The Implementation of Green Supply Chain Management Practices in Electronics Industry

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Abstract—This research aims to survey current green activities in computer parts' manufacturers in Thailand and to evaluate green supply chain management. To survey current green activities in computer parts' manufacturers in Thailand, 11 manufacturers are case studies who provide in-depth interview about green procurement, green manufacturing, green distribution, and/or reverse logistics. To evaluate green supply chain management, the questionnaire related to investigate GSCM practices, measure GSCM performance, and explore GSCM pressure/ driver within Thai electronics industry is used to obtain survey results. Then suggestions to develop GSCM in electronics industry are presented.

Index Terms— electronics industry, environmental performance, green supply chain management, reverse logistics.

I. INTRODUCTION

Supply chain management is the coordination and management of a complex network of activities involved in delivering a finished product to the end-user or customer. All stages of a product's life cycle will influence a supply chain's environment burden, from resource extraction, to manufacturing, use and reuse, final recycling, or disposal [1]. Beyond this definition with adding the "green" component, it refers to green supply chain management (GSCM) which is defined as "green procurement+ green manufacturing+ green distribution+ reverse logistics". The idea of GSCM is to eliminate or minimize waste (energy, emissions, chemical/hazardous, solid wastes) along supply chain [2]. Environmental issues under legislation and directives from customer especially in the US, the European Union (EU), and Japan become an important concern for manufacturers. As a more systematic and integrated strategy, GSCM has emerged as an important new innovation that helps organizations develop "win-win" strategies that achieve profit and market share objectives by lowering their environmental risks and impacts, while raising their ecological efficiency [3].

Recent studies of GSCM can be separated into two ways: framework for GSCM, and performance measurement. Some frameworks propose how to improve the collaborative relationships between manufacturers and suppliers, to explore the gaps between the framework and the present state, to aid managerial decision making, or to develop

general procedure towards achieving and maintaining the green supply chain [4,5,6]. A set of performance measures is used to determine the efficiency and/or effectiveness of an existing system, to compare competing alternative systems, or to design proposed systems by determining the values of the decision variables that yield the most desirable levels of performance [1,2,6]. This research aims to survey current green activities in computer parts' manufacturers in Thailand and to evaluate green supply chain management.

II. ELECTRONICS INDUSTRY IN THAILAND

Electronics industry plays an important role to Thailand's economic growth in top ranking. In 2008 the export value of electronics products was US$29.2 billion which 60% was computers and their parts. In recent years electronics manufacturers face some barriers such as instability in manufacturing costs, skill labor need, technology change, exchange rate, and impacts of high competitiveness, environmental legislation and directives as well.

Reverse views of electronics supply chain also challenge with incremental wastes of end-of-life (EOL) products such as computers and home appliances. In addition low quality of electronics products is imported with higher rate which has increased waste from short lifetime. Small number of effective recycling and disposition system, incomplete collection infrastructure, lack in incentives to separate recycled or hazardous substances, ineffective law enforcement, and technology limitation in community level also are obstacles for waste management.

With strong collaborative among several parties from electronics manufacturers, private and public sectors such as Electrical and Electronics Institute, the Federation of Thai Industries, National Metal and Materials Technology Center, Pollution Control Department, Thailand Environment Institute, short and long-term strategies for electronics manufacturing and electronics waste management are determined and forced to implement seriously for better effective forward supply chains and reverse logistics.

III. GREEN SUPPLY CHAIN MANAGEMENT

To survey current green activities in computer parts' manufacturers in Thailand, 11 manufacturers are selected for case studies who provide in-depth interview about green procurement, green manufacturing, green distribution, and/or reverse logistics. Their products or services are related to computer parts which are IC, hard disk drive, power supply, print circuit board and monitor. Also, several stakeholders in EOL electronic parts: used computer stores (2nd hand markets), waste collectors (called SaLeng), disassembly/recycle plants, and final treatment/landfill company are involved. Most of them comply with WEEE and RoHS directives to minimize the hazardous or toxic in
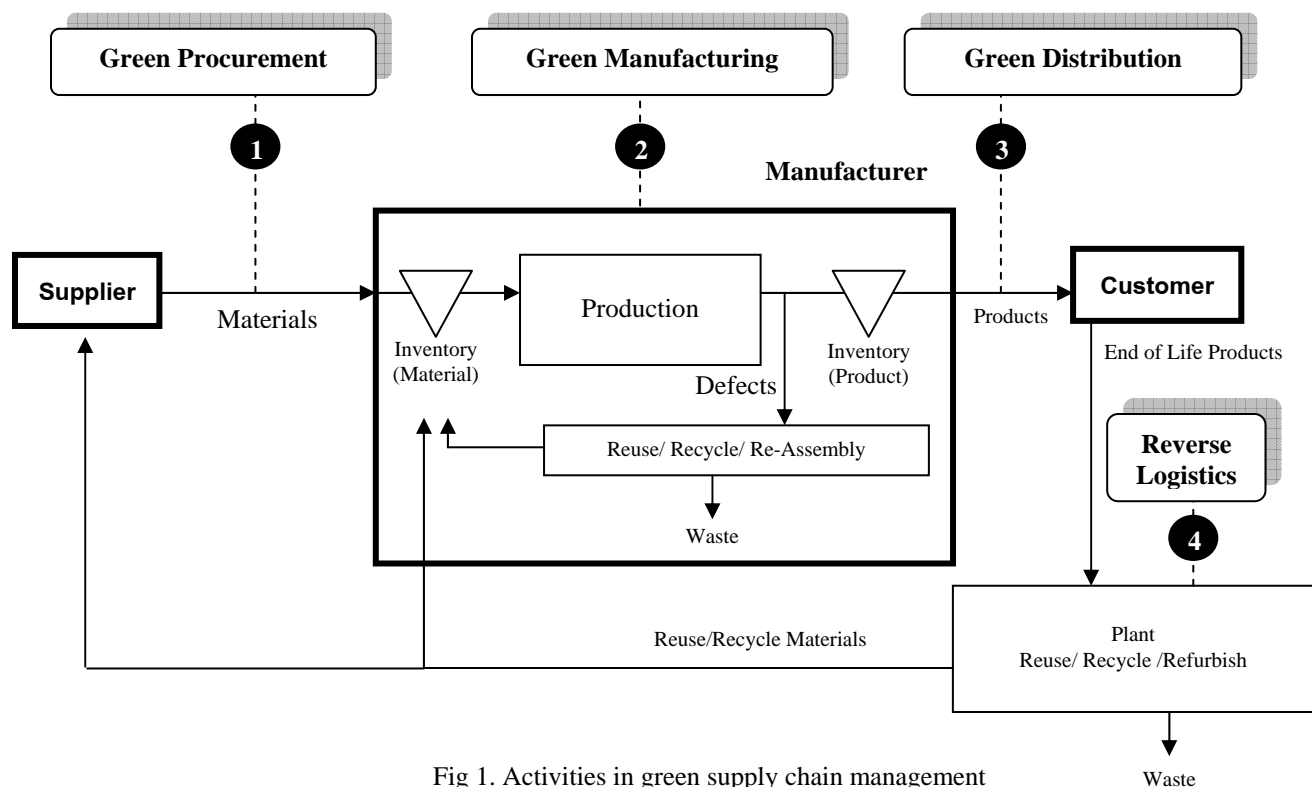
Fig 1. Activities in green supply chain management

electronic parts. Their green activities can be revealed as shown in Fig. 1

A. Green Procurement

Green procurement is defined as an environmental purchasing consisting of involvement in activities that include the reduction, reuse and recycling of materials in the process of purchasing. Besides green procurement is a solution for environmentally concerned and economically conservative business, and a concept of acquiring a selection of products and services that minimizes environmental impact [7]. The findings in green procurement activities of Thai manufacturers are presented:

• Supplier selection: (1) purchase materials or parts only from "Green Partners" who satisfy green partner environmental quality standards and pass an audit process in following regulations for the environment-related substances (2) consider suppliers who acquire ISO14000, OHSAS18000 and/or RoHS directives (3) select suppliers who control hazardous substances in company's standard lists and obtain green certificate achievements

• 3Rs in procurement process: (1) reuse or recycle – paper, parts container (plastic box/bag) (2) order via email (paperless)

B. Green Manufacturing

Green manufacturing is defined as production processes which use inputs with relatively low environmental impacts, which are highly efficient, and which generate little or no waste or pollution. Green manufacturing can lead to lower raw material costs, production efficiency gains, reduced environmental and occupational safety expenses, and improved corporate image [8]. The findings in green manufacturing activities of Thai manufacturers are presented:

• Hazardous substance control: (1) lead free – replace other substances such as bismuth, silver, tin, gold, copper (2) rinse parts with clean water instead of using chemicals and reuse water (3) quality control in inputs at vendor site and recheck before processing

• Energy-efficient technology [9]: (1) reduce power consumption in products such as ramp load/unload technology in HDD (2) increase product life-span resulting in higher efficiency and productivity (3) improve machine uptime (4) improve machine performance, for example a process of solder jet bonding (using jet in soldering up to 2000 gold balls/hr instead of pressing 500-700 gold balls/hr) (5) design product, for example compact design with improved features yet using fewer resources to produce, Strive for higher %recyclability and % recoverability for products as stipulated by WEEE directive, product exterior using bio-based plastics achieves high level of fire retardancy

• 3Rs and waste minimization: (1) promotes reuse/ recycle of parts (2) enhance environmental consciousness via 3Rs activities (3) reduce indirect materials such as epoxy glue

C. Green Distribution

Green distribution are consists of green packaging and green logistics. Packaging characteristics such as size, shape, and materials have an impact on distribution because of their affect on the transport characteristics of the product. Better packaging, along with rearranged loading patterns, can reduce materials usage, increase space utilization in the warehouse and in the trailer, and reduce the amount of handling required [10]. The findings in green distribution activities of Thai manufacturers are presented:

• Green packaging: (1) downsize packaging (2) use "green" packaging materials (3) cooperate with vendor to standardize packaging (4) minimize material uses and time to

unpack (5) encourage and adopt returnable packaging methods (6) promote recycling and reuse programs

- Green logistics/transportation: (1) deliver directly to user site (2) use alternative fuel vehicles (3) distribute products together, rather than in smaller batches (4) change to modal shift

D. Reverse Logistics

Reverse logistics is the process of retrieving the product from the end consumer for the purposes of capturing value or proper disposal [11]. Activities include collection, combined inspection/selection/sorting, re-processing/direct recovery, redistribution, and disposal. The findings in reverse logistics of stakeholders are presented:

- Used computer stores: (1) get computer parts 50% from import (e.g. China, Japan and Korea), 30% from auction in organizations, and the rest from household (2) generally be small shops with purchase volume up to 40 used computers per month (3) the five most reused parts: ram, LCD monitor, CD Rom, CRT monitor and main board (4) waste parts treated in different ways: 44% to waste collectors, 26% to walk-in buyers, 26% to store in shop or warehouse, and the rest 4% to garbage
- Waste collectors (called SaLeng) gather EOL computers from community, private/public organization, and used computer store then inspect, select and sort initially to get used parts which are shipped to disassembly/recycle plants. There is lack of obvious database about quantities and value provided in this stage.
- Disassembly/recycle plants collect used computers and parts 50% from manufacturing plants, 20% from community, 20% from waste collectors, and the rest 10% from private/public organization. About 40% of disassembling parts are small electronic parts (e.g. IC, diode, transformer) and materials (metal, glass, plastic) which are derived and sold to big electronic markets. The rest of it are shipped to recycle plants which recycle some precious metals like copper, gold, platinum.
- Final treatment/landfill company has received the benefit of technology transfers, technical and management assistance from USA. The facility has industrial waste treatment and disposal systems for computer waste by secure landfill or stabilization and solidification systems (a process of detoxification and converting waste into a solid form before disposal in the landfill).

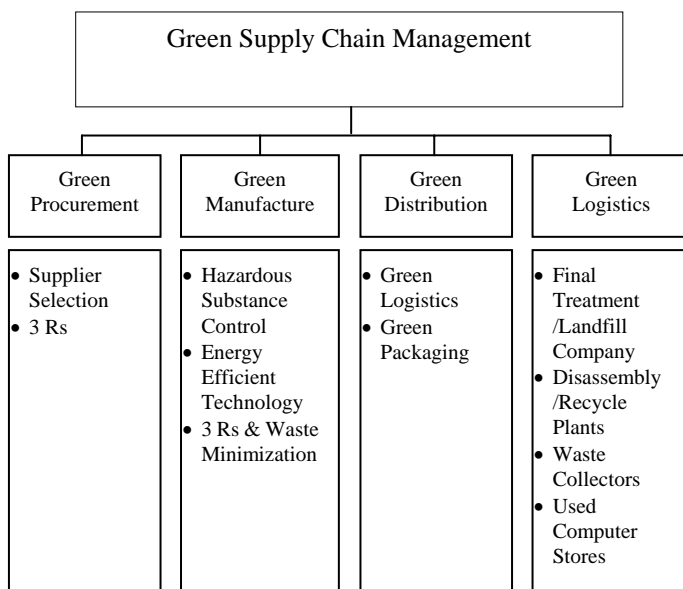All green activities in green supply chain of electronics industry are concluded in Fig 2.

Fig 2. Activities in green supply chain of electronics industry

IV. ENVIRONMENTAL PERFORMANCE

To evaluate green supply chain management, the questionnaire [1] related to investigate GSCM practices, measure GSCM performance, and explore GSCM pressure/driver within the Chinese automobile industry is applied in evaluating in electronics industry in Thailand. Before using this questionnaire, working with experts in environmental management is done along with validity and reliability assessment of questionnaire. A total of 118 surveys were administered to electronics industry supply chain mid-level managers focusing on computer parts manufacturers. Then we arrived at a final sample of 37 organizational responses which 86.5% are large-sized company.

A. Questionnaire Items

The questionnaire contained three sections: GSCM practices, GSCM performance, and GSCM pressure/driver.

GSCM practices: questions about current GSCM practice adoption were answered using a five-point Likert-type scale (1 = not considering it, 2 = planning to consider it, 3 = considering it currently, 4 = carrying out to some degree, 5 = carrying it out fully). The questions can be grouped as five topics which are:

1.Internal environmental management
1.1 Commitment of GSCM from senior managers
1.2 Support for GSCM from mid-level managers
1.3 Cross-functional cooperation for environmental improvements
1.4 Total quality environmental management
1.5 Environmental compliance and auditing programs
1.6 ISO 14001 certification
1.7 Environmental Management Systems exist
1.8 Eco-labeling of Products
1.9 Support of regulations environment

2. Green purchasing
2.1 Cooperation with suppliers for environmental objectives
2.2 Environmental audit for suppliers' internal management
2.3 Suppliers' ISO14000 certification
2.4 Second-tier supplier environmentally friendly practice evaluation

3. Eco-design
3.1 Design of products for reduced consumption of material/energy
3.2 Design of products for reuse, recycle, recovery of material, component parts
3.3 Design of products to avoid or reduce use of hazardous of products and/or their manufacturing process
3.4 Design of product for support regulation
3.5 Design the products that weight and the least capacity for decrease taking time, the area stores, and the energy between the transportation leas
3.6 Design the products to be easy set up for the users in the most energy saving way
3.7 Design usability of part particularly for Extend using products, repair easy and increase efficiency
3.8 Make the maintains table for the capacity certainly of products and don't deteriorate which will cause gas glass house abandonment less

4. Cooperation with customers
4.1 Cooperation with customer for eco-design
4.2 Cooperation with customers for cleaner production
4.3 Cooperation with customers for green packaging

5. Investment recovery
5.1 Investment recovery (sale) of excess inventories/ materials
5.2 Sale of scrap and used materials
5.3 Sale of excess capital equipment

GSCM performance: questions about the influence of implementing GSCM on these performance factors were answered using a five-point scale (1 = not at all, 2 = a little bit, 3 = to some degree, 4 = relatively significant, 5 = significant). The questions can be grouped as three topics which are:

1.Environmental
1.1 Reduction of air emission
1.2 Reduction of waste water
1.3 Reduction of solid wastes
1.4 Reduction of physical
1.5 Decrease of consumption for hazardous/harmful/toxic materials
1.6 Decrease of frequency for environmental accidents
1.7 Improve an enterprise's environmental situation
2.Positive economic
2.1 Decrease of cost for materials purchasing
2.2 Decrease of cost for energy consumption
2.3 Decrease of fee for waste treatment
2.4 Decrease of fee for waste discharge
2.5 Decrease of fine for environmental accidents
3.Negative economic
3.1 Increase of investment
3.2 Increase of operational cost
3.3 Increase of training cost
3.4 Increase of costs for purchasing environmentally friendly materials

GSCM pressure: questions about affecting or motivating implementation were answered using a five-point scale (1 = not at all important, 2 = not important, 3 = not thinking about it, 4 = important, 5 = extremely important). The questions can be grouped as three topics which are:

1.Market
1.1 Export
2.Regulatory
2.1 Central governmental environmental regulations
2.2 Regional environmental regulations
2.3 Regulations: WEEE
2.4 Regulations: RoHS
2.5 Regulations: REACH
2.6 Regulations: EuP
3.Competition
3.1 Competitors' green strategies
3.2 Industrial professional group activities

B. Survey Results

GSCM practices:

As seen in Fig. 3, Thai electronics supply chain enterprises carry out to some degree of GSCM practices' adoption with mean values over 4.00 for the five GSCM factors; especially for environmental management systems exist with the highest mean value of 4.43. Besides GSCM practices' adoption rate lagged, with the lowest mean values of 3.03 is eco-labeling of products.
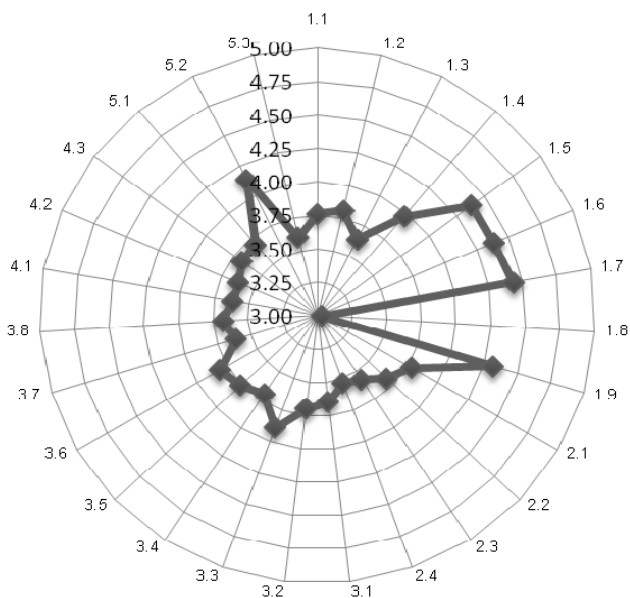

Fig. 3 Survey results of GSCM practices

GSCM performance:

All GSCM performance dimensions are ranked from higher to some degree to relatively significant, with mean values consistently within the 3.00 and 4.00 ranges. Both environmental and positive economic are in relatively significant as shown in Fig. 4.
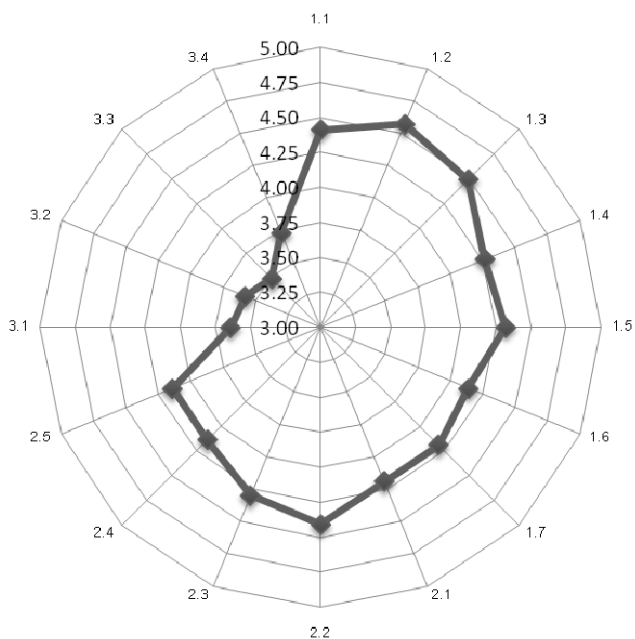

Fig. 4 Survey results of GSCM performance

GSCM pressure:

Electronics enterprises have experienced significant pressures and incentives to implement GSCM, with mean values over 4.00 for the two driver factors. Pressure from environmental regulations is the highest with a mean value of 4.11. Export pressure is the second important driver for Thai electronics supply chains to implement GSCM. This survey result appears in Fig. 5.
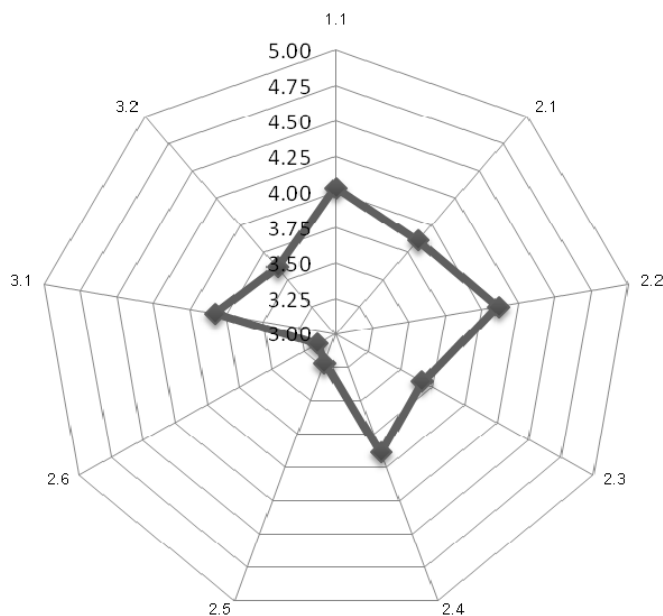

Fig. 5 Survey results of GSCM pressure

This survey was also extended to study in-depth in each type of computer parts. For GSCM practice, semiconductor, hard disk drive, and print circuit board are three products with carrying out from some degree to full adoption. Hard disk drive and print circuit board reveal relatively significant in GSCM performance. In experience from GSCM pressure, print circuit board and semiconductor are considered in important implementation.

V. SUGGESTION

To obtain efficient and effective in GSCM, collaborative among important stakeholders in electronics industry must be strongly concerned. After making discussion about research results with experts and manufacturers, some important suggestions are noted here:

- Promote Ecodesign: Ecodesign as an activity that integrates environmental aspects into product design and development, the integrated activities lead to continual improvement of the environmental performance of the entire product through technological innovation. Developing environmentally friendly products is cause to change in product design using 2 principles: (1) designed to extend lifetime of product, it can be improved, repair, and re-use of products such as modular design (2) designed for recycling / design for disassembly, after end of life products that can be more recovery
- Control hazardous substances: complying with RoHS and other regulations
- Set rules for disposing electronics waste and consider

more investment in recycle plants

- Propagate GSCM knowledge and encourage using environmentally friendly goods and services
- Set a direct responsible unit to take in charge of electronics waste only which will increase reverse logistics efficiently
- Promote refurbishing and recycling through campaigns/ activities to raise reuse/recycle awareness in electronics consumption
- Expand product lifespan by designing for disassembly or upgrading computer specification instead of buying new ones or using computer rental services
- Set a database unit to collect and record information About production, import/export data, and waste management (do traceability)
- Encourage team building and train skilled labors for reverse logistics management
- Raise the applications in Extended Producer Responsibility (EPR); EPR is an environmental protection strategy based on the "polluter pays" principle, by making the manufacturer of the product responsible for the entire life-cycle of the product and packaging they produce
- Promote Product Service System (PSS); services and product-service combinations are recognized as a potentially powerful concept for sustainable development. A product-service system (PSS) is a new trend that has the potential to minimize environmental impacts of both production and consumption. Thus, more traditional material intensive ways of product utilization are replaced by the possibility to fulfill consumers' needs through the provision of more dematerialised services

ACKNOWLEDGMENT

REFERENCES

[1] Q. Zhu, J. Sarkis, and K. Lai, "Green supply chain management: pressures, practices and performance within the Chinese automobile industry," *Journal of Cleaner Production*, vol.15, 2007, pp.1041-1052.

[2] A. A. Hervani, M. M. Helms, and J. Sarkis, "Performance measurement for green supply chain management," *Benchmarking: An International Journal*, vol. 12, no. 4, 2005, pp. 330-353.

[3] R.I. Van Hock, " From reversed logistics to green supply chains," *Logistics Solutions*, vol.2, 2000, pp.28-33.

[4] H.K. An, T. Amano, H. Utsumi, and S. Matsui, "A framework for green supply chain management complying with RoHS directive," Available:http://www.crrconference.org/plaintext/downloads/2006ky unganamanoutsumimatsui.pdf

[5] J. Sarkis, "A strategic decision framework for green supply chain management," *Journal of Cleaner Production*, vol.11, 2003, pp.397-409.

[6] B.M. Beamon, "Designing the green supply chain," *Logistics Information Management*, vol.14, no.4, 1999, pp.332-342.

[7] M.A. Salam, "Green procurement adoption in manufacturing supply chain," *Proceedings of the 9th Asia Pasific Industrial Engineering & Management Systems Conference* (APIEMS2008), 3-5 December 2008, Indonesia, pp.1253-1260.

[8] M. Atlas, and R. Florida, "Green manufacturing," *Handbook of Technology Management*, 1998 Available: http://creativeclass.com/rfcgdb/articles/13%20Green%20Manufacturi ng.pdf

[9] K. Kamigaki, "Generation of green brand," Asian Electrical and Electronic Green Society International Conference, 7-9 October 2009, Thailand.

[10] J.C. Ho, M.K. Shalishali , T. Tseng, and D.S. Ang, "Opportunities in green supply chain management," *The Coastal Business Journal*, vol.8, no.1, 2009, pp.18-31. Available: http://www.coastal.edu/business/cbj/pdfs/articles/spring2009/ho_shali shali_tseng_ang.pdf