# Green Supply Chain Management: A Case Study from Indian Electrical and Electronics Industry

**Sanjeev Kumar, Somnath Chattopadhyaya, Vinay Sharma**

***Abstract— This study aims to investigate the green supply chain management practices likely to be adopted by the manufacturing industry of electrical and electronics products in India. The approach of the present research includes a literature review, in depth interviews and questionnaire surveys. The relationship between green supply chain management practices and environmental performance is studied. The industries in the electrical and electronics products industry in India were sampled for empirical study. The data were then analyzed using "mean score". The results indicate that performance of eco procurement, eco accounting, eco logistics design, eco product design, eco manufacturing, economic performance, etc practices in response to the current wave of national & international green issues and also environmental performances of the electrical and electronics industry.***

***Index Terms— Indian industry, electrical and electronics, green supply chain, environmental performance, case study.***

## I. INTRODUCTION

Increasing awareness about environmental protection in India and world, the green trend of conserving the Earth's resources and protecting the environment is overwhelming, thereby exerting pressure on industries in India and worldwide. India has gained its position among the top ten countries and has become one of the largest manufacturing economies of the world (Chetan Kumar M. Sedani, Ramesh R. Lakhe, 2011) [1]. The pressure and drive accompanying globalization has prompted industries to improve their environmental performance (Zhu and Sarkis, 2006) [10]. Consequently, industries have shown growing concern for the environment over the last decade. Industrial environments have experienced drastic change and face competitive challenges. Recently supply chain management has directed its attention to the role of the supply chain in impacts to the natural environment. The supply chain is an integrated manufacturing process wherein raw materials are converted into final and finished products, then delivered to consumers or end user. An increasing number of supply chains invest in recycling systems intended to retrieve waste or used product from consumers. Green supply chain management, also known as ESCM (environmental supply chain management) or SSCM (sustainable supply chain management), combines green procurement, green manufacturing/materials management, eco accounting, green distribution/marketing and reverse logistics. There are two basic processes in the supply chain: (1) production planning and inventory control, and (2) distribution and logistics. (Seok Jin Lim, Suk Jae Jeong, Kyung Sup Kim, MyonWoong Park, 2006)[8]. Environmental protection and conservation of natural resources has become an absolute necessity at national and international levels. Management of hazardous waste is an important part in attaining environmental protection throughout the world. Minimizing the generation of hazardous waste, recovery of valuable materials from the waste and preventing the environmental deterioration are some complex issues which require prime attention (G. Kannan et al., 2010)[2].

This study explains the practices and implementation of green supply chain and environmental performance among electrical and electronics products manufacturing industry located in India. Green Supply Chain Management practices implementation as encompassing 14 factors of practices including Eco-Procurement, Eco-Accounting, Eco-Logistics Design, Eco-Product Design, Eco-Manufacturing, Marketing & Communication, Economic Performance, Environmental Performance, Customer Co-operation, Human and Technological Resources, Internal Environmental Management Performance, Operational Performance, Stakeholders, Vendor Management.

Paper consists of six sections. After this introduction, in Section II, a short review of the relevant literature helps to establish a link among green supply chain management and environmental performance. Section III states the objective of the research. Research methodology is in Section IV. Result and comparative analysis of various factor of green supply chain management by calculating 'mean score' are presented in section V. Finally, conclusions presented in section VI.

## II. LITERATURE REVIEW

There are only a few studies related to green supply chain management. Approaches towards Green Supply Chain Management (GSCM) practice have been identified by various researches; they are briefly outlined below. Shang et al. (2010) [4] conducted a study based on six dimension of green supply chain management i.e. eco design, green manufacturing and packaging, environmental participation, green marketing, stock and suppliers. The results inferred that the firms which were focusing on green marketing had been successful competitors against the rivals. Lamming and Hampson (1996) [5] explored the concepts of environmentally sound management and linked them to supply chain management practices such as vendor assessment, collaborative supply strategies, establishing environmental procurement policy and working with suppliers to enable improvements.

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A decision model to measure environmental practice of suppliers using a multi attribute utility theory approach developed by Handfield et al. (2002) [3]. Walton et al. (1998) [9] identified several dimensions of change to increase the impact of procurement on environmental results. Quinghu Zhu et al (2008) [6] conceptualize Green Supply Chain Management practices implementation as encompassing different dimensions of practices including Green Procurement, Internal Environmental Management, Eco Design, Customer Cooperation, and Investment Recovery. Ramudhin A., et al. (2010) [7] proposed a strategic planning model and insisted that internal and external control mechanism are of great importance to decision makers while designing sustainable supply chain network.

This study aims to examine the measurement model of Green Supply Chain Management practices implementation focusing on 14 factors with 105 underlying dimensions.

## III. OBJECTIVE OF THE RESEARCH

Investigate the practice and implementation of green supply chain management in Indian electrical and electronics product manufacturing industries.

## IV. RESEARCH METHODOLOGY

The Competitive Strategies and Best Practices Benchmarking Questionnaire have been developed. Based on review of studies, finally researcher had arrived at set of 105 items after eliminating the redundant items by submitting the statements to respondents and discussing with experts, who were believed to have knowledge of the subject for fair judgment. The questionnaire consists of total 14 factors with 105 underlying dimensions. Performance strategies will depend upon their aggregate score. The model aims to explore possible near future developments in the competitive strategies of the companies by addressing their competitive priorities, manufacturing objectives and action plans. The target respondents of our survey were requested to indicate, using a five-point Likert scale (1- Below average/Completely disagree, 2-Average/ Rarely agree, 3-Good/ Partly agree, 4 –Very good/ Rather agree, 5- Excellent/Completely agree), the extent to which they perceived their companies implementing each of the dimensions of GSCM practices. Item analysis was conducted for each of the 105 statements through a "**mean score**". These dimensions are represented in the form of questionnaire, for measuring the different facets of GSCM practices implementation, enabling organizations to evaluate their strength and weakness in the course of implementing these practices.

## V. COMPARATIVE ANALYSIS OF FACTOR, RESULT AND DISCUSSION

Table: 1 to 14 and Graph: 1 explains about the comparative analysis of effectiveness green supply chain factors with 105 underlying dimensions for Indian enterprises. As discussed earlier, 14 green supply chain factors with 105 underlying dimensions considered in this study and each dimension has its own importance for effective green supply chain performance. As per the literature review & experts view, used linkert scale in this questionnaire, where '1' employs below average & '5' employs excellent. Each scale signifies how these factors for an industry for effective green supply chain factors. For these competitive '**mean score**' have been calculated.

**Table-1: Performance of Eco Procurement [Factor 1] (Average Mean score: 1.904)**

| DIMENSION | MEAN SCORE |
|---|---|
| Provides design specification to suppliers that include environmental requirements for purchased item | 1.775 |
| Co-operation with suppliers for environmental purchasing | 2.208 |
| Existence of cell for environmental audit for suppliers internal management | 1.75 |
| Procurements mainly from ISO14000 certified suppliers | 2.229 |
| Second-tier supplier's environmentally friendly practice evaluation | 1.729 |
| Implementation of eco-labeling/eco-logo of products | 1.729 |
| Work with other business functions to discuss and improve purchasing procedures. | 1.625 |
| Provision of education/assistance to suppliers on environmental matters in order to increase supply chain efficiency. | 1.687 |
| Communication regarding environmental procurement criteria/requirements to marketing staff, employees, stakeholders, and customers | 1.770 |
| Co-operation with customers for environmental packaging | 2.541 |

"Eco Procurement", which has 10 underlying dimensions. In industry the most important dimension is Co-operation with suppliers for environmental packaging (2.541) followed by Procurements mainly from ISO 14001 certified suppliers (2.229), Co-operation with suppliers for environmental purchasing (2.208) and the least important dimension is Work with other business functions to discuss and improve purchasing procedures (1.625) followed by Provision of education/assistance to suppliers on environmental matters in order to increase supply chain efficiency (1.687), Implementation of eco-labeling/eco-logo of products (1.729), Second-tier supplier's environmentally friendly practice evaluation (1.729) .

**Table-2: Performance of Eco Accounting [Factor 2] (Average Mean score: 1.700)**

| DIMENSION | MEAN SCORE |
|---|---|
| Environmental costs associated with operations and processes (e.g. monitoring and abatement equipment, waste disposal etc.) are taken care | 1.916 |

| | |
|---|---|
| Accounting the costs to the customers associated with the use and disposal of the products | 1.562 |
| Communication of environmental costs to customers and within the industry in key business functions | 1.708 |
| Assisting in evaluation of environmental cost with respect to capital purchases and new technology | 1.729 |
| Generate activity based costing in various department or business function | 1.583 |

"Eco Accounting", which has 5 underlying dimension. In industry the most important dimension is Environmental costs associated with operations and processes (e.g. monitoring and abatement equipment, waste disposal etc.) are taken care (1.916 ) followed by Assisting in evaluation of environmental cost with respect to capital purchases and new technology (1.729), and the least important dimension is Accounting the costs to the customers associated with the use and disposal of the products (1.562) followed by Generate activity based costing in various department or business function (1.583).

**Table-3: Performance of Eco Logistics Design [Factor 3] (Average Mean score: 1.787)**

| DIMENSION | MEAN SCORE |
|---|---|
| Reverse logistics applied in stock planning | 1.604 |
| Application of environmental issues in the design of logistics management | 1.583 |
| Identification, Collection & distribution of products/parts that will be recycled, reused | 1.645 |
| Recollection planning for packaging material | 1.458 |
| Minimizing the use of packaging considered | 2.645 |

"Eco Logistics Design", which has 5 underlying dimensions. In industry the most important dimension is Minimizing the use of packaging considered (2.645) followed by Identification, Collection & distribution of products/parts that will be recycled, reused (1.645), and the least important dimension is Recollection planning for packaging material (1.458), Application of environmental issues in the design of logistics management (1.583).

Table-4: Performance of Eco Product Design [Factor 4] (Average Mean score: 1.884)

| DIMENSION | MEAN SCORE |
|---|---|
| Design of products for optimum consumption of material/energy | 2.52 |
| Product designed for reuse, recycle, recovery of material, components parts | 2.02 |
| Design consideration of products to avoid or reduce use of hazardous of products | 1.767 |
| Design of products to reduce waste & costs | 2.271 |
| Products are design & develop meet environmental regulation and safety standards | 1.583 |
| Co-operation & feedback with customer in developing eco-design | 1.812 |
| Products are design & developed for ease in dismantling & remanufacturing | 1.708 |
| Application of value engineering/analysis in the design of products | 1.5 |
| Evaluation of product durability | 1.791 |
| Possibility of eliminating secondary processes (polishing/painting etc.) considered. | 1.875 |

"Eco Product Design", which has 10 underlying dimensions. In industry the most important dimension is Design of products for optimum consumption of material/energy (2.520) followed by Design of products to reduce waste & costs (2.271), Product designed for reuse, recycle, recovery of material, components parts (2.020) and the least important dimension is Application of value engineering/analysis in the design of products (1.500) followed by Products are design & develop meet environmental regulation and safety standards (1.583), Products are design & developed for ease in dismantling & remanufacturing (1.708).

**Table-5: Performance of Eco Manufacturing [Factor 5] (Average Mean score: 1.863)**

| DIMENSION | MEAN SCORE |
|---|---|
| Possibility of product being recyclable, reusable | 1.791 |
| Avoid or minimize the amount of hazardous material used in product production | 2.437 |
| Are designers using life cycle engineering to improve the environmental performance and production efficiency of the products | 1.791 |
| Measures taken to reduce material, water & energy used in manufacturing | 2.020 |
| Optimizing the use of energy generated from renewable sources in manufacturing operations | 1.895 |
| Inclusion of recycling program for manufacturing operation | 1.137 |
| Industry has established program to increase the service intensity of the products | 1.291 |
| Determination of environmental impacts and costs of the products throughout their life-cycle | 1.500 |
| Minimizing toxic/hazardous waste during manufacturing | 2.291 |
| Optimum energy consumption during manufacturing process | 2.291 |

| | |
|---|---|
| Integrated environmental & efficiency criteria implementation in process design | 1.416 |
| Minimizing use of natural resources during manufacturing is considered | 1.916 |
| Consideration of environmental issue in the process of production planning and control | 1.416 |
| Environmental issue considered during selection of manufacturing process | 1.583 |
| Reduced setup time | 2.875 |

"Eco Manufacturing", which has 15 underlying dimension. In industry the most important dimension is Reduced setup time (2.875) followed by Avoid or minimize the amount of hazardous material used in product production (2.437), and the least important dimension is Inclusion of recycling program for manufacturing operation (1.137) followed by Industry has established program to increase the service intensity of the products (1.291), Consideration of environmental issue in the process of production planning and control (1.416), Integrated environmental & efficiency criteria implementation in process design (1.416).

**Table-6: Performance of Marketing and Communication [Factor 6] (Average Mean score: 1.591)**

| DIMENSION | MEAN SCORE |
|---|---|
| Assisting customers to improve their environmental performance | 1.791 |
| Environmental requirement and activities of customer concern are monitored | 1.687 |
| Awareness regarding environmental information to new and existing employees | 1.416 |
| Departmental interaction and exchange of information regarding environment, performance, efficiency etc. | 1.500 |
| Use of environmental information during product marketing & communications material | 1.562 |

"Marketing and Communication", which has 5 underlying dimension. In industry the most important dimension is Assisting customers to improve their environmental performance (1.791) followed Environmental requirement and activities of customer concern are monitored (1.687), and the least important dimension is Awareness regarding environmental information to new and existing employees (1.416) followed by Departmental interaction and exchange of information regarding environment, performance, efficiency etc (1.500).

**Table-7: Performance of Economic Performance [Factor 7] (Average Mean score: 2.220).**

| DIMENSION | MEAN SCORE |
|---|---|
| Waste discharge methodology for reducing cost | 2.104 |
| Reduction in cost for materials purchasing without affecting the quality of the product | 2.083 |
| Reduction in cost of energy consumption | 2.604 |
| Effective waste treatment management for reducing cost | 2.145 |
| Reduction of the fine for environmental accidents | 2.165 |

"Economic Performance", which has 5 underlying dimension. In industry the most important dimension is Reduction in cost of energy consumption (2.604) followed by Reduction of the fine for environmental accidents (2.165) and the least important dimension is Reduction in cost for materials purchasing without affecting the quality of the product (2.083) followed Waste discharge methodology for reducing cost (2.104).

**Table-8: Performance of Environmental Performance [Factor 8] (Average Mean score: 2.089).**

| DIMENSION | MEAN SCORE |
|---|---|
| Minimization of air emission | 2.666 |
| Minimization of solid waste | 2.812 |
| Improve production procedure/method for reducing waste/scrap | 2.291 |
| Recovery through sale of scrap and used/rejected material | 1.458 |
| Recovery through sale of excess capital equipment | 1.375 |
| Recovery through sale of old/obsolete equipment | 1.375 |
| Recycling of waste water | 1.500 |
| Optimization of man power resources in production process | 2.750 |
| Reduction of consumption for hazardous materials | 2.458 |
| Reduction in frequency of environmental accidents | 2.208 |

"Environmental Performance", which has 10 underlying dimension. In industry the most important dimension is Minimization of solid waste (2.812) followed by Optimization of man power resources in production process (2.750) and the least important dimension is Recovery through sale of old/obsolete equipment (1.375) followed by Recovery through sale of excess capital equipment (1.375), Recovery through sale of scrap and used/rejected material (1.458).

**Table-9: Performance of Customer Co-operation [Factor 9] (Average Mean score: 2.608).**

| DIMENSION | MEAN SCORE |
|---|---|
| Co-operation from customers for eco-design | 2.708 |
| Co-operation from customers for cleaner production | 2.687 |
| Co-operation from customers for green packaging | 2.604 |
| Co-operation from customers for using less energy during product transportation | 2.770 |
| Co-operation with customers for environmental procurement | 2.271 |

"Customer Co-operation", which has 5 underlying dimension. In industry the most important dimension is Co-operation from customers for using less energy during product transportation (2.770) followed by Co-operation from customers for eco-design (2.708), and the least important dimension is Co-operation with customers for environmental procurement (2.271) followed by Co-operation from customers for green packaging (2.604).

**Table-10: Performance of Human and Technological Resources [Factor 10] (Average Mean score: 2.279).**

| DIMENSION | MEAN SCORE |
|---|---|
| Improvement in worker safety | 2.875 |
| Motivate workers for environmental consciousness | 2.166 |
| Increase supervisor training | 1.791 |
| Use of energy efficient technologies | 2.666 |
| Consultation with environmental experts before using new technology | 1.896 |

"Human and Technological Resources", which has 5 underlying dimension. In industry the most important dimension Improvement in worker safety (2.875) followed by Use of energy efficient technologies (2.666) and the least important dimension is Increase supervisor training (1.791) followed by Consultation with environmental experts before using new technology (1.896).

**Table-11: Performance of Internal Environmental Management Performance [Factor 11] (Average Mean score: 1.675).**

| DIMENSION | MEAN SCORE |
|---|---|
| Promotion of quality circles | 2.500 |
| Existance of environmental and auditing program | 2.041 |
| Provision of training in environmental management | 1.875 |
| Implementation of ISO 14001 certification | 2.083 |
| Commitment of green supply chain management policy by senior managers | 1.375 |
| Awareness about the green supply chain management measures adopted by the competitors | 1.291 |
| Existance of total quality environmental management | 1.416 |
| Updating the current and proposed environmental regulations and legislation that may impact on business | 1.437 |
| Existence of policy related to green supply chain management linking environmental, economic, process performances | 1.500 |
| Support for green supply chain management from junior & middle level managers/executive | 1.437 |

"Internal Environmental Management Performance", which has 10 underlying dimension. In industry the most important dimension is Promotion of quality circles (2.500) followed by Implementation of ISO 14001 certification (2.083) and the least important dimension is Awareness about the green supply chain management measures adopted by the competitors (1.291) followed Commitment of green supply chain management policy by senior managers (1.375).

**Table-12: Performance of Operational Performance [Factor 12] (Average Mean score: 2.283).**

| DIMENSION | MEAN SCORE |
|---|---|
| Reduced inventory level | 2.541 |
| Reduction in scrap | 2.625 |
| Promote environmental quality products | 2.083 |
| Optimization of capacity utilization | 3.125 |
| Amount of goods delivered on time | 3.291 |
| Monitoring the environmental and implementation for the improvement within industry | 2.000 |
| Program to promote and track the reduction of waste | 1.791 |
| Waste management program for compliance with all applicable regulations | 1.791 |
| Selection and use of energy efficient equipments and fixture for electrical, mechanical and lighting application | 1.854 |
| Development of a prevention program to identify and eliminate sources of pollution | 1.729 |

"Operational Performance", which has 10 underlying dimension. In industry the most important dimension is Amount of goods delivered on time (3.291) followed by Optimization of capacity utilization (3.125) and the least important dimension is Development of a prevention program to identify and eliminate sources of pollution (1.729) followed Program to promote and track the reduction of waste (1.791), Waste management program for compliance with all applicable regulations (1.791).

**Table-13: Performance of Stakeholders [Factor 13] (Average Mean score: 1.324)**

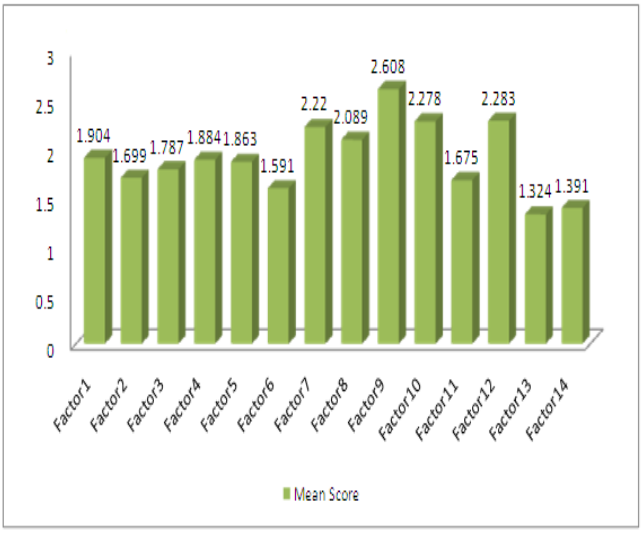
| DIMENSION | MEAN SCORE |
|---|---|
| Consideration & application of environmental issues because of regulatory concerns | 1.500 |
| Consideration & application of environmental issues because of suppliers | 1.291 |
| Consideration & application of environmental issues because of trade organizations | 1.375 |
| Consideration & application of environmental issues because of employee concerns | 1.229 |
| Consideration & application of environmental issue because of customer & market pressure | 1.229 |

"Stakeholders", which has 5 underlying dimension. In industry the most important dimension is Consideration & application of environmental issues because of regulatory concerns (1.500) followed by Consideration & application of environmental issues because of trade organizations (1.375) and the least important dimension is Consideration & application of environmental issues because of employee concerns (1.229) followed by Consideration & application of environmental issue because of customer & market pressure (1.229).

**Table-14: Performance of Vendor Management [Factor 14] (Average Mean score: 1.391).**

| DIMENSION | MEAN SCORE |
|---|---|
| Environmental performance is an important criteria in vendor selection | 1.500 |
| Environmental awareness among the vendors | 1.229 |
| Environmental certified vendor is considered | 1.229 |
| Environmental issues are regularly shared by vendors. | 1.500 |
| Feedback on environmental issues for the product supplied. | 1.500 |

"Vendor Management", which has 5 underlying dimension. In industry the most important dimension Feedback on environmental issues for the product supplied (1.500) followed by Environmental awareness among the vendors (1.500), Environmental performance is an important criteria in vendor selection (1.500) and the least important dimension is Environmental awareness among the vendors (1.229) followed by Environmental certified vendor is considered (1.229).




**Graph: 1 Comparative analysis of effectiveness of green supply chain factors.**

While analyzing the green supply chain factors in electrical and electronics product manufacturing industry it has been observed that the most important factor is "customer co-operation" (2.608) followed by "Operational Performance" (2.283) and "Human and Technological Resources" (2.278) and the least important factor perceive is "Stake Holders" (1.324) followed by "Vendor Management" (1.391) & "Marketing and Communication" (1.591). Therefore for the management point of view they should give more strength on "stakeholders", "Marketing and Communication", "Vendor Management" "Internal Environmental Management Performance "for improving green supply chain factors". Also it very important that the management of the industry should give special focus on the least mean scored factor as well as dimension in their organization, so that industry leads to provide customer satisfaction through green supply chain performance.

## VI. CONCLUSION

Research presents practitioners with a 105 item measurement scale for evaluating the different facets of their green supply chain practices implementation. Green Supply Chain Management (GSCM) is a relatively new green issue for the majority of Indian industries. The present empirical study investigated the GSCM practices adopted by the electrical and electronics product manufacturing industry in India. The pressures or drives to implement GSCM practices and the relationship between GSCM practices as well as environmental performance were also studied. The approach adopted in the present study included a questionnaire. This study also focused on the impact of environmental collaboration in the supply chain on manufacturing and environmental performance. Importance of approaches for green supply chain factors as shown in table 1 to 14. It also assess the relative importance of identified approaches that would affect the green supply chain implementation and the development

The electrical and electronics products manufacturing vendors have to work under hard time demands situation to meet these goals and have to follow latest & advanced manufacturing technique. From the survey of the industry, the score is not up to the mark. Industries should more concentrate their strategy. This will automatically improve the score card and thereby performance. The results could represent the general status of GSCM implementation in Indian electrical and electronics industries.

As raw material costs increase and environmental protection legislation becomes increasingly stringent, a focus on one industries green operational excellence is becoming the norm in industries. In addition, the model also can help managers/supervisors improve their understanding of Green Supply Chain Management practices and enables decision makers to assess the perception of GSCM in their organization. It is hoped that it can serve as a base for further research on exploring the implications of GSCM for different industry sectors and regions.

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