is used to derive ratio scales from both discrete and continuous paired comparisons in multilevel hierarchy structures (Saaty and Vargas 2001).
According to Saaty (2008) planners who used the AHP to study problem first defined the situation carefully, including as many relevant details as possible. Then they structured it into a hierarchy of levels of detail. The highest level is the overall objective. The lowest included the final actions or alternative plans that would contribute positively or negatively to the main objective through their impact on the intermediate criteria.

After developing the hierarchy, the planners judge the relative importance of all the elements. They quantify these judgments by assigning them numbers from 1 to 9 and sometimes they disagree. On many major issues where an impasse in the judgment of different people occurs, careful assessment of the differences in the intensity with which these people defend their preferences and opinions is necessary. Often words alone or logical argument cannot express the subtleties of deeply felt differences. But these differences can be measured by numbers, as we will see later on. After debate and compromise, the planners determined priorities for the hierarchy. Through a sequential process the judgment are synthesized and the desirability of each of the three alternative plans was estimated mathematically. The plan with the highest numerical value, and therefore priority, is the obvious best choice (Saaty, 2008).

In solving problems by explicit logical analysis, three principles can be distinguished: the principle of constructing hierarchies, the principle of establishing priorities, and the principle of logical consistency, which these natural principles of analytic thought underlie the AHP (Saaty, 2008).

Regarding constructing the hierarchies, the humans are able to perceive things and ideas to realize them and to communicate what they observe (Saaty, 2008). For detailed knowledge our minds structure complex reality into its constituent parts, and these in turn into their parts, and so on hierarchically. The number of parts usually ranges between five and nine (Saaty, 2008).

For setting priorities, human also are be able to perceive relationship among the things they observe, to compare pairs of similar things against certain criteria, and to discriminate between both members of a pair by judging the intensity of their preferences for one over the other (Saaty, 2008). Then they synthesize their judgment—through imagination or, with the AHP, through a new logical process—and gain a better understanding of the whole system (Saaty, 2008).

The third principle of analytical thought is logical consistency. Human have the ability to establish relationships among objects or ideas in such a way that they are coherent—that is, they relate well to each other and their relations exhibit consistency (Saaty, 2008).

In utilizing these principles, the analytic hierarchy process incorporates both the qualitative and the quantitative aspects of human thought: the qualitative to define the problem and its hierarchy and the quantitative to express judgment and preferences concisely. The process itself is designed to integrate these dual properties. It clearly shows that for better decision making the quantitative is basic to making sound decision in complex situation where it is necessary to determine priorities and make tradeoffs. To calculate priorities, we need a practical method of generating scales for measurement (Saaty, 2008).

According to Saaty (2008), sometimes in complex situation words are limit to show our feelings; therefore appropriately chosen numbers can represent variations in feeling more faithfully than can words or rhetoric. Our highly organized civilization depends on scales to measure such qualities as time, length, temperature and money (Saaty, 2008).

The AHP incorporates judgments and personal values in a logical way. It depends on imagination, experience and knowledge to structure the hierarchy of a problem and on logic, intuition, and experience to provide judgments. Once accepted and followed, the AHP shows us how to connect elements of one part of the problem with those of another to obtain the combined outcome. It is a progress for identifying, understanding and assessing the interaction of a system as a whole (Saaty, 2008).
According to Shin-Chan Ting and Danny I. Cho (2008), The AHP divides a complex decision problem into a hierarchical system of decision elements. A pair wise comparison matrix of these elements is constructed, and then the normalized principal eigenvector is calculated for the priority vector, which provides a measure of the relative importance (weight) of each element. The procedure for the AHP can be summarized in four steps as follows:

1. Constructing the hierarchical system. The first step is to construct a hierarchy with two or more levels for evaluating candidate alternatives. The concepts of a system are used to build a hierarchy for deciding the belonged-relation at various levels. Each level includes several independent elements. In general, the AHP divides a complicated problem into three levels: the overall goal of the problem; the evaluation criteria (objectives) used; and the decision alternatives considered. The criteria for the performance evaluation for each dimension should be mutually independent (Saaty, 1980).

2. Making pair-wise comparisons for the criteria and for the decision alternatives. The second step is to follow the hierarchy relevance and to generate input data consisting of pair-wise comparison matrix of each level to find the comparative weights among the attribute of the decision elements. The nominal scale is used for quantification and the decision makers subjectively make many positive pair wise comparison matrices, each of which should pass the consistent test. The outcome of this step is the ranked order priorities of the criteria and the ranked order priorities for the decision alternatives under each criterion.

3. Calculating the weights and testing the consistency. Saaty used the principal eigenvector of the comparison matrix to find the comparative weights among the criteria of the hierarchy systems. For each N×N pair-wise comparison matrix A, by using the theory of eigenvector, i.e. \((A - \lambda_{max} I)w = 0\), to calculate the eigenvalue \(\lambda_{max}\) and the eigenvector \(w (w_1, w_2, \ldots, w_n)\), weights of the criteria can be estimated. To test the consistency of the intuitive judgment, SAATY suggested the consistency index, \(CI = (\lambda_{max} - n) / (n-1)\) to measure the degree of consistency. In general, a value of CI of less than 0.1 is satisfactory.

When the size of the consistency index is exposed to the effect of the nominal scale and the rank numbers of reciprocal matrix, then the consistency index produced from such a reciprocal matrix is dubbed a random index (RI). The test of consistency ratio (CR) has employed the comparison value of CI and RI (CR = CI/RI). CR ≤ 0.1 can be taken as sufficiently consistent.

4. Calculating the overall priorities for the decision alternatives. Finally, the overall priority for each decision alternative is calculated by multiplying the priority for each alternative under each criterion by the priority (weight) of the same criterion, and then adding them for all criteria. The outcome of this step is the ranked order of the decision alternatives. The decision maker selects the decision alternative with the highest overall priority.
3 METHODOLOGY

3.1 RESEARCH PROCESS

The survey study has been done for PNL since PNL decided to assess their suppliers’ environmental performance. PNL has no transport vehicles of its own, but purchases all its transport activities from subcontractors. For the assessment of the suppliers the company decided to form a questionnaire that will be able to reveal the environmental performance of the subcontractors on important environmental criteria. On that point they decided to work with the students. They formed up a project which all of the requirements and sample questionnaire had been explained. The first meeting was held with PNL on 7th of April. In the meeting we explained how the questionnaire should be revised and for the analysis of the result and agreed on applying the analytical hierarchy process.

The researches have been made on the necessary subjects to form a questionnaire that will be useful, reliable, valid, and scientific. The environmental aspects and the contribution of haulage transport sector to the environment have been investigated from the books and scientific articles on that subject. By doing this the most important criteria on environmentalism in transport industries have been identified.

To have efficient results from the respondents the right questions should be asked in a right way to achieve an effective questionnaire that gives the desired results that are reliable and useful. Even if the method used to analyze the data is accurate it will not lead us to right results with bad input data. We focussed on related studies and researches made on survey study to have a scientific approach in the design of the questionnaire. Our aim is to form a questionnaire in such a way to ask the questions clear and easy to understand. The answers are set in certain framework and principles for open and closed answers to be able to get the findings we search for. The related measurements of scale were applied for the questions. The questionnaire is made in such a way to keep the respondents’ motivation high. Also, the designing of the layout is important for the comprehensibility of the questionnaire by the respondents.

The survey should be able to help us to investigate, audit and evaluate the environmental performance of the suppliers. The second aim of the survey is to investigate what kind of actions the suppliers take to manage the environmental issues and the contribution of environmental aspects in the decisions of higher management. The third aim is to investigate the structure of the environmental management system of the suppliers. Questionnaire is chosen as the methodology of this survey since it does not require much effort from the suppliers, it is not time consuming. Even though it is not complex it gives standardized answers that make it simple to compile data.

Meetings were held with environmental consultants and managers from the company during this process. The aim was to choose among the environmental criteria that have the greater role and importance for the haulage transport. Discussion were made on the formation of the questionnaire, the questions and the way that they are phrased, the related answers, the measurements of scale and layout. Based on the discussions some questions were omitted, revised and added.

A draft questionnaire has been made as a pilot questionnaire for testing according to the consensus reached in the meetings. It has been sent to some of the chosen suppliers for testing. According to the replies of the suppliers and their suggestions, a final version of the questionnaire is made by meeting with the managers. The final version of the questionnaire is sent to the suppliers of the company for assessment of their environmental performance.
Because of the complexity of decision making environment, new methods should be applied in order to cope with many factors that can affect the goals. On the other hand the approach should be justifiable and appeal to our condition and it should be easy to understand.

For analysing the results of questionnaire the Analytical hierarchy Process is chosen in order to convert the qualitative data into quantitative data for better and easier way to make a decision.

3.2 SURVEY STUDY

In this thesis mail survey methodology has been used. The idea behind is that it is easier to get in contact with the subcontractors and it is most suitable for the type of questions and answers expected. The questions in this questionnaire need closed answers in general; the answers to those questions are predetermined. The answers are set with care to prevent any misleading and provide ease to the analysis. In certain cases there was a need for open questions to get a broader aspect of the field of the question asked to decrease the level of misunderstanding and misinterpretation. The use of the language is carefully phrased not to confuse the respondents. Open questions are asked in a way that the answers will fit to a certain pattern and rules that are developed by the researchers of the thesis. By this way it was aimed to keep the respondents in a certain track to make the analysis more trustworthy. Survey research involves the collection of primary data from all or part of a population, in order to determine the incidence, and interrelationships of certain variables within the population. It encompasses a variety of data collection techniques for example, questionnaire (print or electronic), interviews (face to face or telephone), and observation technique (Williamson, 2002).

3.2.1 Descriptive (or status) surveys

As the term suggests, the main purpose of a descriptive survey is to describe a particular phenomenon: its current situation, its properties and condition, that is, to answer “who”, “what” or “where” (rather than “how” or “why”) questions about it. It is also known as a status survey, that is, a survey of the status quo (Williamson, 2002).

In this thesis the descriptive survey is applied in order to investigate the current situation of PNL suppliers regarding environmentalism and what are their plan for improving green logistics and transport.

3.2.2 Questionnaire

Questionnaires are one of the tools of population surveys - main research method. Surveys usually aim at a comparative and representative picture of particular population. Social scientists use the term ‘population’ in the special sense of the group or least. They are sampling from; they also speak of this list as a ‘sampling frame’ (Gillham, 2008). Questionnaires are just one type of a range of ways of getting information from people (or answers to research questions), usually by posing direct or indirect questions. Incidentally, one of the weaknesses of questionnaires is that they seek to get answers just by seeking questions (Gillham, 2008). Quantitative investigations, as opposed to qualitative investigations, are very inflexible in nature (Björklund, 2005). Therefore it is very important considering the questions, answers, lay out, and the analysis of the gathered information carefully to increase the trustworthiness of the research. All these steps are connected to each other for the success of the questionnaire. No matter how advanced the technology used to analyse data, it cannot improve the quality of bad input data (Björklund, 2005). In research we have to balance the gains and losses in anything we choose to do (Gillham, 2008). The most common research instrument is almost certainly the self-administered questionnaire. It is principally used to collect quantitative data, but open-ended questions can be used for qualitative data (Williamson, 2002). A self-administered questionnaire is appropriate when its purpose is easily explained in printed and when the instruction and questions to be asked are straight forward (Williamson, 2002).
3.2.3 Structures and Types of Questions

The goal of writing a survey question for self-administration survey is to develop a query that every potential respondent will interpret in the same way, be able to respond accurately, and be willing to answer (Dillman, 2000). The questions are the only measurement instrument used when applying survey studies (Björklund, 2005). According to Williamson, 2002 before constructing individual question it is important to decide on the kind of information required to fulfil the research objective. If the researcher does not have an extensive understanding of either the issues to be investigated in the questionnaire, or of the target population, it is a good idea to undertake some exploratory interview with typical respondents. This usually results in a much better understanding of what questions to ask, the categories which need to be offered for specific questions, and the responses which might be expected from a specific target group.

Typical questionnaire questions can be classified in different, but sometimes overlapping, ways.

**Factual questions:** Factual questions usually come first and in chronological order. They are mainly obvious but it may be that not enough to the respondents’ selection or construction (Gillham, 2008).

**Opinion questions:** Questions about attitude, opinion, beliefs, etc are the most difficult to write and the most problematic to answer and they are not suitable for wide ranging questionnaire.

**Closed questions:** A closed question is one where the possible answers are predetermined. Where the answer is a factual one and fairly predictable, a closed question is probably better (Gillham, 2008).

**Open questions:** Open questions are only occasionally used in questionnaires because they are more difficult to analyse (and more troublesome to answer) (Gillham, 2008).

In this study, there are patterns used regarding the questions, answers and layout to guide for the development of the questionnaire. The following is the guiding principles in the design of survey questions.

3.2.4 Guiding Principles in the Design of Survey Questions

The questions are the only source that we rely on while making up a survey. It is important to make them in a right way to get the right answers. The phrasing of the questions is important to form an accurate questionnaire. The following is the checklist that we used as the principles while making up the questionnaire.

- The appearance and arrangement of the questionnaire should be attractive and it should be clearly presented.
- Take great care in deciding on questions to include. Select the questions that are essential to accomplish the objectives of the study.
- To have a clear connection between selected the questions and the aim of the study.
- Only ask one thing at a time. Sometimes a question can be phrased in a way that it actually contains two different questions.
- Make the questions as concise as possible.
- Group items logically, in coherent sections, that is, those that deal with a specific aspect of the topic or that use the same response option.
- Give clear instructions at the beginning of the questionnaire and wherever needed throughout. Make sure questions are crystal clear.
- Avoid bias in questions and alternatives for answering closed questions. Include ‘other… please specify’ category when needed.
- The questions should be phrased in order not to influence the answers of the respondent in a certain direction.
- Ask clear simply worded unambiguous questions which are free from jargon.
- Use different type of questions.
- Specify the questions in time and space (Björklund, 2005; Williamson, 2002).
3.2.5 Guiding Principles in the Design of Survey Answers

The answers also have a large influence on the findings made in a survey. According to Björklund, (2005) following is the principles that we followed in the design of the answers.

- The answers are mainly set in advance. For the open questions there are certain rules for the respondent to answer the questions.
- The answers are relevant and cover all the answers that the respondents might give. The aim is to form in such a way that no important answering alternative is missing.
- There are different types of answers to keep the respondents’ motivation high. The questions are asked in a way to prevent the survey being monotonous.

The answers can have very different characters. The type of the answers selected depends on several aspects such as the required level of detail’ how the results are to be used and what level can be achieved both practically and economically (Björklund, 2005).

According to Björklund (2005), it is important to determine which measurement scale to apply, since this determines which analysis technique is most applicable to the data. There are four different levels of measurement scales which need to be understood, as a basis for statistical analysis:

**Nominal Scale:** This scale consists of non-metric measuring data like qualitative categories without order. Examples of areas investigated with a nominal scale are attributes, characteristics, or categorical properties that identify or describe a subject (Björklund, 2005).

**Ordinal scale:** defines the relative position of object or individuals with respect to a characteristic with no implication as to the distance between positions. This type of scale is also referred to as rank order.

**Interval scale:** provides a ranking of positions, as does the ordinal scale, but the intervals of measurement are equal. The interval scale has a zero point below which scores are given a negative value if they occur, for example a temperature scale. Interval level data are less common than ordinal in the social sciences.

**Ratio Scale:** is comparable to the interval scale except to that it has an absolute zero, below which values cannot occur. The ratio scale allows one to compare the magnitude of responses or measurement. For example, frequency of library use) as long as it is in the form of 1, 2, 3, 4, 5, 6, etc. time a month) could be considered to be ratio level data, that is one could state that one person had used the library twice as often as another. Ratio level data are relatively rare in the social sciences, because few scales have true zero points.

Based on the Questions of the questionnaire, nominal scale and ratio scale are used in this study.

3.2.6 Design of the Survey Layout

The structure and design of the survey can have great influence on the response rate and thereby also the finding made (Holme and Solvang, 1997; Lundhal and Skärvad, 1999).

According to Dillman (2000), questionnaires are written in two languages. One language consists of words. The other consists of graphical symbols. These two language consist of meaningful information can be placed on a page so they work in concert stimulating a person to receive information in the same way one would receive it in an interview. They can also be in conflict, actually pulling people in two different directions so that some people proceed through a questionnaire in one way and some people in another. Therefore, two aspects of a questionnaire must be developed and placed in concert with one another.
• Information organization: the prescribed order in which we want people to process the words and other symbols used to convey the questions and all needed instructions to respondents.
• Navigational guides: the graphical used to visually direct people along a prescribed navigational path for completing the questionnaire.

It is important to think of questionnaire design as an attempt to achieve two objectives. One objective is to reduce non-response. It has been shown that respondent-friendly questionnaire design can improve response rates, but only to modest degree (Dillman, 2000).

The reduction or avoidance of measurement error is the second objective of good questionnaire design. Poor questionnaire layout can cause questions to be overlooked or bias the offered responses. A respondent-friendly questionnaire is attractive and encourages people to read words in the same order as other respondents read them. People are guided by graphical layout features from the cover page through the last question. A well designed layout prevents items or answer categories from being missed because of their location on the page (Dillman, 2000).

Initially, question topics and questions are grouped in a general way from most salient to least salient to the respondent. This decision is based on the research finding that a major predictor of response rates to mail surveys is the salience of the questionnaire topic (Dillman, 2000).

The following are the pros and cons of questionnaires:

**The advantages of questionnaires:**

• Low cost in time and money.
• Easy to get information from a lot of people very quickly.
• Respondents can complete the questionnaire when it suits them.
• Analysis of answers to closed questions is straightforward.
• Less pressure for an immediate response.
• Respondents’ anonymity.
• Lack of interviewer bias.
• Standardization of questions (but true of structured interviews).
• Can provide suggestive date for testing a hypothesis.

**The disadvantages of questionnaires**

• Problems of data quality (completeness and accuracy).
• Typically low response rate unless sample ‘captive’.
• Problems of motivating respondents.
• The need for brevity and relatively simple questions.
• Misunderstandings cannot be corrected.
• Questionnaire development is often poor.
• Seeks information just by asking questions.
• Assumes respondents have answers available in an organized fashion.
• Lack of control over order and context of answering questions.
• Questions wording can have a major effect on answers.
• Respondent literacy problems.
• People talk more easily then they write.
• Impossible to check seriousness or honesty of the answers.
• Respondent uncertainty as to what happens to data. (Gillham, 2008).
3.3 DATA ANALYSIS

The data collected by questionnaires may be either quantitative or qualitative. Questionnaires do, however, lend themselves more to quantitative forms of analysis. This is partly because they are designed to collect mainly discrete items of information, either numbers or words which can be coded and numbered as numbers (Blaxter, Hughes and Tight, 2006). One key point to be aware of when carrying out quantitative analyses is the question of causality. One of the purposes of analysis is to seek explanation and understanding. In order to demonstrate causality, one also has to find, or at least suggest, a mechanism linking the variables together (Blaxter, Hughes and Tight, 2006).

In this study data analysis is made through the empirical material provided from the survey findings. The analysis of the responses differs depending on the type of data being quantitative or qualitative. By that analysis it was aimed to evaluate and rank the performance of the subcontractors in the company. The questions asked in the survey are mainly relying on quantitative data. In the cases when a broader explanation or the opinions of the respondents needed open ended questions were asked resulting in qualitative data input. Those data are recorded, analysed and interpreted.

3.3.1 Quantitative and Qualitative Analysis

Among different kinds of data, a basic distinction between the quantitative (i.e. numbers) and the qualitative (i.e. words and everything else) might be recognized. This distinction has a major influence on how data may be analysed, and also reflects the varied ‘traditions’, philosophies and practices of different social science disciplines or sub-disciplines (Blaxter, Hughes and Tight, 2006). It may be that qualitative data offer more detail about the subject under consideration, while quantitative data appear to provide more precision, but both give only a partial description (Blaxter, Hughes and Tight, 2006). The researchers who adopt an explicitly qualitative stance can find themselves giving prominence to numbers, and vice versa. Thus if the research is made up through qualitative data, the researchers are quite likely to end up using numbers or their equivalents for the data resources (Blaxter, Hughes and Tight, 2006).

Quantitative research includes a substantial amount of literature at the beginning of the study to provide direction for the research questions or hypothesis.

3.3.2 Analyzing Questionnaires

The questionnaire that is prepared for this research includes both qualitative and quantitative data. The questionnaire included in this research has more quantitative data compared to qualitative data. This is because it was aimed to collect discrete items of information mainly depending on numbers. The questionnaire about the environmental performance of the haulage subcontractors of PNL aims to describe the relationship with the statistical information from the subcontractors and their environmental performance.

The studies that use descriptive statistics are supposed to explore the inter-relationships between pair of variables (using for example cross-tabulations). It will be adequate to say that so many respondents (either the proportion or the total) answered given questions in a certain way; and that the answers given to particular questions appear to be related. Such an analysis will make wide use of proportions and percentages, and of the various measures of central tendency (‘averages’) and of dispersion (‘ranges’) (Blaxter, Hughes and Tight, 2006).

The analysis of the results is done through using the AHP. In AHP method, the questionnaire is divided into criteria and sub-criteria. The relative weights for the impacts of those criteria and sub-criteria are decided upon the meetings, interviews and discussions held with the managers and consultants from the company. The aim was to have a numerical summary of the results. The performance of the subcontractors is evaluated according to their results from the questionnaire.
3.3.3 Primary Data

Primary data are original data collected by the researcher for the purpose of his or her own study at hand (Welman, Kruger, 2005). Primary data are data gathered and assembled specifically for the project at hand (Zikmund, 2000). In this project the primary data was collected through the questionnaire which was designed for evaluating suppliers and interviews with manager and environmental consultant.

3.3.3.1 Interview

Mostly is seen as a technique for collecting qualitative data, interviewing can be used in a range of different methods. It is one of the techniques frequently used in case studies; it can be used to supplement survey data; and also in experimental design. Interviews are used in a survey if the information sought is complicated and it is therefore difficult to ask questions simply in a self-administrative questionnaire (Williamson, 2002).

The interviews can be divided into three categories according to their structures which are structured, semi structured and unstructured interviews. Structured interviews are used where it is important to be able to compare results across respondents. There can be the flexibility for individual expression within a more formal structure (Williamson, 2002). Semi structured interviews have a standard list of questions, but allow the interviewer to follow up on leads provided by participants for each of the questions involved (Williamson, 2002). In unstructured interviews each answer basically generates the next question. This type of interview is useful for exploring a subject or gaining insights into people. Unstructured interviews are sometimes used in case studies to collect extensive data from key people. They are also often used before compiling a structured interview schedule or a self-administered questionnaire (Williamson, 2002).

Following is some of the advantages and disadvantages of the interviews according to the Williamson (2002); complex and complete responses are more likely because probing can be used, and explanation and clarification can be provided to the respondent, the interviewer has the opportunity to observe the respondents, face-to-face interaction assists in the establishment of rapport and a higher level of motivation amongst respondents, the interviewer can be a powerful stimulus – more powerful than words on paper, interviews can provide much richer data than self-administered questionnaires, research reports are enhanced by the opportunity to quote the actual words of respondents while there can be threats to validity and reliability because of ‘interviewer effect’, the personal characteristics of interviewer may bias the interview and unstructured interviews can be difficult to record and analyze.

In this project face to face interviews were used with the managers within the company and the consultants. The need for a clear understanding of PNL’s plans, policies and actions regarding environmentalism and sustainable development raised the need for interviews with managers. These interviews helped to build a mutual understanding between the managers and the researches of this project. The vision of the company, its aims regarding environmentalism and their main goals from the project is realized while the tools to search and analyze and the main areas to emphasize were determined. The interviews with the consultants created a basis for the project. Those interviews revealed their viewpoint on the approaches and goals of the project and served for the buildup of the project.

3.3.4 Secondary Data

Secondary, or historical, data are data previously collected and assembled for some project other than the one at hand. Secondary information can often be found inside the company, in the library, on the internet, or it can be purchased from firms that specialize in providing information, such as economic forecasts, that is useful to organizations (Zikmund, 2000). According to Zikmund (2000), secondary data can be always be gathered faster and at a lower cost than primary data. However, secondary data may be outdated or may not exactly meet the needs of the researcher because they were collected for another purpose. Nevertheless, secondary sources often prove to be of great value in exploratory
research. Investigation such sources has saved many a researcher from "reinventing the wheel" in primary data collection.

The chief advantage of secondary data is that they are almost always less expensive than primary data. They can generally be obtained rapidly and may include information not otherwise available to the researcher (Zikmund, 2000).

The main disadvantage of secondary data is that they were not designed specifically to meet the researchers’ needs. Therefore the researcher must examine secondary data for accuracy, bias and soundness (Zikmund, 2000).

In this project, for the literature review and analyzing part, the secondary data was obtained from the reliable sources regarding the subject. For the current status of company part the secondary data was collected from the data base of PNL Company.

3.4 RELIABILITY AND VALIDITY

3.4.1 Reliability

The concept of reliability has to do with how well you have carried out your research project. Have you carried it out in such a way that, if another researcher were to look into the same questions in the same setting, they would come up with essentially the same results (though not necessarily an identical interpretation). If so, then your work might be judged reliable (Blaxter, Hughes and Tight, 2006).

To increase the reliability of the survey study; the questionnaire is sent to a person in company who has the authority and knowledge to respond the questions, to prevent incorrect answers. The questions are asked in a way that they would not reflect any emotions and direct the respondents. The questionnaire is designed in such a way that it will keep the motivation of the respondent high thus increasing the response rate. The weightings of the criteria have been made through discussions together with managers, consultants and the researchers of this study to decrease the bias and subjectivity of the individuals involved in the study.

3.4.2 Validity

Validity has to do with whether your method, approaches and technique actually relate to, or measure, the issues you have been exploring (Blaxter, Hughes and Tight, 2006). Validity is concerned with the issue of whether a variable really measures what it is supposed to measure (Hardy, Brymen, 2004).

3.4.2.1 Internal Validity

A study’s internal validity indicates that one has investigated what one set out to investigate and nothing else, and thus the absence of methodological or systematic errors for shortcomings (Björklund, 2005). Information is always to some extent based on peoples interpretations. The internal validity must therefore be judged according to how people interpret things and not, as a positivist might argue, in a relation to an objective reality (Björklund, 2005).

During this project, we were questioning the validity of the resources that we are supposed to use. We focused on finding the unbiased, reliable and objective information. To increase the validity of our study we were searching for the sources which were independent, reliable and the researchers who have high respect and reputation. The information and documents gathered from the companies might be unbiased or subjective in the favour of the company. In such a case it can affect the validity of the study.

The environmentalism field is a lately developing area and both environmentalism and logistics are very dynamic fields. In this study the newer findings which are up to date have been used. Different sources on the same subjects have been used to increase the validity of the study.
3.4.2.2 External Validity

For a study to fulfill the demand for total generality implies that there must be no circumstances or conditions in the material studied that limit the range of the results, i.e. that the results can be applied and used outside the research area (Wallen, 1996). The study is useful when it has the possibility to be used widely and able to be generalized. The methods and tools used in this study can provide a guideline in different circumstances such as the assessment of suppliers regarding quality, operations and etc. for the company. Also this survey study can be used in different companies within the organization.
4 COMPANY BACKGROUND

In this chapter a glance of the current situation of PNL about environmentalism is given. To give the reader a reflection about PNL’s environmental aspects, the background of the organization PNL’s environmental aspects, the policy and the actions taken regarding the subcontractors and the haulage is explained in detail.

4.1 BACKGROUND

During the course of 2008, PNL carried out an environmental review of its activities. Amongst other findings, the review found that the most negative impact on the environment of the company’s activities was the transportation of parcels and pallets containing the company’s products.

Since PNL wants to make sound environmental choices while at the same time being able to contract out transport services, it needs to be able to evaluate and compare its transport suppliers in order to identify those that best comply with the company’s environmental standards.

Pan Nordic Logistics is a Nordic logistics company and is owned by Bring, which in turn is owned by Posten Norge. PNL provides solutions for companies which need their parcels and pallets transporting to, from and within the Nordic countries. Thanks to its comprehensive network and international partnerships, PNL operates deliveries to companies and private individuals in 190 countries around the world. The company’s operations are spread across its 2 parcel terminals and 8 offices in the Nordic countries. In addition, PNL outsources pick-up, delivery and line haulage services from subcontractors in Denmark, Finland, Norway and Sweden:

Pick up / Delivery:
- 24 subcontractors / subcontractors suppliers in Sweden
- Posten Norge in Norway
- Post Danmark in Denmark
- Itella in Finland

Line haul:
- 24 suppliers in Denmark, Finland and Sweden

PNL’s operations may be divided into product development, marketing, sale, picking up of parcels/pallets from customers, sorting of parcels/pallets at terminals, transporting of parcels/pallets, delivery of parcels/pallets to the customers’ customers and invoicing. In addition, the company has a support entity which manages the company’s operations, finances, IT, information and human resources.

PNL has no transport vehicles of its own, but purchases all its transport activities from subcontractors.

4.2 THE ENVIRONMENTAL POLICY WITHIN PNL

The environmental organisation of PNL is made up of six environmental coordinators. Four of them are local Environmental Coordinators who are responsible for the activities in Malmö, Göteborg, Jönköping and Bromma. The employees in those sites are responsible of the environmental consequences of their actions and are connected to their local environmental coordinators. The other two environmental coordinators are responsible for line haul and pick up/delivery respectively. Those six environmental coordinators are connected to the management representative who is responsible as the central environmental coordinator. They are responsible for carrying out the environmental tasks in accordance with PNL’s environmental policy. And all those six environmental coordinators together with the central coordinator are responsible under the executive management committee.
In the correspondences within the organization, the environmental policy of Pan Nordic Logistics is defined as the following: within its area of operations, Pan Nordic Logistics AB shall offer unique logistics solutions and thus be the ideal cooperation partner for companies that need to transport packages and pallets. The company will also work to achieve continual improvements through the following:

- within all areas of the business, i.e. transport, freight terminal, logistics and offices, prevent pollution and take actions to minimize our negative impact on the environment
- Help our employees to increase their knowledge and thus become more motivated to act in an environmentally responsible way.
- Encourage our suppliers to, from our perspective, maintain a good environmental standard through regular follow-up and feedback on environmental performance.
- Offer our customers smart environmental solutions by giving consideration to their requirements as well as the resources available to us.
- Make sure that the minimum acceptable requirements for our operations are the legislation in force.

4.2.1 The Company’s Environmental Impact

Like any other field of human industry, logistics, too, has an impact on the environment. Pan Nordic Logistics’ single most acute impact on the environment is connected with the vehicles that transport its goods and the company cars and pool cars that the company operates. Even the journeys which an international company like PNL has to carry out have an environmental impact. The company’s other operations have a minimal impact on the environment and are easier to address compared with the transport services but they deserve attention, too.

In order to reduce its environmental load, Pan Nordic Logistics issued a declaration of intent in 2004:

"We must maintain our position as the Nordic logistics leader in the parcel market. With the transport industry’s impact on the environment being a matter of common knowledge, PNL has decided to clarify its responsibilities as a logistics and transport company. PNL wants to minimise the harmful effects of its transports on the environment through environmental policy, environmental programmes and environment management systems compliant with the standards of ISO 14001. These must be implemented by all of the company’s business units and the head of each unit will be responsible for ensuring their implementation".
Also in 2004, PNL introduced an environmental policy whose objectives are as follows:

- In conjunction with its customers and subcontractors, PNL must work continuously towards improving the environment and reducing emissions. This objective must be communicated throughout PNL’s network and to all of the company’s customers.
- PNL must outsource services from environmentally-conscious subcontractors who operate modern, energy-saving and well-maintained vehicles.
- PNL must continuously increase awareness about environmental issues within the company.
- PNL must consider quality and the environment in addition to its financial status when making all decisions and with respect to each and every component of its organisation.
- PNL and its subcontractors must comply with the requirements laid down in environmental legislation.
- PNL must provide the financial and human resources required to maintain its environmental policy, environmental programmes and environment management system.

The company’s declaration of intent stated in an environmental program reads as follows:

"Of all the company’s activities, lorry transport has the biggest impact on the environment. In order for the company to keep its environmental load as low as possible; PNL has imposed the following requirements in addition to those imposed by the authorities on companies engaged in transporting our goods. In order to achieve improvements on a continuing basis, we have added to our list of requirements the substitution principle which stipulates that when an equivalent product with a lesser environmental impact is available, it must be used”.

In Sweden, Pan Nordic Logistics has a comprehensive pick-up and delivery parcel network operating on a delivery consolidation basis, which means that different hauliers’ goods are loaded onto a single shipment in order to benefit Pan Nordic Logistics, its customers and the environment.

Pan Nordic Logistics’ management is charged with the task of ensuring that the company’s transport capabilities are used as fully as possible. When line-hauling pick-up and delivery trips, PNL uses a computer programme called TMS (Transport Management System) in order to optimise haul lines. Such optimisation also has a very good environmental effect because it reduces the total number of the routes used.

4.2.2 Environmental Investigation in PNL

Like all the other human activities Pan Nordic Logistics, as a logistics company has environmental impact also. For Pan Nordic Logistics the greatest environmental impacts are associated with the vehicles that are carrying the goods, and the services/preferences/vehicle pool contained in the company. The trips have a significant impact on the environment since PNL is an international company. The company's other activities have a minimal environmental impact, but these are important and in many cases much easier to fix.

The study shows that it is difficult to collect data when there are no procedures for the tasks investigated. Developing procedures to minimize the manual work is possible in most cases but it takes time. This means that PNL starts at a position where the company lacks the history and the ability to manage the environmental goals is hampered.

In the case of PNL’s subcontractors, PNL is far ahead as to make demands and have the possibility to render account of their distances travelled and spent fuel. Both of these data serves a basis to calculate PNL’s environmental impact related to transport in all respects. It is one of PNL’s most significant environmental aspects.
In the case of services/preferences/vehicle pool, PNL has strong environmental standards in their vehicle policy. Within three years when all the current vehicles are replaced, there will be no environmental problems regarding the vehicles.

Staff travel is governed by PNL’s travel policy which favours to meetings less than two hours shall be carried out with PNL’s video equipment. They suggested complementing Gothenburg office with such equipment and the timing of two hours to be reviewed.

To develop and implement the processes, monitoring is required which is currently missing. To pass a certification under the ISO 14 001, great demands from corporate management should be set in the first place in support of the implementation process. It is natural that employees prioritize what they primarily have as their daily task in the business, and everything beyond lower priority. It is only the top management that can prioritize environmental aspects up by its full support.

Based on the results of this investigation, the major customer requirements and management’s commitment is proposed that, management takes the decision to carry out an implementation process that will lead to an ISO 14 001 certification within one year.

4.2.2.1 Requirements of legislation

To ensure that Pan Nordic Logistics shall always follow the relevant regulations in Sweden, PNL subscribed to Environmental Guide Plus. Environment Wizard Plus is a web-based tool in which all relevant provisions of activities are published in a draft drawing that is created uniquely for Pan Nordic Logistics activities. At the legislative changes, e.g. new, deleted or changed laws, the legislative subscription is updated and PNL receives a mail about the change and can interpret what it means for PNL’s business.

4.2.2.2 Criteria for evaluation of environmental aspects

The evaluation of Pan Nordic Logistics environmental aspects has started from April / May 2008. The organization is keen on addressing their impact on the environment and being environmental friendly by decreasing their negative impact on the environment. They made a plan and a balance list depending on their environmental impact. The balance list includes two parts which are the company’s direct environmental impact and the impact caused by the transport activities of the subcontractors which is indirectly none the less significantly affecting the company’s environmental performance. Evaluation is based on these two actors “the company’s environmental impact” and “transport – subcontractors’ impact”. The criteria for PNL’s environmental impact includes; consumption of office supplies, residues and wastes, purchasing - transport work, cleaning, energy consumption in offices, missions, environmental risks of accidents, Nordic, national and local environmental issues and requirements, and education. The transport-subcontractors criterion includes their emissions. The criteria are ranked according to the environmental review made within the company. The impact and the volume of these sub-criteria are ranked between one and four (Table 1), if the value of the sum of volume and impact is equal to five or more it is regarded as the significant environmental aspect. This means that environmental objectives will be based on these aspects.

A number of activities have been included in the action plan. These are also followed up and they form the basis for the formulation of environmental objectives. There are also a number of environmental aspects with lower scores, which is to be followed up in similar ways when they are regarded as having a great symbolic value.

The environmental impacts of environmental causes are described in Table 2, based on the Swedish Environmental Protection Agency list of the 14 greatest environmental threats. These are set for every environmental aspect of Pan Nordic Logistics to get an idea of the environmental business creates.
Table 4.1 Criteria for the Evaluation of environmental aspects (PNL internal).

<table>
<thead>
<tr>
<th>Score</th>
<th>Criteria</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>a) Significant impact on the environment which is / can be a threat to the environment and / or its survival.</td>
<td>a) Threats can occur to the firm’s activities, for example, if the requirement for costly restructuring / measures may mean that the company not meet their financial commitments.</td>
</tr>
<tr>
<td></td>
<td>b) Serious deviation from the requirements of environmental legislation which poses a threat to its survival.</td>
<td>b) With environmental laws here means all laws, regulations and other regulations affecting the business environment and health impact, chemical substances, products and services.</td>
</tr>
<tr>
<td></td>
<td>c) The environmental impact is not sufficiently clarified. New score is made after the investigation / evaluation.</td>
<td>c) A final score of the environmental impact is anticipated following completion of the investigation / evaluation, which may mean that the assessed risk to the environment may be valued again.</td>
</tr>
<tr>
<td>3</td>
<td>a) The environmental impact which is / can be a serious risk to the environment.</td>
<td>b) With environmental laws here means all laws, regulations and other regulations affecting the business environment and health impact, chemical substances, products and services.</td>
</tr>
<tr>
<td></td>
<td>b) Deviation from the requirements of environmental legislation which may imply a judicial review.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c) Lack of instructions / procedures that may cause serious risk to the environment of improper handling.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>a) The environmental impact which is / can be a demonstrable impact.</td>
<td></td>
</tr>
<tr>
<td>Score</td>
<td>Criteria</td>
<td>Comment</td>
</tr>
<tr>
<td>-------</td>
<td>----------</td>
<td>---------</td>
</tr>
<tr>
<td></td>
<td>b) Minor deviation from regulatory decisions, conditions for the activities under environmental legislation.</td>
<td>b) With less tolerance for example. Temporary overshoot of benchmarks and other provisions related to business environmental and health impact, chemical substances, products and services.</td>
</tr>
<tr>
<td></td>
<td>c) Deviations to indicate that conflicts with future environmental legislation may arise in the future.</td>
<td>c) As an example, the chemical substances listed in the Chemical Inspectorate's PRIO.</td>
</tr>
<tr>
<td></td>
<td>d) Lack of instructions / procedures that may cause demonstrable impact on the environment and / or significant additional costs for the company.</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>a) Low but detectable environmental impact.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) Lack of instructions / procedures that may cause less impact on the environment, considerable additional costs for the company, bad publicity and / or are otherwise expected to improve environmental performance.</td>
<td>For example aspect that today is considered strength of the company.</td>
</tr>
<tr>
<td>-</td>
<td>Not commented further.</td>
<td></td>
</tr>
</tbody>
</table>
Table 4.2 The description of the environment table is based on EPA's list of environmental threats (PNL internal).

<table>
<thead>
<tr>
<th>Nr</th>
<th>Environmental</th>
<th>Nr</th>
<th>Environmental</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Greenhouse</td>
<td>8</td>
<td>Organic pollutants</td>
</tr>
<tr>
<td>2</td>
<td>ozone depletion</td>
<td>9</td>
<td>Distribution of alien organisms</td>
</tr>
<tr>
<td>3</td>
<td>Acidification of soil and water</td>
<td>10</td>
<td>Threats to biodiversity</td>
</tr>
<tr>
<td>4</td>
<td>Photo oxidants / ground level ozone</td>
<td>11</td>
<td>Use of natural resource</td>
</tr>
<tr>
<td>5</td>
<td>Urban Near air problems and noise</td>
<td>12</td>
<td>Exploitation of land</td>
</tr>
<tr>
<td>6</td>
<td>Eutrophication</td>
<td>13</td>
<td>Waste</td>
</tr>
<tr>
<td>7</td>
<td>Effect by metals</td>
<td>14</td>
<td>Other unspecified (in NV's definition comprises the fourteenth threat of ionizing radiation)</td>
</tr>
</tbody>
</table>

4.3 CHOOSING SUBCONTRACTORS FOR TRANSPORT SERVICES

PNL provides logistical solutions as well as distribution and supplementary services to companies and private individuals who need their goods transporting to, from and within the Nordic countries. Since the company does not have any vehicles of its own, it relies exclusively on subcontractors to carry out its transport services. From today’s perspective, transport represents one of the major environmental threats of our time, harming the environment through climate change, to name but one of its negative impacts. The ever increasing pressure on the environment results in loss of biodiversity and ever poorer living conditions in large urban areas.

Following an environmental review which PNL carried out in 2008 with a view to identifying the most harmful environmental aspects of its business, it became clear that transport comes top of the list and that the company can only influence its negative impact in this regard through indirect means, i.e. by carefully choosing its transport suppliers and assessing their impact on the environment.

PNL operates transport services to and/or from 190 countries, all of which have achieved varying degrees of environmental maturity. This is why our ability to influence and, therefore, steer these countries’ activities in a direction that has a positive impact on the environment is highly relative. For this reason, the company’s transport suppliers in the Nordic market will be the primary object of this environmental assessment/evaluation.

Of all PNL’s activities, transport services have the biggest impact on the environment. In order for the company to minimise its negative load on the environment as much as possible, it makes use of current knowledge and enforces the following requirements on its transport services, in addition to those imposed by the authorities.

In the current situation of the company, there is no assessment made regarding the real impact of the products, services and the transport work on the environment. Consequently, there is no evaluation of suppliers’ environmental work or if the service / product from any perspective constitute "good environmental choice" in its range.
PNL tends to reduce its direct and indirect negative impacts on the environment therefore; they started making investigations on their subcontractors. The aim is to evaluate the environmental performance of the suppliers and purchase the service with less harm to the environment when all the other variables are the same. One problem with these investigations was to find a scientific, reliable and consistent way to evaluate the results of these investigations. Even though they collected the data regarding the environmental performance of the supplier before no valid way to evaluate the performance was used before. The outcomes of those surveys were blurry. The aim of our study is to provide PNL a method such that it can use the relevant information to evaluate the environmental performance of the suppliers in an accurate, reliable, efficient way.

A supplier assessment must be carried out and documented for each purchase of transport services and an annual supplier evaluation must be carried out in order to ensure compliance with the company’s requirements.

The company may request sight of any data relating to routes, fuel consumption, tyre consumption etc.

Suppliers must be able to provide evidence of compliance with the following requirements.

4.3.1 Requirements for Subcontractors

Basic requirements

PNL suppliers must:

- be well-acquainted with the environmental impact of their activities
- incorporate environmental concerns in their decision-making
- disseminate knowledge of environmental preservation measures among their employees and suppliers.

Fuels

Vehicles must use fuel of the best environmental class available.

Other chemicals

When purchasing chemicals, the company must exercise the best environmental choice by taking account of any instructions issued by the manufacturer. The substitution principle must apply here, i.e. when a product with a lesser environmental impact and equivalent technical properties is available, it must be used.

Tires

Lorry and trailer tyres, whether new or retreaded, may not contain oils which are subject to labelling requirements laid down by EU directives. Where tyres have to be replaced, retreaded tyres must be used as a first recourse whenever technically possible.

Wind deflectors

Vehicles with an internal cabin height of more than 2 metres which are primarily used for road haulage must be equipped with wind deflectors adjusted appropriately to the cabin height.
Engine heaters

All vehicles must be equipped with timer-fitted engine heaters which must be turned on every time a vehicle is parked in standard parking areas. Engine heaters should remain turned on for as short duration as possible.

Cleaning of vehicles

Cleaning of vehicles or load units of any type must be carried out at facilities which comply with the registration requirement laid down by local authorities.

Service/Maintenance

Vehicles must be serviced/ maintained at facilities which allow the company to exercise the best environmental choice when purchasing chemicals, by taking account of any instructions issued by the manufacturer, and which manage all their waste in accordance with the local authority sanitation schemes. The substitution principle must apply here, i.e. when a product with a lesser environmental impact and equivalent technical properties is available, it must be used.

Waste

Whenever hazardous products (such as batteries, tyres, glycols, paints, oils etc.) are disposed of, they must be handed over for recycling or destroyed in a prescribed manner.

Purchase of new vehicles

When purchasing new diesel-powered vehicles with a weight above 3.5 tonnes, the company must ensure that such vehicles are equipped with the best Euro/Environmental Class engines available at the time of purchase.

Training

Drivers and transport managers must possess all the practical and theoretical knowledge concerning fuel-efficient driving and transport planning required to carry out their duties.

The IKEA Way on Distributing Home Furnishing Products (IWAY)

The company’s subcontractors must abide by the provisions of IWAY.
5 DESIGN OF SURVEY

At the start of the project, there was an initial questionnaire that was prepared for PNL use. The aim for the company was to revise and improve that questionnaire in an independent and scientific way. The company’s expectation from that project was to have a questionnaire that is not too complex, that is easy to understand and easy to use while covering the necessary and important environmental aspects. Also, a useful and accurate tool was required for the company to evaluate the results of the answers given by suppliers when the questionnaire is to be used.

To achieve the desired objectives scientific approach was needed. At this point as the researchers of this project, we started working on the relevant literature review to build up a scientific, efficient and reliable questionnaire and tool for assessment of suppliers. The aim was to achieve the connection between the questionnaire and the literature regarding the environmental aspects. Together with the literature review, interviews with the experts and managers within the company also helped to clarify the current situation regarding environmentalism within the company and build the project in a way that it would assist the company’s requirements.

Depending on the environmental studies and our reflections on the case, revisions on the questionnaire have been made. This process included meetings and discussions with the company. Based on the reflections from these meetings and brainstorming, the questionnaire has been revised several times to achieve the most proper one. At the end of that process, a pilot questionnaire has been prepared to get the results and the reflections from chosen suppliers. The next step was to make the necessary changes based on the outcome from the suppliers to reach the point to meet the requirements of PNL and on the other hand being easy to understand for the suppliers. The information should be in a character that the suppliers can provide also. The outcome of these processes led us to the final version of the questionnaire.

5.1 THE DESIGN OF THE QUESTIONNAIRE

The approach for preparation of the questionnaire is done by top to bottom approach. When the relevant sources within the area of environmentalism and the necessities for the company had been determined building of the questionnaire started. Eleven important aspects were determined at first step to persuade the suppliers to take actions in an environmental prospect and to assess their environmental performance. Those eleven standpoints included:

- Basic Requirements (Regarding Environmental Management)
- Fuels
- Other Chemicals
- Tires
- Wind Deflectors
- Engine Heaters
- Cleaning of Vehicles
- Service and Maintenance
- Waste
- Purchase of New Vehicles
- Training
- The IKEA way on distributing home furnishing products (IWAY)

The next step was to evaluate the most relevant and important criteria for the questionnaire. It was done by taking into account the relevant literature review and the experiences and information gathered from the company to best meet the objectives of the survey. The challenge was to choose the criteria in such a way that they can reflect the environmental performance of the suppliers and is reliable. The complexity and the extent of the questionnaire should not confuse the respondents and decrease their motivation while answering the questionnaire. Such a case might lead to increase
inconsistency of the answers given which will result in decrease of the reliability of the results taken from the questionnaire.

As a result, the relevant questions to satisfy the expectations from the questionnaire had been aggregated under the relevant criteria. The final criteria in the questionnaire are defined as:

- Environmental Management System
- Vehicles
- Fuel Consumption
- Training
- Data Generation

Environmental Management System criterion included the basic requirements for the management of the environmental aspects of the subcontractors. The aim was to understand and evaluate if the subcontractors have environmentalism in their decision making procedure, what priority environmentalism has, if they meet the standards set by organizations such as ISO and so forth.

Vehicles criterion is created so that PNL Company can get a reflection about its subcontractors’ fleet management, the EURO class of the vehicles and the average age of the fleet meanwhile checking if the subcontractors are including more environmental friendly fuels in their purchases.

Fuel Consumption part is related with the average fuel consumption of the subcontractors, keeping their track and comparing with their consumption with previous years and also with other subcontractors. On the other hand if they care about fuel efficient driving and dangerous gases and particles emitted to the atmosphere as a result of their organizations activities.

Training is the part where subcontractors’ educational and training policies are questioned to assess how they are managing the environmental awareness within their company and if and how much they train their workers.

Data Generation criterion is related to the information about the aspects that are related to the environmentalism. The aim in this part is to check how accurate they keep track of their information regarding the routes and distance travelled by their vehicles.

The questionnaire starts with an introduction part describing the intention of PNL about the questionnaire. The aim in this part is to inform the respondents about PNL’s new policy on choosing the suppliers that are environmentally conscious, that are aware of their environmental responsibilities. It was aimed to clarify the questions that might arose by the respondents about the importance and operation of the process and making them more reluctant to respond to the questionnaire and consider their actions regarding environmentalism seriously as PNL’s strategic partners.

The Organizational Information part situated after introduction and before Environmental Management Systems criterion aims to gather relevant organizational information and key contacts in case of any problems. The sections include the name of the company, registration number, address, telephone and fax numbers, e-mail and website, the transport insurance, and key contacts. The relevant contact addresses should be filled here.
The questionnaire ends with a declaration part in which the name and position of the respondent is taken to make sure that it is filled by an authorized person that has enough responsibility to fill up the form. The aim is to increase the reliability of the answers to the questionnaire by making sure that the form is filled by an authorized person that would respond to the questionnaire with the highest of devoutness and also that might be contacted in any case of inconsistency. A section of explanatory documents is also included to make sure that every related document is attached to check the consistency of the answers. The scores of the subcontractors are determined according to those answers. The values of the answers are pre-determined to be between [0, 1]. The respondent gets the score according to the defined procedure for each question depending on their performance regarding the question. The procedure how to determine what score respondent will get for each question will be explained in analysis part for each question included in the questionnaire.
5.2 ENVIRONMENTAL MANAGEMENT SYSTEM

To achieve high environmentally performing organisations, having a consistent and continuous environmental policy is needed. The management’s role is very crucial in that case. The management should be aware of its environmental responsibilities and should support the environmental policies with attention. Environmentalism is a newly improving subject because of that reason in many cases implementation of environmentalist approaches in the companies means a change in the performing and priority of the actions. In such a case to control the disturbances and resistances in the company during the change, management’s support gains high importance. The organisations can turn into become environmentally conscious, only by managements that are aware of their responsibilities and roles.

The goal of Environmental Management System criterion is to understand and assess the performance of management regarding environmentalism. By this criterion it is aimed to get the reflection about the subcontractors’ policies, if environmentalism is included in the policies and what its priority is, also if they standardized their procedures.

5.2.1 Environmental Policy

Q1. Do you have environmental policy approved by the management? If yes please enclose □ yes □ no

This question helps PNL to see the environmental policy of the subcontractors. If the responding subcontractor has a policy regarding environmentalism, it will help PNL to check if the subcontractor’s policies are in parallel with PNL’s future plans with regard to environmentalism. Suggestions and co operations can be made depending on that policy to achieve a healthier partnership in the future. It will also show that the organisation has plans on environmentalism and they consider
environmentalism in their decision making process. The respondent will get the score of 1 for a positive answer and the score of 0 for a negative answer. It should be considered that having a written policy on environmentalism is binding aspect it that case no matter how broad or narrow the policy is. That is due to a written policy will indicate that suppliers have environmentalism in their decision making process and any further partnerships and suggestions can be made according to their policy and PNL’s demands.

5.2.2 Environmental Reports

<table>
<thead>
<tr>
<th>Q2. Will you be able in future to provide PNL with an annual environmental report containing details of</th>
</tr>
</thead>
<tbody>
<tr>
<td>• your consumption levels</td>
</tr>
<tr>
<td>• emissions</td>
</tr>
<tr>
<td>• the level of attainment of your environmental targets</td>
</tr>
</tbody>
</table>

The reports of the subcontractors’ activities are needed for PNL to keep track of the consequences of their logistics activities. It will help PNL to compare and evaluate their performance with regard to the previous years and also with the other subcontractors. Also subcontractors will be able to keep track of their performance and by this way they can evaluate and compare their performance with the previous years’ which will increase their awareness about their environmental performance and help to find and solve the problematic areas. The second part together with the first persuades respondents to keep track of their activities. The score for each question will be 1 for a positive answer and 0 for a negative answer.

5.2.3 Standardization

<table>
<thead>
<tr>
<th>Is the organization currently registered to any of the following standards:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference Standard</td>
</tr>
<tr>
<td>Q4a: ISO 14001:2004</td>
</tr>
<tr>
<td>Q4b: ISO 9001:2000</td>
</tr>
<tr>
<td>Q4c: EMAS</td>
</tr>
</tbody>
</table>

The standardization of processes is very important to have consistent systems. There are independent bodies checking the standardization of processes. It is an important criterion to be admitted by those institutions like ISO to prove that the organisation is performing environmental friendly. ISO 14001 or Eco-Management and Audit Scheme (EMAS) will help to reflect the subcontractors’ situation to the company. The last question aims to persuade the subcontractors to introduce in the future if they do not have those currently. The positive answers for those questions are assigned with 1 and negative answers are assigned with 0. For the last question if the respondent has an intention to introduce one of the mentioned standardization system they will be assigned with the score of 1 for that question no matter which one. If the respondent has all of the mentioned standards they will be assigned with the score of 1 for the last question also.
5.2.4 The Reflection of Respondents:

<table>
<thead>
<tr>
<th>Q5. How environment friendly do you think your company is? Comment why? (1 indicates negative, 7 indicates positive)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
</table>

This question is included in the questionnaire to reflect their situation in their own words. That question has a qualitative sense differently from other questions. It is aimed in this question not to miss any important aspects regarding environmental management in the subcontractors’ sense. By this question, the management’s plans about environmentalism and the importance and priority of environmentalism while taking decisions in their mind set. Information regarding organisation’s environmental ambitions and objectives are better realized. The part which has the ordinal scale is to keep track of how environmental friendly the supplier thinks their environmental performance is and to keep track of the changes in their opinion for the future. That part will not affect the score for that question. The respondent will get a score between [0, 1] according to the answer they had given.

5.3 VEHICLES

The management of fleet is an important aspect in the performance of a subcontractor in haulage field. The consumption and emission levels of vehicles are closely related with the age, the EURO class and the type of fuel of the vehicles. It is no doubt that, a younger fleet will perform better and the decrease of the performance of the engines due to aging will be less. The EURO class is another crucial parameter. With the introduction of newer EURO regulations, there are important improvements made about emission of hazardous gasses. There is significant decrease in the Green House Gasses such as carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydro fluorocarbons (HFCs), per fluorocarbons (PFCs), and sulphur hexafluoride (SF₆) emitted into the atmosphere with each EURO regulations put. The higher the EURO class of the vehicle, the more environmental friendly the vehicle is. Another aspect we suggested important to evaluate is the type of fuels used for the vehicles. The heavy vehicles are most generally equipped with diesel engines. There are not many options to choose environmental friendly fuels. On the other hand, for the light duty vehicles there are a number of different fuel types to choose from. Those options such as ethanol, biogas, RME prove to be more environmental friendly compared to fossil fuels. Also, if a subcontractor chooses different kind of fuel types other than fossil fuels it gives a reflection that the subcontractor is environmentally conscious and aware of the economic results of fossil fuels. From the previous questionnaires and the pilot questionnaire it is seen that the suppliers have an intention to fill the model year part but not the EURO class part, the EURO class part was neglected while giving the scores because of that reason for this time. The scoring for the model year is done based on the average age of the fleet. 2009 is assigned with the value of 1, 2008 with 0.9, 2007 with 0.8 and so on. The supplier gets the score accordingly, for example if the average age of the supplier’s fleet is 2006.35, the supplier will get the score of 0.735 from that part. The fields for the vehicles older than 5 years old are painted with a light res colour indicating that case is not preferred. For the score that will have no effects other than decreasing the average age but the records of vehicles older than 5 years will be kept and it will be suggested for the suppliers to change those vehicles with newer ones to decrease the negative effect on the environment. It is not common for heavy duty vehicles to use different kinds of fuels other than diesel, the researchers are still continuing on that. But the light duty vehicles that is not the case. If the subcontractors have any heavy-duty vehicles running with fuel other than fossil fuel they get the score 1 for that question. The suppliers get 1 for that question if 25 % of their light-duty fleet is running with fuels other than fossil fuel.
**Vehicles**

The number of vehicles (of which are heavy-duty and light-duty vehicles) used to supply services to PNL on a full-time or part-time basis is:

## Heavy-Duty Vehicles

How many HD vehicles does your company have?

<table>
<thead>
<tr>
<th>Year</th>
<th>Number</th>
<th>for PNL use</th>
<th>Type</th>
<th>Number</th>
<th>for PNL use</th>
<th>Type</th>
<th>Number</th>
<th>for PNL use</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;2002</td>
<td></td>
<td></td>
<td>Euro 0</td>
<td></td>
<td>Diesel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td></td>
<td></td>
<td>Euro I</td>
<td></td>
<td>Ethanol</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td></td>
<td></td>
<td>Euro II</td>
<td></td>
<td>Biogas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td></td>
<td></td>
<td>Euro III</td>
<td></td>
<td>RME</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td></td>
<td></td>
<td>Euro IV</td>
<td></td>
<td>Other</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td></td>
<td></td>
<td>Euro V</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td></td>
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<tr>
<td>2008</td>
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<tr>
<td>2009</td>
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<td>Total:</td>
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</tr>
</tbody>
</table>

## Light-Duty Vehicles

How many LD vehicles does your company have?

<table>
<thead>
<tr>
<th>Year</th>
<th>Number</th>
<th>for PNL use</th>
<th>Type</th>
<th>Number</th>
<th>for PNL use</th>
<th>Type</th>
<th>Number</th>
<th>for PNL use</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;2002</td>
<td></td>
<td></td>
<td>Euro 0</td>
<td></td>
<td>Diesel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td></td>
<td></td>
<td>Euro 1</td>
<td></td>
<td>Ethanol</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td></td>
<td></td>
<td>Euro 2</td>
<td></td>
<td>Biogas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td></td>
<td></td>
<td>Euro 3</td>
<td></td>
<td>RME</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td></td>
<td></td>
<td>Euro 4</td>
<td></td>
<td>Other</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td></td>
<td></td>
<td>Euro 5</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>2007</td>
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<td>2008</td>
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<tr>
<td>2009</td>
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<td>Total:</td>
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</tr>
</tbody>
</table>
5.4 FUEL CONSUMPTION

Nowadays the role of fuel consumption is getting more remarkable than previous and the efficient fuel consumption lead to decrease in the negative environmental effects. Another important advantage of consuming efficiently for the company is the decrease in costs. In this questionnaire the questions regarding fuel consumption and condition of Lorries are asked in order to identify efficiency of supplier in fuel consumption.

5.4.1 Consumption

Due to differences in keeping track of fuel consumption to the suppliers, different methods for calculating of fuel consumption are asked in questionnaire. Although the third version is more revealing the first version is used since the suppliers replied that they do not have the necessary database after the pilot testing. It was planned to use bell curve for calculating the performance of the suppliers about fuel consumption and another approach would have been grouping the similar driving characteristics together, such as inside big city driving. But in this study there were only 13 suppliers responding on time so it was not possible to group the suppliers nor using the bell curve since the number of suppliers was so few to compare for those methods. It could be a good suggestion to use when all of the suppliers reply; use of bell curve will give a fairer grading between suppliers. Instead of those methods it was used to compare the suppliers among each other directly with their proportion. The supplier with the least average consumption is chosen as the reference point and assigned with the score of 1 then the score of the other suppliers are defined accordingly. For example, if the least consuming supplier has the average consumption of 9.5 liters per 100 kilometers and the compared supplier consumes 12 liters per 100 kilometers the score that the supplier gets found as 9.5/12 which makes 0.79.

Version 1

<table>
<thead>
<tr>
<th>Fuel Consumption</th>
<th>Liters per 100 km</th>
<th>For PNL use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumption</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q1. Average fuel consumption for light-duty freight vehicles?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q2. Average fuel consumption for heavy-duty vehicles used for local services?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q3. Average fuel consumption for heavy-duty vehicles used for long-distance services?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In this version the questions and answers are formulated based on the liter per 100 KM. This method is easy to calculate. Although the result from this method will not be too enlightening but sill it will help us to keep track of the suppliers’ efficiency on fuel consumption.
**Version 2**

<table>
<thead>
<tr>
<th>Fuel Consumption</th>
<th>Total Amount</th>
<th>For PNL use</th>
</tr>
</thead>
<tbody>
<tr>
<td>How much kilometres do your HD vehicles make yearly?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How much kilometres do your LD vehicles make yearly?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How much fuel do your HD vehicles consume yearly?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How much fuel do your LD vehicles consume yearly?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In this version questions and answers are formulated based on amount of travelled distance and amount of consumed fuel. This method is easy to calculate but we cannot keep the track of the fuel consumption of HD vehicles in local service, since the consumption change significantly inside and outside of cities and also it depend on load traffic of area. If the fuel consumption of HD vehicles in local service is considered in the questions, the information will be more explanatory but this way will take more space in the questionnaire and it make the respondent bored to answer the questions.

**Version 3**

<table>
<thead>
<tr>
<th>Fuel Consumption</th>
<th>Total Amount</th>
<th>For PNL use</th>
</tr>
</thead>
<tbody>
<tr>
<td>How much ton-kilometre do your HD vehicles carry for local services yearly?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How much ton-kilometre do your HD vehicles carry for long-distance services yearly?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How much ton-kilometres do your LD vehicles yearly?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How much fuel do your HD vehicles consume for local services yearly?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How much fuel do your HD vehicles consume for long-distance services yearly?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How much fuel do your LD vehicles consume yearly?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In this version questions and answers are made based on ton-kilometers. In this method the weight of the load is multiplied by the distance travelled. By this way we can have more precise and more enlightening reflection on the fuel consumption, but the calculation will be too complex and it is not easy to answer by suppliers, on the other hand transport work in ton kilometer should be calculated for each transport journey.
5.4.2 Fuel Efficient Driving

<table>
<thead>
<tr>
<th>Q4. Does your company have promotion system for fuel-efficient driving style?</th>
<th>□ yes □ no</th>
</tr>
</thead>
<tbody>
<tr>
<td>For example, bonuses, competitions etc.</td>
<td></td>
</tr>
</tbody>
</table>

To get some further understanding of supplier’s efficiency in fuel consumption the question is asked regarding promotion system for fuel efficient driving. The idea behind the question is that how the suppliers motivate drivers to consume less. The supplier gets the score of 1 if they reply yes to that question and gets the score of 0 if they reply no.

5.4.3 Engine Idling

<table>
<thead>
<tr>
<th>Q5. Does your company have a policy for engine idling?</th>
<th>□ yes □ no</th>
</tr>
</thead>
</table>

This question is asked due to harmfulness of idling to the environment and human. Idling leads to waste fuel and money, also unnecessary idling causes the more air pollution and it is harmful for engine as well. The supplier gets the score of 1 if they reply yes to that question and gets the score of 0 if they reply no.

5.4.4 Emission Level

<table>
<thead>
<tr>
<th>Q6. Do you calculate your emission levels?</th>
<th>□ yes □ no</th>
</tr>
</thead>
</table>

Due to the significant impact of emission to the environment, the question is asked in order to identify the performance of the suppliers in keeping track of the emission level. Less emission level will lead to less harm to the environment. Also keeping track of the emission level, lead to more attention to the fuel consumption because there is a direct proportion between emission level and fuel consumption, for instance if the consumption is less, then the emission level would be less also. The supplier gets the score of 1 if they reply yes to that question and gets the score of 0 if they reply no.

5.4.5 Equipments

<table>
<thead>
<tr>
<th>Q7. How many of your vehicles are equipped with the following components?</th>
<th>Number</th>
<th>For PNL use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particulate filters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catalytic converters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exhaust gas recirculation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engine heaters</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This question is asked due to importance of engine in emission level and fuel consumption. One of the technical improvement possibilities regarding green logistics is equipping the engines with the aforementioned components. According to Blinge, 1996 the development towards cleaner and more efficient engines have progressed fast during the last years. The NOx-emissions have been reduced with about 30% for a heavy lorry produced in 1993 compared to one produced in 1986. the corresponding figure for particles is 70% and for other emissions and fuel consumption about 10%.
The development of the catalytic converters for passenger cars has indeed lowered the harmful emissions from road traffic. (Blinge M, 1996).

The score of the suppliers in those questions are assigned according to how much proportion of their fleet has the intended equipments. To say if they have 30 engine heaters and 50 cars they get the score of 30/50 which makes 0.6.

### 5.5 TRAINING

In order to promote the environmentalism thinking among the staff and drivers in company, training program regarding traffic safety and fuel efficient driving style should be implemented. By this method company can teach the drivers, how to drive more economically and to decrease fuel consumption as well.

<table>
<thead>
<tr>
<th>Theory Training</th>
<th>Number</th>
<th>For PNL use</th>
</tr>
</thead>
<tbody>
<tr>
<td>How many drivers do you employ?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q1. How many of these have undergone theory training for fuel-efficient driving techniques?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Name of training program:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q2. Do they hold a certificate?</td>
<td>yes</td>
<td>no</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Practical Training</th>
<th>Number</th>
<th>For PNL use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q3. How many of these have undergone practical training of some kind in fuel-efficient driving techniques?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Name of training program:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q4. Do they hold a certificate?</td>
<td>yes</td>
<td>no</td>
</tr>
</tbody>
</table>

In this part the questions are formulated in order to clarify the suppliers’ performance in training the staff and drivers. The questions are divided in theory and practical parts in order to getting more informative data about training program.

According to Blinge M, 1996 the driving behavior can affect the fuel consumption with up to 25% for a passenger car (Laurell, 1985). The fuel consumption increase about 10% when the speed rises from 70 to 80 Km/h and up to 30% if the speed is further raised up to 90 Km/h. Thus, education of the drivers on how to drive environmentally friendly, preferably in connection with a bonus, can be a cheap and effective way to reduce the environmental load.

The score at those questions are defined according to the percentage of the drivers that have undergone training to the number of drivers. For example if the subcontractor has 10 drivers and 6 of them have undergone training then they get the score of 0.6 for those questions. Also the amount of the drivers with the certificate to the total number of drivers gives their score on the related question. It is the same way the score of the drivers who have undertaken training is calculated. The record of the certificate they hold is kept to make a comparison.
5.6 DATA GENERATION

Documenting data regarding distance and travelled route is important, in order to clarify how much distance they travelled and how much they consumed. For keeping track of these kinds of data they should be able to generate the data in an efficient way.

<table>
<thead>
<tr>
<th>Data Generation – Consumption</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1. How do you generate data on your vehicles’ fuel consumption?</td>
<td>For PNL use</td>
</tr>
<tr>
<td>□ Via special data support Name of system/software</td>
<td></td>
</tr>
<tr>
<td>□ Driver’s notes, as per fuel invoices / tachograph readings</td>
<td></td>
</tr>
<tr>
<td>□ Two-card system</td>
<td></td>
</tr>
<tr>
<td>□ Other, please specify:</td>
<td></td>
</tr>
</tbody>
</table>

This question is asked in order to identify, how the suppliers generate data. Some of the mentioned tools are manually and some of them are systematic and more efficient. So for being a way from asymmetric and incorrect data it is better to apply the more reliable and systematic methods. The way to generate data is compared to each other using AHP method and their relative weights are assigned. The subcontractor will get the relative score according to the type that they use.

5.6.1 Route Optimization System

Q2. Do you have a load/route optimisation system? Please specify

[ ] yes [ ] no

According to Blinge (1996), Rout planning can be effective. It is by implementing route planning systems is possible to reduce the number of distribution vehicles by about 15% (Swahn and Soderberg, 1992). Software packages to improve the efficiency of load planning and vehicle routing typically achieves saving of 5-10% in vehicles kilometres when compared with manual scheduling (Mc Kinnon, 1995). The supplier gets the score of 1 if they reply yes to that question and gets the score of 0 if they reply no.

5.6.2 GPS System

Q3. How many of your vehicles are equipped with the GPS?

<table>
<thead>
<tr>
<th>Number</th>
<th>For PNL use</th>
</tr>
</thead>
</table>

One of the reasons that can increase the fuel consumption is choosing the wrong route or the long one. By using the GPS System the managing the routes would be easier so it leads to consume less. Also by using GPS, drivers cannot drive fast and we can control their behaviour during the journey. The supplier gets the score of 1 if they reply yes to that question and gets the score of 0 if they reply no.
6 RESULTS

This chapter contains a presentation and details of the gained results of survey study. The chapter starts by presenting the information about the suppliers and respondents. Then elaboration of suppliers’ responses is done regarding main criteria such as Environmental management system, Vehicles, Fuel consumption, Training and Data generation.

The survey was sent to 22 suppliers within different areas in Sweden. The evaluation of the results is done based on the 13 respondents who have replied to the survey on time. It is assumed by the researchers of this project that that amount will be enough to reflect how the assessment process is working and it would be enough to analyze what further actions can be taken by company. The respondents were mainly quality manager and environmental manager. Since the respondents have high responsibility, it increases the trustworthiness of the replies. According to the survey the environmental manager and quality manager are the same in most of the suppliers while in some cases the names are not mentioned.

6.1 ENVIRONMENTAL MANAGEMENT SYSTEM

The result regarding environmental policy has shown that only 6 subcontractors approved environmental policy in their company.

For the annual environmental report regarding emission level, the level of attainment of your environmental targets and consumption level, 10 sub contractors stated that they are able to make report for aforementioned parts, while only 2 of them can make report for 2008.

For the environmental and quality certification, the result is shown that among the 13 subcontractors only 7 of them are certified for ISO 14001 and 4 of them for EMAS and 6 of them are certified for ISO 9001 and 5 of them are not certified for any of certification, while all of the subcontractor that are not certified, have addressed that they will introduce it in future but they did not mention the time.

The result of environment friendly question has shown that all subcontractors did not answer properly because the idea of this question was to clarify other aspects of environmental thinking which was not asked in questionnaire while almost all of them did not comment the way that was expected from the question.

6.2 VEHICLES

6.2.1 Light Duty Vehicles

The gathered information of vehicles from all subcontractors is shown by the graph based on the number of vehicles and model. PNL’s subcontractors have 334 Light Duty vehicles in the service. As it is shown in Light Duty graph, the number of 2006 model is higher than others because one of the biggest suppliers of PNL which has purchased 204 vehicles at that year. The average model year of all suppliers’ vehicles is 2006.04. It should also be mentioned that 25 of the vehicles belonging to the suppliers are older than 5 years old.
Regarding fuel type, most of the suppliers have addressed that diesel fuel is used for their Light Duty vehicles. Using different types of fuels other than fossil fuels is not a common thing among the suppliers. 8 of the light duty vehicles were using gasoline while 39 of them runs with biogas and only 1 of them runs with ethanol.

6.2.2 Heavy Duty Vehicles:

As it is shown in the Heavy Duty graph the total number of Heavy Duty Vehicles is 82 and the average year model of all vehicles is 2005.84.

Regarding the fuel type, it is seen from the study that the suppliers did not think about purchasing vehicles that runs with fuels other than diesel. It should also be kept in mind that in heavy duty vehicles the technology about alternative fuels is not as advanced as the light duty vehicles. In this case all the subcontractors in all the vehicles were using diesel powered engines. 9 of the heavy duty vehicles in PNL service are older than 5 years old.
Figure 6.3 Number of Heavy Duty Vehicles

6.3 FUEL CONSUMPTION

6.3.1 Average Fuel Consumption of Light-Duty Vehicles:

Based on the responses given to the survey, the average fuel consumption of the light-duty vehicles which serve for PNL use, have been calculated as 11.64 litres per 100 kilometres. The relevant performances of the suppliers have been assigned based on comparison of suppliers among each other. The supplier that has the least fuel consumption per 100 kilometres has been assigned with the value of 1.0. In Light-Duty vehicles case it was 9.5 litres per 100 kilometres. For example, a subcontractor with an average of 13 litres per 100 kilometres is compared to the one with the best performance which is 9.5 litres per 100 kilometres and its performance is found as 9.5/13; which gives the subcontractor the value of 0.730.

6.3.2 Average Fuel Consumption of Heavy-Duty Vehicles:

The procedure for calculating the performances of the heavy-duty vehicles is the same that we had for light-duty vehicles. The reason the division of heavy duty vehicles’ fuel consumption among local service and long distance service is that, the fuel consumption of vehicles inside the city traffic increases significantly when compared to the performance on high ways. Some of the respondents were not able to provide the results for local and long distance services separately. Further suggestions on that case are to be made in analysis part. The average fuel consumption for heavy-duty vehicles in local service is 31.29 litres per 100 kilometres and 26.43 litres per 100 kilometres for long distance service.
6.3.3 Promotion for Fuel Efficient Driving Style

Among the 13 respondents only 3 of them was using promotion to decrease the fuel consumption of the vehicles. The supplier claimed that they use bonuses as the reward system for the drivers who drive most fuel efficiently.

6.3.4 Engine Idling

In the recent studies the benefits of engine idling have been observed, but none of the respondents had a policy for engine idling.

6.3.5 Emission Levels

The number of subcontractor that measures their emission levels is 5 which make 38.5% of the subcontractors. PNL also has an intention to measure the emission levels of their services by the help of software.

6.3.6 Equipment of the Vehicles

To decrease the fuel consumption and the hazardous gasses emitted to the atmosphere, some important parts are investigated among the subcontractors. Particle filters and exhaust gas recirculation are among the newest technological inventions to decrease the emission of hazardous gasses and particulates from diesel engine to the atmosphere. Also engine heaters and catalytic converters will help to decrease the fuel consumption. The response rate for those questions was low which makes it hard to make reliable suggestions on the amount of those equipments in the PNL’s subcontractors’ vehicle fleet. While calculating the scores, no responses are accepted as zero score as always used in the calculation of the scores in the survey. The average rate that the suppliers have the equipments is considered while calculating the scores.

6.4 TRAINING:

6.4.1 Number of Drivers:

The number of drivers for PNL use is measured according to 12 respondents, one of the subcontractors did not reply for that question. In one case, the supplier has given an approximate value because of the fact that it is a common thing among suppliers to have drivers on part time contracts. The total number of drivers working in the PNL services among those 12 subcontractors is 228. The number of drivers employed per subcontractor is 19.75. One of the biggest suppliers of PNL employs 130 drivers which increases the drivers per subcontractors drastically.
6.4.2 Training of Drivers:

98 of 228 drivers have taken both practical and theory training on driving. The average number of drivers who had taken training is 8.17 per supplier. 43% of those drivers have taken training in total. Drivers have taken training in 5 suppliers out of 12. The drivers have taken ECODRIVING training in 4 of those cases.

Figure 6.5 The Percentage of Drivers Undergone Training

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6.5 DATA GENERATION:

6.5.1 The Readings:

3 of the 13 suppliers use software to generate their data on the distance travelled and fuel consumed by their vehicles. 8 of them rely on driver notes and tachograph readings and 1 of the subcontractor uses two-card system. One of the respondents answer was not readable and it is accepted as no reply.

Figure 6.6 Data Generation System
6.5.2 Load/Route Optimization System

7 of the 13 suppliers use load/route optimization systems which makes 54% of the suppliers. Out of those 7 suppliers only 2 of them mentioned the name of the software that is used.

6.5.3 GPS Equipment

GPS is useful for checking if the drivers are on the right way, their driving behaviour and making decisions according to the traffic density. 9 out of 13 suppliers have equipped their vehicles with GPS systems which makes 69.2% of the suppliers involved in this survey.

6.6 APPLICATION OF ANALYTICAL HIERARCHY PROCESS

AHP is used after gathering the responses to the questionnaire by the subcontractors. The evaluation of their performance is done by applying AHP based on their answers to the questionnaire. The selection of criteria and sub-criteria and their relevant hierarchies and priorities are defined depending on the reviews done on various studies made related to the subject, experience and with brainstorming among the managers, experts and the researchers of this project. Depending on those efforts 5 criteria and 26 sub-criteria are defined for assessment of suppliers regarding environmental performance. The hierarchal structure of the supplier assessment process is shown in the figure below.

Figure 6.7 Hierarchy for selection suppliers
The goal of this process is to evaluate the environmental performance of the subcontractors and provide an accurate tool to assist the firm to include environmentalism in the selection process of their suppliers. By this way they can chose the suppliers who are more environmentally friendly when the suppliers with similar performances other than environmentalism are being compared. It should be kept in mind that the only dimension is environmental performance in this study so, other dimensions such as quality, finance, delivery reliability and etc. not included for the selection of suppliers.

AHP is a decision making tool in which the decision maker compares the criteria options among each other. In this study, at first each criterion is compared among each other and then the relative subcriterion is compared among each other to find their relative priorities. The results gathered from the suppliers are compared according to those criteria to evaluate their performance.

For evaluation of the suppliers performance there is a need to assign the weights of the criteria and sub-criteria. It is chosen to weight criteria and sub-criteria instead of suppliers among the criteria since the survey relies mainly on quantitative data. Although AHP is a very useful tool to evaluate both quantitative and qualitative input the survey study is accepted as having a quantitative nature because of having 2 qualitative sub-criteria among 26. To begin with, a sample weighting has been done and demonstrated to the environmental manager and the expert in the firm. This is done to explain the process in practice to the authorities in the firm since they did not have the necessary background about AHP. This process helped all the members of assessment team to better understand process and cover any parts that are not clear.

The next step was the calculation of the weights according to the AHP by each member of the team. Each member of the team had gone through AHP individually and independently by that way it was aimed to constrain the affection of team members from each other’s opinions. The average of priorities of each individual team member for criteria and sub-criteria had been taken to assign the final weightings.

To compare the criteria and sub-criteria among each other, the 9-point comparative scale for qualitative pair-wise evaluations formulated by Saaty (2008) had been used. That scale is described in the table 6.1 In that scale even values represent intermediate scale values between the two adjacent scale values. The decision maker assigns these values to the criteria and sub-criteria as if they were the actual measurements (i.e. quantitative). To explain this process deeper, one of the matrixes created by decision makers to evaluate the relative priority of the criteria is attached (table 6.2). The rows in the matrix are compared to the columns. If environmental management system criterion is rated as 9, and the data criterion is rated as 2 the value in the cell comparing EMS to Data is 4.5. If we consider the cell comparing Data to EMS the cell value will be the reciprocal of that value which is 0.22(2/9).

The main diagonal cells’ values are 1 since it is the comparison of criterion to itself. The matrix is filled with the values in accordance with the rates given by the decision maker which at the end yields a complete matrix of pair-wise comparisons of the criteria. The calculation of the matrix gives the weight of each criterion which will be used for the assessment of the suppliers’ performance. There are 6 matrixes formed to measure the priorities of criteria and sub-criteria. Those matrixes include the matrix to evaluate the priorities of each criteria one of which is shown as an example in table 6.2. When the priorities of the criteria were assigned according to the results of the matrixes the next step was to calculate the priorities of each sub-criteria under the criteria. By that way the priorities of sub-criteria under relevant criterion had been calculated. The procedure was the same as the way to calculate the priorities of criteria which was shown in table 6.2. There were 6 matrixes formed which were 5*5, 8*8, 7*7 and etc depending on the number of criteria and sub-criteria that was measured. Since the calculations of the matrixes was complex a computer software called Expert Choice is used to evaluate the results of those matrixes which made it fairly easy to obtain the results.
Table 6.1 the Fundamental scale for pair wise comparisons

<table>
<thead>
<tr>
<th>Intensity of importance</th>
<th>Definition</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Equal Importance</td>
<td>Two activities contribute equally to the objective.</td>
</tr>
<tr>
<td>3</td>
<td>Moderate Importance</td>
<td>Experienced and judgment slightly favour one activity over another.</td>
</tr>
<tr>
<td>5</td>
<td>Strong Importance</td>
<td>Experienced and judgment strongly favour one activity over another.</td>
</tr>
<tr>
<td>7</td>
<td>Very strong or demonstrated importance</td>
<td>An activity is favoured very strongly over another; its dominance demonstrated in practice.</td>
</tr>
<tr>
<td>9</td>
<td>Extreme Importance</td>
<td>The evidence favouring one activity over another is of the highest possible order of affirmation.</td>
</tr>
<tr>
<td>2, 4, 6, 8</td>
<td>For compromise between the above values</td>
<td>Sometimes one needs to interpolate a compromise judgment numerically because there is no good word to describe it.</td>
</tr>
<tr>
<td>Reciprocals of above</td>
<td>If activity $i$ has one of the above nonzero numbers assigned to it when compared with activity $j$, then $j$ has the reciprocal value when compared with $i$</td>
<td>A comparison mandated by choosing the smaller element as the unit to estimate the larger one as a multiple of that unit.</td>
</tr>
<tr>
<td>Rational</td>
<td>Ratios arising from the scale</td>
<td>If consistency were to be forced by obtaining n numerical values to span the matrix.</td>
</tr>
<tr>
<td>1.1-1.9</td>
<td>For tied activities</td>
<td>When elements are close and nearly indistinguishable; moderate is 1.3 and extreme is 1.9.</td>
</tr>
</tbody>
</table>

The procedure for calculating the weights of sub-criteria is the same with the calculation of the weights of criteria. The measuring starts from criteria and then continues with sub-criteria which at the end yield the weights of each criterion and sub-criterion that would be used for comparison of the performance of the suppliers.

The next procedure is to normalize the matrixes to produce the vector of the priorities of the criteria and sub-criteria. There are a variety of theoretical approaches introduced by Saaty to calculate the normalized matrix, in this study help of software have been taken to calculate the normalized priorities.
In addition, for each of the matrix the inconsistencies have been calculated. The inconsistencies might arise due to changing proportion of values given to the criteria and sub-criteria while comparing among each other. The consistency index (CI) is calculated to evaluate the consistency of pair-wise rating. The values of inconsistencies less than 0.1 are considered as acceptable. It should be noted that in all of the matrixes of each team member the inconsistency index was significantly lower than 0.1 which reveals that each member were consistent in their logic of pair wise ratings which in turn makes the result of weightings consistent.

The results of those weightings had given us the hierarchy of the criteria and sub-criteria. Having obtained the weights of criteria and sub-criteria, the survey data collected from the suppliers had been transferred to the constructed AHP model. The score of suppliers for each sub-criterion have been multiplied with the weight of the relevant sub-criterion to evaluate the suppliers’ performances regarding the criterion. The addition of the performances of the suppliers according the sub-criteria of the related criterion gave the scores of the suppliers related to the criterion. The multiplication of the score related to the criterion with the weight of the criterion and adding those performances together gave the overall performance of suppliers regarding environmentalism. The weightings of the criteria and sub-criteria and the results of the suppliers based on AHP are shown on the Table 6.3 that is attached.

To start with, it is again mentioned that The respondent will get a score between [0, 1] according to the answer they had given for any question. For example to explain the questions that are asked under EMS sub-criterion has nominal nature, so the answers are yes or no. In that case 1 is assigned for “positive” answers and, 0 is assigned for “negative” answers.

For the vehicles criterion, from the previous questionnaires and the pilot questionnaire it is seen that the suppliers have an intention to fill the model year part but not the EURO class part, the EURO class part was neglected while giving the scores because of that reason for this time. The scoring for the model year is done based on the average age of the fleet. 2009 is assigned with the value of 1, 2008 with 0.9, 2007 with 0.8 and so on. The supplier gets the score accordingly, for example if the average age of the supplier’s fleet is 2006.35, the supplier will get the score of 0.735 from that part.

For the fuel consumption part, The supplier with the least average consumption is chosen as the reference point and assigned with the score of 1 then the score of the other suppliers are defined accordingly. For example, if the least consuming supplier has the average consumption of 9.5 litres per 100 kilometres and the compared supplier consumes 12 litres per 100 kilometres the score that the supplier gets found as 9.5/12 which makes 0.79. Those questions make the Q1, Q2, Q3 under fuel consumption part. It should be mention that in Q2, or Q3 the answers with no response are put as 1000000, since it is assumed that 29/1000000 will give the result close to 0 and there would be no need to fix the formula. The values which are not between [0, 1] intends to show the percentage positive answer to the total. For example, 0.6 value under training criterion intends that 60% of the drivers were trained in that supplier.
<table>
<thead>
<tr>
<th>Suppliers</th>
<th>Weight</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.27</td>
<td>0.35</td>
</tr>
<tr>
<td>B</td>
<td>0.12</td>
<td>0.05</td>
</tr>
<tr>
<td>C</td>
<td>0.08</td>
<td>0.02</td>
</tr>
<tr>
<td>D</td>
<td>0.06</td>
<td>0.01</td>
</tr>
<tr>
<td>E</td>
<td>0.04</td>
<td>0.005</td>
</tr>
</tbody>
</table>

Table 6.3: Weights and Scores of Suppliers

Note: The table above represents the weights and scores assigned to various suppliers based on specific criteria.
Table 6.4 The Final Result of Supplier Assessment

<table>
<thead>
<tr>
<th>Supplier</th>
<th>EMS</th>
<th>Vehicles</th>
<th>Fuel Consumption</th>
<th>Training</th>
<th>Data generation</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>supplier 5</td>
<td>0,27</td>
<td>0,17</td>
<td>0,13</td>
<td>0,18</td>
<td>0,07</td>
<td>0,82</td>
</tr>
<tr>
<td>supplier 9</td>
<td>0,27</td>
<td>0,16</td>
<td>0,16</td>
<td>0,18</td>
<td>0,04</td>
<td>0,81</td>
</tr>
<tr>
<td>supplier 4</td>
<td>0,27</td>
<td>0,18</td>
<td>0,03</td>
<td>0,18</td>
<td>0,04</td>
<td>0,70</td>
</tr>
<tr>
<td>supplier 3</td>
<td>0,29</td>
<td>0,18</td>
<td>0,12</td>
<td>0,00</td>
<td>0,01</td>
<td>0,60</td>
</tr>
<tr>
<td>supplier 12</td>
<td>0,24</td>
<td>0,14</td>
<td>0,12</td>
<td>0,00</td>
<td>0,08</td>
<td>0,59</td>
</tr>
<tr>
<td>supplier 6</td>
<td>0,05</td>
<td>0,16</td>
<td>0,06</td>
<td>0,18</td>
<td>0,04</td>
<td>0,49</td>
</tr>
<tr>
<td>supplier 10</td>
<td>0,07</td>
<td>0,18</td>
<td>0,03</td>
<td>0,13</td>
<td>0,07</td>
<td>0,48</td>
</tr>
<tr>
<td>supplier 11</td>
<td>0,22</td>
<td>0,16</td>
<td>0,03</td>
<td>0,00</td>
<td>0,03</td>
<td>0,44</td>
</tr>
<tr>
<td>supplier 1</td>
<td>0,07</td>
<td>0,15</td>
<td>0,10</td>
<td>0,00</td>
<td>0,07</td>
<td>0,39</td>
</tr>
<tr>
<td>supplier 2</td>
<td>0,10</td>
<td>0,16</td>
<td>0,06</td>
<td>0,00</td>
<td>0,03</td>
<td>0,36</td>
</tr>
<tr>
<td>supplier 7</td>
<td>0,05</td>
<td>0,15</td>
<td>0,11</td>
<td>0,00</td>
<td>0,06</td>
<td>0,36</td>
</tr>
<tr>
<td>supplier 13</td>
<td>0,05</td>
<td>0,12</td>
<td>0,14</td>
<td>0,00</td>
<td>0,04</td>
<td>0,34</td>
</tr>
<tr>
<td>supplier 8</td>
<td>0,07</td>
<td>0,15</td>
<td>0,04</td>
<td>0,00</td>
<td>0,06</td>
<td>0,31</td>
</tr>
</tbody>
</table>
7 ANALYSIS

This chapter aims to interpret the results gained from the supplier survey and the effect of AHP in the evaluation of results. The expectations from the suppliers are mentioned, their level of attainment to those demands is discussed, and further comments are made to assist PNL to assess the environmental performance of their suppliers to achieve a more environmentally friendly partnership. The suggestions aim to reflect what changes can be done on the environmental perspective of the suppliers to improve their practices and services.

7.1 ANALYSIS OF QUESTIONNAIRE

7.1.1 Environmental Management System:

Among the 13 suppliers who responded the questionnaire 6 of mentioned that their company has a policy for environmentalism. Having a policy for environmentalism is seen as the basis for a company to move into environmentally friendly approaches. The environmental policy will make the companies to consider the environmental outcomes of their operations. For a partnership that is environmentally conscious, PNL should encourage and assist all its suppliers to form their own environmental policy.

The environmental reports are necessary to keep track of the effects of their services and their attainments on the targets. Those reports will help PNL and its suppliers as tangible indicators of the outcomes of the suppliers’ operations. Only 2 of the respondents make aforementioned reports but 10 of them are able to make it for the future. Due to those reasons it is a necessity for PNL to encourage its suppliers.

ISO certificates and EMAS are useful indicators of subcontractors’ environmental situation. Having an environmental policy will help suppliers to gain those accreditations since it is one of the subjects that are investigated while being certified for the ISO 14001 and EMAS. Because of that reason gaining those certificates could be accepted as the later stage after forming an environmental policy. Since all of the suppliers who responded to the survey showed their intention to register for standards PNL can encourage those suppliers who have environmental policy to gain those certificates. Since those certificates are given by independent bodies, it is reliable and makes use of the former experiences of those bodies, gaining those certificates could increase the trustworthiness of the suppliers for PNL. The results regarding the certificates showed a satisfactory level of suppliers is accredited to the mentioned certificates. One interesting point was that 7 of the respondents mentioned that they are accredited to ISO 14001 but 6 respondents mentioned that they have an environmental policy. One of the suppliers who mentioned to have ISO 14001 certificates replied negatively for the environmental policy question. Since environmental policy is one of the main points that are investigated in the process of gaining that certificate it is seen as an interesting that the supplier did not have an environmental policy. Since that supplier did not send a copy of their certificate, the reply of the supplier for that question is left in suspense. The reliability of the survey findings would increase if the suppliers send all the necessary documents needed and if the suppliers are audited when needed.

The last question of that criterion on own reflections of suppliers on environmentalism was not answered in the way that it was intended from the question. The phrasing of the question could be changed for the future surveys. The average points that the suppliers have given to their environmental performance can be used for comparison between consequent years to see if the steps taken forward by PNL have been useful in suppliers’ point of view.

7.1.2 Vehicles

The average model year for the light duty vehicles is 2006.04 and 2005.84 for the heavy duty vehicles. The fleet can be considered as relatively young. But it could be suggested that PNL encourages its suppliers to use vehicles no more than 5 years old since by the increasing age of the vehicles there is a significant decrease in the performance of the vehicles and increase in the fuel consumption which would increase the costs and the emission of green house gases and hazardous particulates to the
environment due to the intense use of vehicles. The use of alternative fuels for heavy duty vehicles is not that common in nowadays conditions but it could be a good suggestion to encourage the suppliers to choose the vehicles operating with alternative fuels that are more environmental friendly for the future purchases. By this way the negative impact of the vehicles on the environment could be decreased.

7.1.3 Fuel Consumption

For the fuel consumption, it is chosen to compare the consumption of suppliers relative to each other. Since the fuel consumption depends on factors such as speed, the load, and the traffic conditions it is hard to suggest an optimum consumption level for the vehicles. Instead, in this survey it was chosen to compare the suppliers to the supplier with the least consumption level. But it is seen that that way is not clearly reflecting the performance of the suppliers since the factors mentioned above are not taken into account in that case. Suggestions for a better measuring method are to be made in the discussion section.

According to the results of the survey, only 23.1% of the suppliers use reward systems to promote fuel efficient driving style while none of the suppliers have a policy for engine idling. Those results are lower than expected. It can be suggested that benefits from the rewards for fuel efficient driving will be higher than the cost of the rewards. It would help to decrease the fuel consumption, thus decreasing the negative impacts on the environment and costs. The lesser the engine working, unnecessarily the lesser the amount of fuel consumed and the emitted harmful gasses. PNL could consider motivating their suppliers to pay more attention to engine idling.

The response rate for the questions on the equipments of the vehicle was low which makes it hard to make accurate analysis of the results of the answers.

7.1.4 Training

According to the findings of the survey 43% of the drivers working for the suppliers of PNL have gone both practical and theoretical training on fuel efficient driving styles. That could be accepted as a decent amount while the number of drivers that have training could be increased by purchasing services from suppliers who employ trained drivers or motivating the existing suppliers to send their drivers to training on fuel efficient driving style. Depending on the result it is seen that the drivers have taken theoretical and practical training both. It is probably due to the fact that it is preferred to take packet trainings which include the theoretical and practical training together.

7.1.5 Data Generation

Among the suppliers who responded to survey 8 out of 13 uses driver notes for keeping track of the distance travelled. This is a significantly high amount. Only 3 supplier uses software while 1 of the supplier uses two-card system which is more trustable compared to driver notes and tacograph readings. The driver notes and tacograph readings used by the suppliers gives less accurate data which might decrease the reliability of the consumption levels and etc.

Software for load/route optimization system is used by 54% of the suppliers. That could be accepted as a decent amount. Meanwhile since that kind of software is very useful on planning the loads for the destinations with an effective usage of fleet and the makes optimum route plans that kind of software is very important for the suppliers to lessen the fuel consumption, the negative effects on the environment due to hazardous gasses and the costs which are crucial factors for PNL to achieve a more environmental friendly company.

%69.2 of the suppliers have GPS which is a considerably high amount which shows that most of the suppliers have a chance to track the driver behaviours and the drivers have the opportunity to track their path and decrease the possibility of using the wrong roads.
7.2 ANALYSIS OF AHP

In order to test the responsiveness and sensitivity of the results, sensitivity analysis has been made in this project. Sensitivity analysis is made to investigate the impact of changing the priority of each criterion and its overall outcomes. As it is shown in table 7.1 changing the priority of the criteria indicate that the overall result would be changed due to differences in the supplier performance in each criterion. By that way it was aimed to demonstrate the effect of the assigned priorities and how it could change the overall ranking of the suppliers.

To demonstrate those effects more clearly drastic changes have been made in the priorities assigned. For instance increasing the Data generation from 0.084 to 0.484 and decreasing Environmental management system from 0.286 to 0.086 indicate that suppliers rating are sensitive and rates will be changed due to differences in their performance in each criteria, meanwhile it could be assumed that supplier 5 is not sensitive to changes in the priorities since they performed good in all of the criteria when compared to the other suppliers while the rank of supplier 12 has been promoted from 5 to 2 because they have a better performance in Data Generation criterion.

Table 7.1 Result of Sensitivity Analysis

<table>
<thead>
<tr>
<th></th>
<th>EMS</th>
<th>Vehicles</th>
<th>Fuel consumption</th>
<th>Training</th>
<th>Data generation</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>supplier 5</td>
<td>0.08</td>
<td>0.03</td>
<td>0.19</td>
<td>0.08</td>
<td>0.43</td>
<td>0.81</td>
</tr>
<tr>
<td>supplier 12</td>
<td>0.07</td>
<td>0.02</td>
<td>0.18</td>
<td>0.00</td>
<td>0.48</td>
<td>0.76</td>
</tr>
<tr>
<td>supplier 9</td>
<td>0.08</td>
<td>0.03</td>
<td>0.24</td>
<td>0.08</td>
<td>0.25</td>
<td>0.68</td>
</tr>
<tr>
<td>supplier 1</td>
<td>0.02</td>
<td>0.03</td>
<td>0.14</td>
<td>0.00</td>
<td>0.43</td>
<td>0.62</td>
</tr>
<tr>
<td>supplier 10</td>
<td>0.02</td>
<td>0.03</td>
<td>0.04</td>
<td>0.06</td>
<td>0.43</td>
<td>0.58</td>
</tr>
<tr>
<td>supplier 7</td>
<td>0.01</td>
<td>0.03</td>
<td>0.16</td>
<td>0.00</td>
<td>0.32</td>
<td>0.52</td>
</tr>
<tr>
<td>supplier 4</td>
<td>0.08</td>
<td>0.03</td>
<td>0.05</td>
<td>0.08</td>
<td>0.24</td>
<td>0.48</td>
</tr>
<tr>
<td>supplier 6</td>
<td>0.02</td>
<td>0.03</td>
<td>0.09</td>
<td>0.08</td>
<td>0.24</td>
<td>0.45</td>
</tr>
<tr>
<td>supplier 13</td>
<td>0.01</td>
<td>0.02</td>
<td>0.21</td>
<td>0.00</td>
<td>0.21</td>
<td>0.45</td>
</tr>
<tr>
<td>supplier 8</td>
<td>0.02</td>
<td>0.03</td>
<td>0.05</td>
<td>0.00</td>
<td>0.32</td>
<td>0.42</td>
</tr>
<tr>
<td>supplier 3</td>
<td>0.09</td>
<td>0.03</td>
<td>0.18</td>
<td>0.00</td>
<td>0.07</td>
<td>0.37</td>
</tr>
<tr>
<td>supplier 2</td>
<td>0.03</td>
<td>0.03</td>
<td>0.10</td>
<td>0.00</td>
<td>0.18</td>
<td>0.34</td>
</tr>
<tr>
<td>supplier 11</td>
<td>0.07</td>
<td>0.03</td>
<td>0.04</td>
<td>0.00</td>
<td>0.18</td>
<td>0.32</td>
</tr>
</tbody>
</table>
8 CONCLUSION AND DISCUSSION

8.1 CONCLUSION

The studies on environmentalism have increased during the last decades; this is due to the increasing negative consequences of human related activities. The awareness in public, corporations and political authorities to develop more environmental friendly practices in every field is increasing. That orientates the companies to assess their activities and to develop more environmentalist approaches. Logistics is one of the business fields that have the most negative effects on the environment. Therefore the assessment of effects of logistics companies’ activities on the environment and development of practices to decrease them is gaining more importance.

PNL have started emphasizing on environmentalist approaches in their business. They have an intention to increase consciousness about environmentalism and to turn into a more environmental friendly organization. Nevertheless, PNL’s most important negative impact on the environment arose from the transportation activities. It makes purchasing of transportation from suppliers one of the most crucial points in turning the organization into a more environmental friendly condition.

It was needed to find a tool that will be able to assess the environmental performances of the suppliers by the company, to purchase the services that are less harmful to environment. PNL had some of the necessary data from the suppliers but they were not certain about which of these data they need and what else data can be used. The survey helps to collect the crucial data regarding environmentalism also it will help to keep records of the suppliers’ situation and performance in the future.

Another important fact is that there was a need for a method to make the necessary measurements according to those data to assess the performance of the suppliers. The goal of this project was to attain PNL with a useful tool that will be able find out the effects of their suppliers’ transportation activities on the environment and to assess and compare the environmental performance of the suppliers.

The necessary criteria had been defined and a survey had been made based on those criteria to find out the related data on technology, organization, policy and etc. of the suppliers. The survey questions were prepared depending on the scientific studies made about environmentalism and connected with the previous experiences of the expert who made such kind of survey study in the company previously. The connection of literature review with experience assisted on choosing the criteria and important points those are most related with the operations of PNL. Therefore the questionnaire is reflecting the ambition of PNL about environmentalism. The phrasing and arrangement of questions together with the outline of questionnaire is prepared in a way not to reflect emotions and keep the motivation of the respondents high. The high response rate to the questions could be accepted as evidence that the survey had been successful on that point. The responses given to the survey are mainly from the authorities who are responsible for environmentalism or transportation in the suppliers. That would decrease the rate of incorrect answers from the suppliers since they are assumed to be the most acquainted people regarding the subject which will in turn increase the reliability of the survey study.

Once those data were obtained from the suppliers, Analytical Hierarchy Process had been applied evaluate, rate and compare the performances of the suppliers. AHP was chosen by the researchers of this study because depending on the studies made on assessment, AHP proved itself to be very efficient since it is able to break down complex decision making problems which are based on multiple criteria into sub-problems which are easier to manage. It should also be mentioned that AHP can handle dynamic situations. It can also manage changing requirements in the future about environmentalism, new criteria can be added or the priorities can be changed to handle those conditions. AHP method was able to evaluate the suppliers depending on the predetermined criteria. It assisted to have a clearer understanding of the situation of the suppliers regarding environmentalism. The survey was set in a way to reflect most important points regarding environmentalism and by the
help of AHP the project was able to come up with relative rankings of the suppliers which increase the validity of the study.

In this study it was experienced that AHP was very useful and effective in ranking the suppliers’ performance based on different criteria and it is an applicable tool to support and improve the decision making process in supplier selection. It is an efficient tool that can handle both qualitative and quantitative problems and can decrease the subjectivity while assessing the suppliers’ performance. The decrease in subjectivity also increases the reliability of the method. That is due to the AHP supports the decision making process with a systematic, objective and structured approach that can give scaled outputs while covering all relative and related factors that are needed to assess the performance of suppliers.

Finally, the research was able to reflect the environmental effects of suppliers of PNL. Once those effects were determined the survey study was made to gain the related data about those effects from the suppliers. Application of AHP in that research helped to assess and rank the performance of the suppliers. Depending on the experience from the study it could be commented that AHP is a useful, efficient tool which is appropriate in that kind of cases to assess the performance of companies regarding environmentalism.

8.2 DISCUSSION

8.2.1 Discussion on the Survey Study

The survey aims to obtain the necessary data about the subcontractors’ activities regarding environmentalism. It aims to collect the necessary data on information about the organization of the subcontractors, the relevant reports and the data on five defined criteria. It served as a useful tool to gather the necessary information except some questions. In the question about the equipment of the vehicles the response rate was low; this could be due to the fact that the suppliers were not tracking the related information. In one qualitative question about the reflections of the subcontractors on their current situation most of the responses did not satisfy what was expected from the question. This might be because the question was not phrased in a clear way to express what was expected from that question which in turn created a misunderstanding in the minds of the respondents. One suggestion on that case might be to establish a better information flow between the company and its subcontractors to explain what is expected from the questionnaire and more importantly what is expected from them to make their operations more environmental friendly since the company’s environmental policy is updated and it will bring a change in their expectations from the suppliers. Except those questions the questionnaire was answered with a high response rate and it helped the authors with the crucial data on the situation of the subcontractors regarding environmentalism.

Since the company plans to introduce software to calculate emission levels of their suppliers which would provide more accurate and crucial information on the suppliers’ environmental performance another important suggestion could be an addition in the questionnaire on emission levels when this software is implemented.

The fuel consumption levels of vehicles change significantly between inside city traffic and high way traffic without depending on the driving behaviour of the drivers. Another important aspect affecting the consumption levels is the load rate of the vehicles. If the load rate is low the fuel consumption decreases. In some cases the goods brought to city and taken from city differs significantly. A good example for this would be northern towns in Sweden where there is a high load of ore going out of city and the trucks are loaded but on the other hand the population in towns are low and there is not much demand from the city for supplies so the trucks come with low load rate but return with high load rate. The vehicle kilometres and tonne kilometres could be included in the questionnaire but it was omitted since the suppliers do not have the necessary data. It can be suggested that those information can be added in questionnaire if the suppliers would be able to provide it. Information flow and discussion is needed between PNL and suppliers for that question to be included.
This study was based on 13 subcontractors when the responses from all suppliers are collected when the data from all subcontractors are collected the subcontractors operating in similar situations regarding the traffic could be grouped together and bell curve could be used to rate their performance among each other to measure their performance.

8.2.2 Discussion on AHP

In this project AHP proved to be a useful tool in assessing the performance of the suppliers. It is experienced that AHP can handle both qualitative and quantitative data. By the help of AHP the authors of this research was able to compare and rate the performance of suppliers among each other. Once the questionnaire was structured AHP was able to breakdown the complex situation into smaller components that were easier to manage. Because of that it was easy to measure the performance of the suppliers. One difficulty while using AHP is that it needs a lot of matrixes to be calculated to assign the weights and the relative performance of the suppliers but there are software related to AHP in the market which makes those calculations much simpler. Using AHP will significantly decrease the subjectivity, but the process still has subjectivity in the manner that the rates assigned depend on the perspective of the executives.

Finally, AHP provided a clear understanding of the situation about the performance of suppliers and was able to rate and rank the suppliers quantitatively. AHP can be described as a very useful and easy to manage tool that provides an explicit reflection on the situation of the suppliers to support decision making process in assessing the suppliers and purchasing services.

8.2.3 Discussion on Future Improvements for PNL

Regarding environmentalism, even though it is not a part of supplier assessment it should be mentioned that aspects such as inter-modality, packaging, reverse logistics and etc. can be emphasized to turn into a more environmental logistics company.

It is believed that the finding of this project will help to reflect the performances of the suppliers of PNL on environmentalism. The findings could serve as a reference for the company while making purchasing decisions from the suppliers. The results of the survey could be kept as the past performance records of the suppliers in the database. The ratings of the suppliers according to AHP enable the company to assess how environmental friendly the suppliers are. AHP enables the users to compare different suppliers, different criteria and different dimensions. In this study only one dimension is being considered which environmentalism is. But AHP can handle different dimensions in decision making process such as quality, delivery reliability, financial aspects, costs and etc. while purchasing suppliers. It can be suggested that the introduction of AHP including more dimensions as a supportive tool in decision making process while purchasing suppliers will help PNL to compare and rate the performance of their suppliers more accurately. By this way it can reflect the overall performance of the suppliers. Integrated with the related database it can support the decision making system.
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