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Performance measurement system for green supply chain management in the electric power industry

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ABSTRACT

Nowadays, supply chain management (SCM), as a framework to optimize the environmental performance of organizations and institutions, is an important and distinctive management science. In the meantime, different organizations as well as small and large industries such as the electric power industry have defined several ways to measure and evaluate the performance of the SCM. This paper, using a descriptive research framework, first defines and explains the green supply chain and then introduces the role of the green supply chain in improving environmental performance and eventually, while using the SCOR model, explains, in general terms, performance measures for green supply chain management in the electric power industry.

KEYWORDS: Supply chain, Green supply chain management, Performance measurement for green supply chain management, the electric power industry, The SCOR model

1. INTRODUCTION

The globalization of competition in the present era has brought about some difficulties for businesses. On the one hand, there is customer demand for diverse and high-quality products and fast services; and on the other, the endless, disproportionate use of environment and energy as well as resources and mines that eventually has led to environmental degradation and ozone depletion; and changes in environmental conditions.

In recent years, many companies have tried to go green. The acceleration of these efforts stems from external forces including increasing laws and regulations and day to day changes in consumer preferences as well as internal forces including the values of company directors [1] which of course companies are also committed to fulfill the requirements of laws and regulations with the aim of addressing issues of environmental degradation and the ongoing global concern to meet the expectations of their customers. The European Union (EU), for example, has adopted a directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment (see Table 1) [2]. Furthermore, the incompatibility of some clean energy producing industries with environmental factors, such as the electric power industry, has focused many researchers' attention on defining performance measures for green supply chain management in such industries in addition to governments' determination to push for the implementation of environmental laws. In this regard, the researchers of supply chain management have tried to help companies to improve their green performances in different areas by offering GSCM/PMS at three tactical, strategic and operational levels. In this paper SCOR (Supply Chain Operations Reference) model, as the reference model for supply chain operations, is utilized to analyze GSCM at four levels of supplier, manufacturer, distributor and consumer in the electric power industry.

2. Green Supply Chain Management

Following industrial development, increasing social progress and acceleration of the complexity of the supply, production and consumption loop, the adjustment and execution of SCM (Figure1) was theorized by Bechtel and Jayaram[3], Chen and Panlraj[4], Cooper et al. [5], or Mentzer et al., [6] which followed by some experimental works, although just a few, done by some researchers including Cigolini et al. [7], Fawcett and Magnan[8], Kotzab et al.[9,10] and Wisner [11]. This continued until 2007 when the first definitions of GSM were introduced to the management arena.

Table 1: RoHS Restricted Substances and Limits

Metal	Unit of Measurement (ppm)
Lead (Pb)	<1000 ppm
Mercury (Hg)	<1000 ppm
Cadmium (Cd)	<1000 ppm
Hexavalent Chromium (Cr VI)	<1000 ppm
Polybrominated Biphenyls (PBB)	<1000 ppm
Polybrominated Diphenyl Ethers (PBDE)	<1000 ppm

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Srivastava defined green supply chain as "incorporating environmental thinking into supply-chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the customers as well as end-of-life management of the product after its useful life".

3. Green Supply Chain Performance Measurement

The trend of environmental pollution and warnings about ecological, climatic threats and more importantly the extinction of species have highlighted the need to implement closed-loop green supply chain at four defined levels of supplier, manufacturer, distributor and consumer. In recent years, GSCM has focused scientists and professionals' attention on reducing waste and maintaining product quality life cycle and natural resources; economic efficiency that seeks to minimize ecological damage, however, to maximize the efficiency of production and reproduction, has become the core assets to achieve the best methods [12]. This has led researchers to introduce the new topic of green supply chain management/performance measurement system (GSCM/PMS)[1 in order to] measure the feasibility of implementing GSCM in various sectors including industries.

4. The Electric Power Industry and its Pollution

Many industries are greatly dependent on the electric power industry. Although generating electricity in the early emergence of this technology was done using very different methods, technological advances have changed the stages of generating and consuming this valuable energy. Clean electricity generation itself has become a problem at water, soil and air pollution levels and has led researchers to seek new methods of electricity generation.

Although the electric power industry has undergone numerous changes throughout its history, researchers hold that this industry still faces new challenges. The electric power industry may encounter even greater changes in the form of problems such as new technologies, climate change and growing demand for electricity which can bring about considerable challenges for the industry. The success of this industry depends on identifying and managing opportunities to reduce the risks associated with these challenges [13]. Therefore, giving a precise definition and detailed attention to the indicators of GSCM /PMS seems inevitable.

4. 1. GSCM/PMS in the electric power industry

As an old and important industry that has a large share in the country GDP, the electric power industry in all parts of its life cycle from consumption of natural resources to production and consumption is in direct and indirect interaction with environment. Hence, GSCM/PMS indicators in this industry were categorized according to strategic, tactical and operational levels.

4.1.1. Strategic level

GSCM stimuli at the strategic level can be divided into two categories: internal and external stimuli.The external stimuli for being green include:

- Meeting consumer demand and fulfilling social commitments;
- Reacting to competitors actions and adopting green strategy with the aim of expanding market share;
- International and state laws;
- Increasing environmental pollution;
- Non-governmental environmental activities;

The internal stimuli include:

- Cost reduction due to reduced consumption of resources and raw materials;
- Environmental goals;
- Sustainable competitive advantage

4. 1. 2. Operational level

Activities at the operational level to achieve green supply chain management are divided into two overall categories:

- Executive measures within the organization;
- Executive measures outside the organization;

Environmental executive measures within the organization are as follows:

- Managers' support;
- Achieving ISO 14031 certificate;
- The codified objectives in the environmental area;
- A planned program to create green and sustainable marketing;
- Designing products and processes with the aim of reducing raw materials and energy consumption and waste management;
- Planning to reduce and eliminate the use of harmful elements;

[1]- green supply chain management/ performance measurement system

- Planning to reduce water, air and soil pollution;
- Replacing raw materials with environmentally friendly raw materials;
- Measuring the amount of water being used and planning to decrease water consumption;
- Using renewable energy in the manufacturing process;
- Taking advantage of new technologies;
- Education, research and culture building practices

Executive measures to manage organization's external environment are as follows:

- Attaining the ISO 14000 environmental certification by suppliers;
- Selecting suppliers based on environmental criteria;
- Environmental guidelines in the logistic unit;
- Tree planting and green space development;
- Environmental cooperation;
- Improving environmental performance of products;
- Panning to reduce water, soil and air pollution

4. 1. 3. Tactical level

- Lack of voluntary compliance with environmental standards;
- Inability to have technical and updated knowledge of technology for replacement;
- Monopolization and absence of competitors;
- Lack of coordination between units to implement and cover green supply chain costs;
- Absence of solid legal leverages;
- Lack of knowledge and training pertaining to environmental issues;
- Negligent managers;
- Absence of the strategic environmental objectives and plans in the industry

5. GSCM/PMS Indicators in the Electric Power Industry

As mentioned above, pollution caused by the electric power industry has focused the most attention in GSCM cycle in the electric power industry on environmental issues. Since dealing with the full set of indicators in this industry is out of the scope of this paper, thus the indicators of GSCM / PMS in the environmental area are briefly described here.

5. 1. ISO 14031(United nations Environmental programming International Conference Geneva, 4-6 December, 2012, Session)

Environmental performance evaluation ISO 14031 (ISO 14031), which is an effective method to implement environmental performance indicators for a cost effective method, coherently and clearly describes:

- Environmental management systems (ISO 14001);
- For environmental statements (ISO 14025);
- To label items relating to environment (ISO 14020, ISO 14021, ISO 14024);
- For life cycle assessment

ISO standards help to harmonize approaches to work with organization's specific indicators.

ISO14031 has two categories of indicators for environmental performance evaluation (EPE):

- Environmental condition indicators: these provide more information about the environmental conditions that may hurt an organization.
- Environmental performance indicators:

A. Management performance indicators: these provide more information regarding management efforts to influence environmental performance of the organization's operations.
B. Operational performance indicators: these provide more information about the environmental performance of an organization's operations [14].

5. 2. Toxic release inventory and global reporting initiative

Other indicators for GSCM/PMS in the electric power industry are toxic release inventory (TRI) and global reporting initiative (GRI). The following list contains the selected measures of environmental performance of these two indicators which ranges from gas emissions to energy recovery and recycling:

- Non-point source of air pollution emissions;
- Point source of air pollution emissions or smoke towers;
- Depletion in order to attain the main routes and the volume of water;
- Underground injection of wastewater and harmful substances in the environment;
- Releasing on the ground;
- Depletion for operational tasks with public ownership;

- Transporting waste to a place away from the place of production;
- On-site energy recovery and away from energy consumption;
- Recycling;
- On-site and off-site operations
- Non-production release;
- Source reduction activities;
- Preventing substance leaks and;
- Goods control list;
- Modifying raw materials;
- Modifying process, cleaning and reducing of surface preparation and product preparation;
- Product modification;
- Addressing the opportunities to prevent pollution;
- Auditing bills of material;

Additional general measures are described below:

- Participatory management and contractor;
- Value judgments and general missions;
- Management systems relating environmental and social performance;
- The severity and nature of punishment for not satisfying customers;
- The number, size and unusual nature of substances released to the earth, air and water;
- Environmental compliance costs;
- Environmental obligations under applicable laws and regulations;
- Site restoration costs under applicable laws;
- The main received bonuses;
- Total energy consumption;
- Total electricity consumption;
- Total fuel consumption;
- Total consumption of other energy sources;
- Total consumption of alternative fuel sources;
- Total water use;
- Modifying habitat changes and damages caused by companies operations;
- The quantity of non-manufacturing output returned to the process or the market by recovery or recycling;
- Overall socio-economic- environmental impacts associated with product and service life cycle;
- Formal and written commitments needed for life cycle formal assessment;
- Programs and methods to prevent the potential of undesired impacts of products and services or to minimize them;
- Methods to evaluate product and services designers in order to create products or services with descending undesired life cycle effects [15]

6. SCOR Model

The purpose of performance evaluation systems definition, which was one of the main concerns in the 1990s, was basically to develop and plan measurement systems which its aspects were supposed to be widely balanced and coordinated with a collective strategy. There were a huge variety of measurement systems which began with some works including Balanced Scorecard [16] or the EFQM Excellence Model (EFQM, 2010) [17]. SCOR model has been developed by supply chain council and adopted by 70 member companies and manufacturers of the world. The model was described as the most promising model for supply chain strategic decision making [18].

6. 1. Outline summary of SCOR model

SCOR is a process reference model designed for effective communication among supply chain partners. The model is a standard language which can help managers to focus on management issues and as an industry standard helps the management to focus on entire supply chain within an organization as well. SCOR is used to describe, measure and evaluate supply chain configurations. In this paper we selected SCOR model as one of the reference models in this area to implement GSCM/PMS in the electric power industry.

6. 2. Ways to implement GSCM/PMS in the electric power industry using SCOR model

SCOR model examine supply chain operations at four-levels: suppliers, manufacturers, distributers and customers. According to the definitions of SCOR model, this model faces the following requirements in the

electric power industry: at suppliers' level, it faces fuel monitoring such as mazut, gas and diesel fuel and replacing them with clean fuels including solar, wind and nuclear energies. At the manufacturers' level, it faces monitoring SAX and NAX emissions which, of course, as noted above this problem will be solved by alternative fuels. At distributers' level, it faces using green equipment and finally at the consumers' level, it faces removing products containing hazardous gases such as mercury gas.

7. Summary and Conclusions

Introduction of green supply chain and subsequently presentation of performance measurement for green supply chain management is one of the important achievements of mankind in its path to protect and preserve the environment for future generations. Although this topic is of interest to many researchers in various industries in recent decades, it has been less researched and examined in clean and yet polluting energy of the electric power industry. The impacts of emissions such as fossil, gas and diesel fuels at the supply level; producing greenhouse gases, SAX and NAX hazardous gases, water pollution caused by wastewater produced by plants and etc. at manufacturing level; absence of appropriate methods to eliminate Askarel oil at distribution level and finally the availability of lamps and lighting equipment containing toxic substances such as mercury at consumption level are the factors that need a closer look and more effort to find green solutions for them and need more attention to match with the requirements of supply chain and performance measurement for green supply chain in the electric power industry.

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