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GREEN SUPPLY CHAIN MANAGEMENT

Green practices

Thesis
CENTRIA UNIVERSITY OF APPLIED SCIENCES
Industrial Management
June 2019

ABSTRACT

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Degree programme Industrial Management		
Name of thesis GREEN SUPPLY CHAIN MANAGEMENT. Green practices		
Instructor Marja-Liisa Kaakko		**Pages** 31 + 1
Supervisor Marja-Liisa Kaakko		

Due to globalization and raising consciousness of environmental problems, companies start to implement one or more green supply chain management practices in their processes and products in order to improve environmental performance. Green supply chain management is a framework that incorporates environmental thinking in every aspect of supply chain management.

The main objective of this thesis is to discover best practices and techniques of green supply chain management and its part that are implemented by companies all over the world. The author believes that information provided in the thesis will be useful for entrepreneurs.

The thesis is fully based on theoretical research. The author describes the types of impact business has on the environment and how to measure it by life cycle assessment. In addition, the author introduces green supply chain management and green practices: green purchasing, green design, green manufacturing, green distribution and reverse logistics.

Key words
Environment, Green Practices, Green Supply Chain Management

CONCEPT DEFINITIONS

GP	Green Practice
GSCM	Green Supply Chain Management
EMS	Environmental Management System
LCA	Life Cycle Assessment
LCM	Life Cycle Management
SC	Supply Chain
SCM	Supply Chain Management
SME	Small and Medium-sized Enterprise

FIGURES

TABLES

1 INTRODUCTION

Due to the globalization, industrialization and the raising consciousness of the environment in recent decades, large companies have had to adapt their economic and environmental performance to maintain continuous development. For this reason, many subjects and issues that are connected to Green Supply Chain Management (GSCM) have been discussed and resolved by governments and companies. GSCM is a scope of Supply Chain Management (SCM) policies "held, actions taken, relationships formed in response to the natural environment" with regard to procurement, design, production, use, reuse, recycle and disposal of the firm's products and services (Cosimato & Troisi 2015, 260). GSCM differs from the traditional SCM because it incorporates environmental thinking in every aspect of Supply Chain (SC) processes (Jaggermath & Khan 2015).

Since the concept of GSCM is recently developed, the main aim of this thesis was to analyze GSCM and current Green Practices (GP) such as green purchasing, green design, green manufacturing, green distribution and reverse logistics and to analyze how they can be used to improve a company's performance. In this thesis, the objective was to answer such questions: What is GSCM, GP? How does the GSCM fit within the strategy of SC? How the GSCM framework is implemented and structured? What techniques and tools are currently used to reduce environmental impact? How to analyze and measure the current company's performance - make a product or process Life Cycle Assessment (LCA)? It is expected that the theme and the questions that are answered in this thesis will support existing or future entrepreneurs to introduce GPs in their company.

All chapters of this thesis are based on a theoretical framework. In Chapters 2-3, the author presents theory on the topics of SCM, GSCM and environmental problems caused by industrial and service industries. The concept of GSCM is defined, its barriers and benefits are described as well as its content parts and implementation strategies. Afterwards, in Chapter 4, history and meaning of life cycle assessment, parts and ways of implementation are explained. LCA is an essential tool to measure current environmental impact which an organization creates.

In the further chapters, each of GP is introduced. Green purchasing is described since it is one of the most essential GP in Chapter 5. This chapter includes various techniques which are used at both reactive and proactive green purchasing strategies.

Moreover, Chapter 6 represents definition of green manufacturing and methods on how to implement it in an enterprise such as using EMS (e.g. ISO 14000). Green manufacturing includes all initiatives to optimize manufacturing processes in order to reduce waste and other emissions (Masoumik, Abdul-Rashid, Olugu, Ghazilla 2015). The author assumes that eco-design is a part of green manufacturing. In sub-chapter 6.1, eco-design is defined as well as steps of its establishment. In addition, tools that help to create and/or choose the proper eco-design are classified and described. Finally yet importantly, the author in Chapter 7 describes green and reverse logistics, their meaning, functions and relevant methods.

2 IMPACT OF BUSINESS ON ENVIRONMENT

Industrialization and globalization are essential for the development of society and economic growth. Nevertheless, they can have a harmful impact on the environment. Environment concerns such as energy or water consumption; air, land and water pollution are intricately linked to the SC of various goods.

Pollution can take a form of solid waste, hazardous materials, pesticides and noise. Solid waste is any sludge, garbage and other rejected materials produced by business (industrial, commercial) activities (NYS Department of Environment Conservation). Institute of Hazardous Materials describes hazardous material as a biological, chemical or physical item that has a potential to cause damage to humans, wild-life or ecosystem. Pesticides are toxic materials that are released intentionally into the environment and that can potentially be harmful to the environment and human's health (Toxic Action Center). Noise is a loud excessive sound that has harmful effects on the environment and human well-being which generated inside industrial facilities or workplaces, transport or building activities (Nathanson & Berg 2018).

According to Sarkis and Dou (2018), global environmental problems that are affected by business activities are global warming and climate change; ozone depletion; animal and plant decimation. In this chapter, the author will describe the types of effect which business has on the environment.

2.1 Wastewater and marine pollution

Different types of wastewater that are released into surface waters from industrial plants and outlets can affect the ecosystem on local and even national levels. An example of the environmental impact could be damage to the wastewater treatment system or pollution of groundwater reservoirs. In order to reduce or prevent this environmental damage, businesses should collect surface runoff, sewage waste, industrial waste in separated infrastructure, use and discharge the wastewater according to its quality, make constant sampling and monitoring of water, and remove sludge, etc. (Israel Ministry of Environment Protection 2015.)

Moreover, a marine is also affected by pollution of solid materials such as plastic, hazardous materials such as fuel, emissions (e.g. carbon dioxide) and noise from the ships, which cause water acidification and life of water species (Denchak 2018).

2.2 Land pollution

Land pollution is the degradation of the earth's surface and soil in a direct or indirect way as a result of human activities such as deforestation, agricultural or mining activities, nuclear or fuel waste, etc. This type of pollution can negatively affect the ecosystem as well as people's and wildlife's health. In addition, soil pollution and soil erosion resulting in loss of fertile land for agriculture, forest cover (Land Remediation Expo 2019).

To reduce or prevent land pollution, it is recommended to create or follow existing guidelines concerning land pollution; accurately use, store and transport the hazardous materials; report a suspicion that particular land is contaminated. (Israel Ministry of Environment Protection 2015).

2.3 Air emissions

Industrial operations are the main cause of air pollution because they result in the emission of organic solvents, respirable particles, sulfur dioxide and nitrogen oxides. This can negatively influence both the health of people and the environmental condition by contributing to climate change or/and the greenhouse effect. In order to reduce air emissions, companies can monitor current emissions and check the guidelines in order to improve and optimize operations. (Israel Ministry of Environment Protection 2015.)

2.4 Waste management

According to Science Daily, waste management is a part of SC that including such processes as "collection, transportation, processing or disposal of waste materials" to decrease their impact on human health and on the environment. Standard Industrial Classification (SIC codes) states that there are 17 different industrial groups of waste: organic and inorganic chemicals, primary iron and steel, stone, clay, glass, pulp, paper, plastic, concrete, food and other products (Lyons 2015, 84).

Guidebook for industrial waste management (US EPA b) clarifies that there are two most common waste management areas in manufacturing: management of waste and efficiency (6S) and selection of waste

management approaches. There are different ways of processing waste: landfill, incineration, recycling, biological reprocessing, and recovery of energy.

2.4.1 6S system

Conferring to US EPA b, 6S is a system to reduce waste, environmental, and human health risks to optimize productivity by managing the uncluttered work conditions and using visual notes to achieve valid operational results. The 6S pillars are Sort (Seiri), Set in Order (Seiton), Shine (Seiso), Standardize (Seiketsu), Sustain (Shitsuke) and Safety (FIGURE 1).

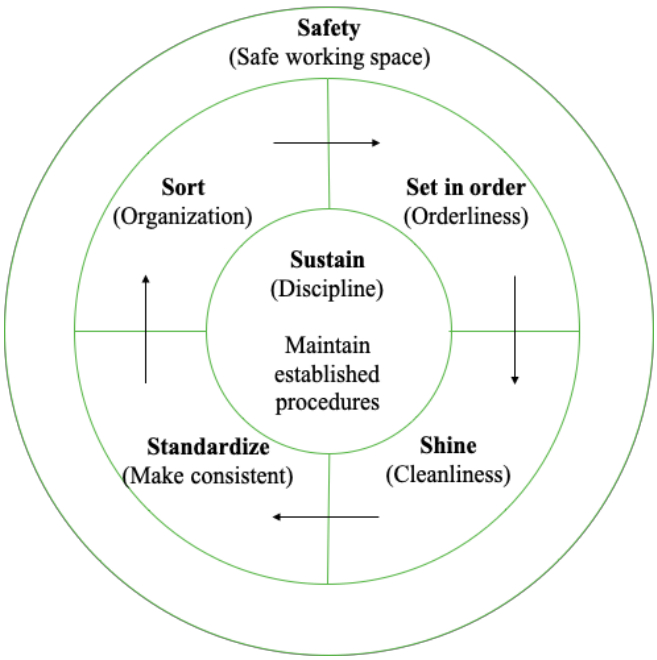

FIGURE 1. The Six Pillars of 6S (adapted from US EPA b)

Sort is the first step of 6S when all unnecessary objects are eliminated from the workplace. The "red tagging" method can be used to distinguish the unnecessary items. The next step, Set in order is focused on the creation of effective storage technique to arrange items for further labelling. Strategies of Set in order are painting floors, affixing labels and placards. After sorting the existing items, a working area should be cleaned. This step is called Shine. (US EPA a.)

The next part of 6S is aimed to standardize the best practices in the workplace and to eliminate potential errors. The tools used in the Standardize pillar are job cycle charts, visual cues, checklists. Sustain is the last part of 5S and it is the process of maintaining or improving all of the 6S processes. (US EPA a.)

Safety is an additional step that is focuses on identifying existing and potential hazards to set preventive strategy and measurements in order to keep employees safe during working activity. The digital safety checklist can be implemented to identify hazards. (US EPA b.)

Major benefits of 6S implementation are an increase in a company's productivity and the reduced number of product defects and work accidents because of the improved space use for existing operations and useful labels. (US EPA b.)

3 GREEN SUPPLY CHAIN MANAGEMENT

In order to reduce environmental pollution, to improve a company's image and to receive additional profit and market share, organizations nowadays develop the environmental practices in different steps of the SC (Mishra, Gunasekaran, Papadopoulos, Hazen 2017). Traditional SCM that includes environmental awareness and environment thinking at all processes and partners of SC is called Green Supply Chain Management (GSCM) (Jaggermath & Khan 2015). In this chapter, GSCM is defined, its history, benefits, drivers as well as parts and implementation strategies are described.

3.1 Supply chain management

SCM is a modern concept, which has evolved over the last three decades. According to Lummus and Vokurka (1999), the history of supply chain management can be traced to the beginning of the textile industry with the quick response program and later to well-organized customer response system in the grocery industry.

Nowadays SCM plays a significant role in industrial and service companies because it is an efficient tool to integrate and improve business activities (e.g. operation, transportation). This enables companies to decrease cost and increase production flexibility and output that in turn brings a competitive advantage. (Sadraouil & Mchirgui 2014, 60.)

Supply chain is an integrated process of cooperation of different business parties (suppliers, manufacturers, distributors and retailers) which work together in order to procure raw materials, convert these materials into a final product and deliver this product to retailers (Besbes, Allaoui, Goncalves & Loukil 2015, 18-19).

Handfield and Nichols (1999, 2) stated that supply chain management includes all activities connected to the "flow and transformation of goods from raw material (extraction), through the end user", as well as associated information and money flows. In addition, SCM can be extended to such processes as reuse and recycling of a used product (Baatz 1995). This is called a closed-loop supply chain. The Council of Supply Chain Management Professional (2013) defined SCM as integration of planning, analyzing, coordinating activities involved in "sourcing and procurement, conversion and logistics management

activities". Efficient SCM requires cooperation between all of the parts of SC: suppliers, agents, intermediaries, distributors and customers.

Successful implementation of complex SC system is affected by customer requirements, globalization of the market, and application of advanced information technologies in production and distribution and governmental environmental regulations (Sarkis & Dou 2018, 30). The core principles of supply chain management (TABLE 1) are based on segmentation of consumers according to their needs and provision of customized services in a way that is profitable for the company and efficient for the customer through the SC. The traditional methods of customer segmentation are surveys, interviews and industry research, ABC analysis. After the segmentation of customers, it is significant to adapt the logistics activities of an organization. The efficient forecasting of demand system will allow a company to create an optimal allocation of raw materials. (Anderson, Britt & Favre 1997.)

TABLE 1. Principles of supply chain management (Anderson, Britt & Favre 1997, 31-41)

Principle 1	Segment customers based on their needs and adapt the SC to serve these effectively.
Principle 2	Customize logistics network to the process requirements and profitability of customer segments.
Principle 3	Pay attention to market signals and adjust forecasting demand plan in accordance with SC, ensuring regular and consistent forecast; optimal allocation of resources.
Principle 4	Adapt product closer to the customer needs and ensure speed conversion across SC.
Principle 5	Manage sources of supply strategically and efficiently to reduce the total cost of raw material and services.
Principle 6	Develop an SC-wide technology strategy that supports multiple levels of decision-making and gives a clear view of the different flows: products, services and information.
Principle 7	Adopt SC performance measures to regulate a company's objectives in reaching the end-user effectively and efficiently.

3.2 History of GSCM

Green Practices (GP) have been introduced in several parts of SC since the 1980s (FIGURE 2). Before that, no particular environmental governmental and internal management regulations had been implemented, except for regulations for air pollution and discharged waste at the manufacturing facilities. In 1988, the development of environmentally friendly products marked the beginning of GP. At first, there

were three main areas of reducing environmental impact: dematerialization, detoxification and decarbonization that resulted in the development of 4R which stands for reduce, reuse, recycle and recover principle. Moreover, ISO 14020 and ISO 14024 standards were introduced. They prescript environmental labels and aimed to reduce carbon and greenhouse gas emissions. (Jaggermath & Khan 2015, 39-40.) According to Min and Kim (2012), nowadays GSCM incorporates environment-friendly initiatives into sourcing, product design, manufacturing, transportation, packaging, storage, retrieval, disposal and post-sales services including end-of-product-life management, which allows increasing company's environmental quality and efficiency and reducing waste and pollution.

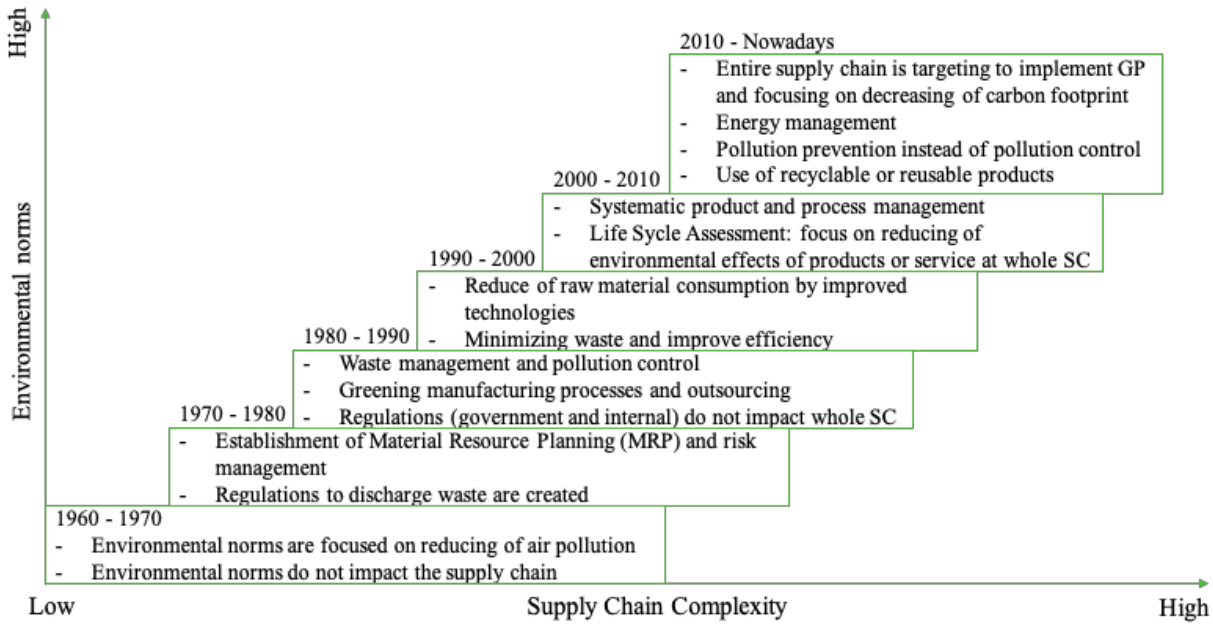

FIGURE 2. Development of GSCM (adapted from Jaggermath & Khan 2015, 39)

3.3 Benefits of GSCM

GSCM is designed to bring various environmental and business advantages for stakeholders including customers, employees, community and government. The environment benefits are energy, waste, pollution reduction, water conservations, improved packaging design and other benefits. According to Jaggermath and Khan (2015, 41-42), example of the business benefits are reduced cost and improved efficiency and quality, increased customer service and retention, increased innovation and reliability, etc. (APPENDIX 1).

3.4 Drivers of GSCM

According to Singh, Rastogi & Aggarwal (2016, 258), there are 12 main factors which influence the implementation of GSCM: top management commitment, integration among SC members, supplier's development, green marketing and logistics, reverse logistics management and development of green performance management system (FIGURE 3). Top management commitment is the main driver in the implementation of GSCM because it can influence the creation of green performance measurement system and integrate the members among the supply chain. Other factors that strongly influence the implementation of GSCM are IT tools and technologies, trained workers and suppliers, which understand the importance of GSCM. Material management is a significant driver too since it can affect the implementation of reverse logistics management and environmentally friendly marketing and logistics. The last factors that allow to fully implement the GSCM are pollution and waste prevention and EMC. (Singh et al. 2016, 256-260.)

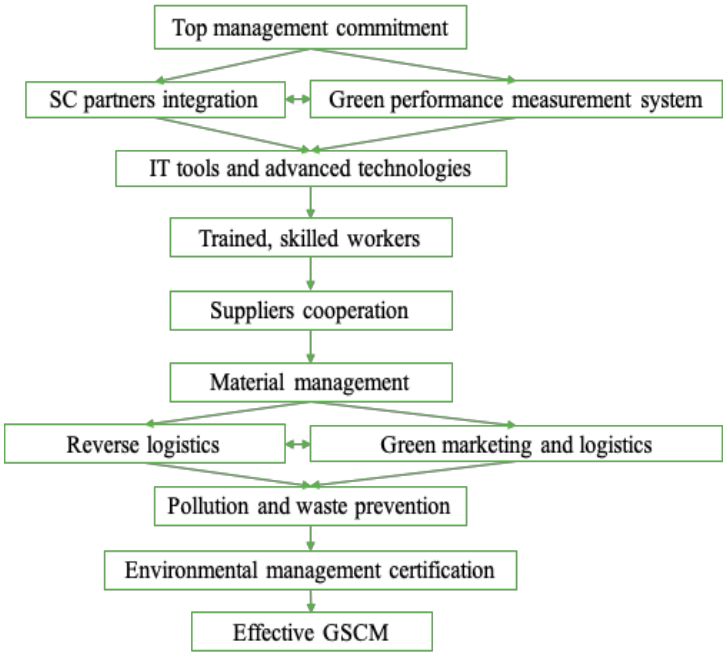

FIGURE 3. Drivers of GSCM (adapted from Singh et al. 2016, 258)

3.5 Green practices

Figure 4 illustrates internal SC of an organization, major processes and the linkage to other organizations. In order to reach the maximum results in productivity and effectiveness, GSCM should be implemented in all stages of SC from raw materials acquisition (green purchasing) and product design to green

manufacturing, distribution of final product to consumers as well as reverse logistics (Jaggermath & Khan 2015, 39). All the GP will be described in detail in the following chapters. The effective implementation of all GPs will allow achieving environmental objectives of a firm (i.e. reducing solid, hazardous, emissions, energy wastes) at every step of the creation of a product or service. Life Cycle Assessment (LCA) can measure environmental impact and level of pollution and waste made by the company.

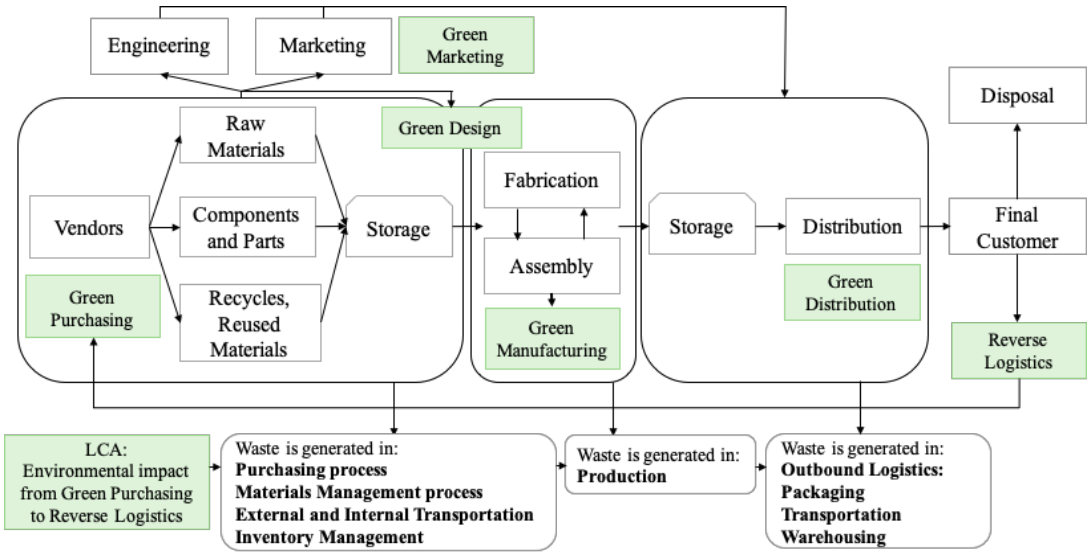

FIGURE 4. Structure of GSCM (adapted from Hervani et al. 2005, 335)

Table 2 introduces GSCM practices and their main characteristics. According to Zsidisin and Siferd (2001), green purchasing is environmentally friendly purchasing from reliable suppliers that are meeting an organization's environmental specifications. Green design or eco-design is the process of creation of the specific design of products that correlated to the environmental objectives of a firm, such as reuse, recycling, reduction of environmental pollution. Furthermore, green manufacturing includes all initiatives to optimize manufacturing processes in order to reduce waste and other emissions. (Masoumik et al. 2015.)

The structure of GSCM continues with green distribution and logistics. Green logistics includes approaches to decrease environmental impact in transportation and warehousing of products along the SC (Masoumik et al. 2015). Lastly, Rogers and Tibben-Limbke (2001, 130) have defined reverse logistics as the "process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods, and related information from the point of consumption to the point of origin for the purpose of recapturing or creating value or proper disposal".

TABLE 2. Parts of GSCM (Meythi 2013)

Green Purchasing	Green Design	Green Manufacturing	Green Distribution	Reverse Logistics
Green suppliers Supplier inspection Supplier training	Recycling and unloading design Green customers and products	Green techniques Green materials	Green technologies	Recovery process Recycling Waste Disposal

GP are frequently implemented by introducing green innovation. Green innovation is a set of technologies (biological, monitoring and other) which are used to create green products and green processes that have an impact on corporate performance. In addition, green innovation increases efficiency and reduces the use of raw materials and costs related with environmental issues (Cosimato & Troisi 2015, 260-261).

3.6 Implementation strategies of GSCM

There are various strategies in the implementation of GSCM: risk-based strategy, efficiency-based strategy, innovation-based strategy and closed-loop strategy (Simpson & Samson 2008). Strategies are divided based on inter-organization and top management commitment and investment into GP.

3.6.1 Risk-based strategy

This GSCM strategy is based on minimal inter-organizational commitment and investment in SC to reduce risks connected to the environmental actions and to satisfy stakeholders' needs and requirements. This simple strategy is excellent for the initiation phase of GSCM. Actions, which are usually taken by companies at this phase, are creation of environmental requirements for suppliers that are stated in basic clauses and establishment of EMS such as ISO 14001. (Meythi 2013.)

The results of the implementation of this strategy are risk minimization and reputation improvement by the establishment of a universal system which is recognized globally by other companies. However, additional innovation and economic benefits are questionable. (Meythi 2013.)

3.6.2 Efficiency-based strategy

Efficiency-based GSCM strategy is based on "eco-friendly" approach towards SCM when the organization implements requirements or techniques beyond regulation demanded by governments or stakeholders. For example, an organization can create specifications for the suppliers, which are based on environmental and/or operational performance objectives of an organization. This strategy requires a higher level of engagement between an organization and its suppliers than risk-based strategy, but at the same time, it allows to receive both economic and environmental performance advantages for an organization such as reduced waste and efficient use of raw materials. (Meythi 2013.)

3.6.3 Innovation-based strategy

The innovation-based GSCM strategy is more environmentally focused than efficiency-based strategy. Compared to the efficiency-based strategy, this approach obliges a higher level of innovation and integration of GP in SC which requires additional resources and skilled workers. The strategy usually involves specialized environmental processes, equipment and performance standards which are created by organizations for suppliers. This, in turn, increases the level of experience exchange between organizations and develops collaboration between a supplier and a buying company. The innovation-based strategy requires a proactive approach towards suppliers in green purchasing. (Meythi 2013.)

In the long run, resources developed by this strategy could be used in the planning/creation of product design, functionality, characteristics, 4R related activities of a new developing product. At the production and distribution processes, it will possibly be used to develop innovative methods or systems. (Meythi 2013.)

3.6.4 Closed-loop strategy

Closed-loop or reverse logistics strategy is the most complex and collaborative form of GSCM implementation. This strategy includes the acquisition and recovery of materials for re-manufacturing or recycling which requires integration of partners from the whole SC. These materials can take the form of returned, post-use and end-of-life products. Moreover, systems that are more complicated include recycling/remanufacturing of used products and waste by the company. (Meythi 2013.)

4 LIFE-CYCLE ANALYSIS

Before implementing any of GPs, it is essential to define and measure the current environmental impact made by the company in the creation of a single product. Life Cycle Assessment (LCA) is a systemic process of calculating and analyzing such parameters as energy and materials used and wastes or emissions released by a product, equipment or process in each phase of its life cycle. The general life cycle of a product or service consists of five different elements that are purchasing process, internal manufacturing, transportation and logistics, use and maintenance, reverse logistics (reuse, recycling and final disposal). (Lyons 2015, 25.)

The origin of the modern LCA based on such analysis as Resource and Environmental Profile (REPA) and net energy analysis in the 1960s. These techniques focused on the measurement of direct and indirect energy and materials consumption over entire SCs without reflection of impact on the environment. The modern technical and methodological structure of LCA is based on the Society of Environmental Toxicology and Chemistry (SETAC) framework that was developed in 1991. This framework consists of four parts: goal and scope definition, inventory analysis, impact assessment and improvement analysis. (Wang 2009, 3-4.)

The next step in establishing the modern LCA taken in 1998 when the International Standard Organization (ISO) created ISO 14040 - an international LCA analysis procedure. ISO 14040 is a set of processes for collection and evaluating the inputs and outputs of energy and/or materials, and influence that they have on the environment directly attributable to the functioning of a goods or services throughout its life cycle. The current ISO standards for LCA are ISO 14040 (Principles and framework), ISO 14044 (Requirement and guidelines), ISO 15047 (Examples of the application of ISO 14042) and ISO 14048 (Data documentation format). (Wang 2009, 4.)

4.1 Implementation of LCA

There are different methods to conduct LCS depending on a company's goals and available funds. However, in this thesis, the author will follow the structure of the implementation of ISO 14040 guidelines. As SETAC framework, ISO 14040 standards consists of 4 main components: goal and scope definition, inventory analysis, impact assessment and improvement analysis.

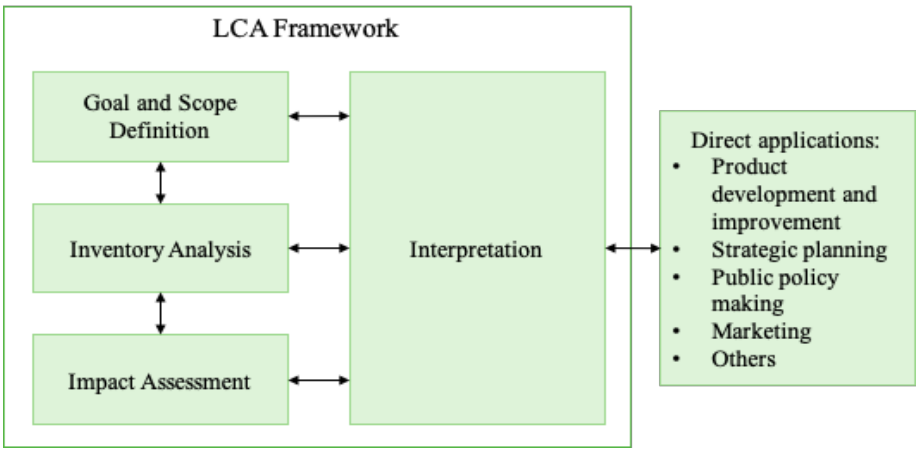

FIGURE 5. The framework of LCA (adapted from ISO 14040, 2006)

The first step in implementation of LCA is goal and scope definition. During this process, an organization must quantify the environmental impact of its current practices, products, materials or services and identify those that produce more environmental pollution. The goal and scope definition is essential since it portrays the product or service, which requires evaluation or improvement and sets the parameters for future assessments. A company has to define such characteristics for future assessment as the type and depth of assessment needed, targeted audience and method which will be used, the type of data needed in order to achieve a goal and procedural logistics (Lyons 2015, 26.)

The next step is the life cycle inventory analysis. It includes procedures which quantify energy and materials requirement, solid waste, air emissions, wastewater and other environmental pollution (described in Chapter 2) that occur during the life cycle of a product, process or equipment. The target of this analysis is to define and examine all direct input and outputs during all stages of the life cycle. (Sarkis and Dou 2018.) During this step, it is significant to collect accurate data by using different methods such as quantitative sampling. The data can be acquired from different sources: theoretical material and energy balances, economic input-output tables, scientific publications, company records, in-site measurements. (Wang 2009, 5.)

According to Sarkis and Dou (2018, 42) life cycle impact assessment is an "evaluative process of assessing the effects of the environmental findings identified in the inventory component for all inputs and outputs through the activities of an organization of supply chain". The impact assessment frequently addresses such impact as ecological, social, cultural, economic or human health. (Sarkis & Dou 2018.) In order to conduct an impact assessment, an organization has to do steps listed below.

1. Design impact categories described before.
2. Sort impacts to their categories created in Step 1.
3. Evaluate each impact using suitable modelling forecasting tools. The examples of tools are Building Research Establishment (BRE) Green Guide to Housing Specification, LCAid TM, ATHENATM.
4. Make the data collected relevant to the company's goals and decisions by normalizing it.
5. Evaluate the impact and make a decision concerning product, service or process. (Lyons 2015, 28.)

Life Cycle Improvement Analysis (LCIA) is the last part of LCA. LCIA is a continuous improvement process that defines level of impact produced on the environment after changes in product, process or utility (Sarkis & Dou 2018).

5 GREEN PURCHASING

Purchasing is the process of obtaining, storing, managing and recovering raw materials from suppliers to meet customers' requirements. Purchasing includes such activities such as supplier and materials selection, outsourcing, scheduling and materials management. Green purchasing is an eco-friendly procurement that aims to ensure that purchased products or materials meet an organization's environmental objectives such as reducing waste. World-leading companies (e.g. IKEA,Ford and IBM) now require their suppliers to develop EMS. (Sarkis & Dou 2018.) GPs of green purchasing are informal and informal evaluation, environmental audit, supplier training, collaborative product (design for recycling with reduced consumption of raw materials in production) and process design (TABLE 3). (Tachizawa, Gimenes & Sierra 2015, 1549.)

The main drivers of green purchasing implementation are government regulations, customer expectations, strategic objectives such as an increase market share and top management commitment. Green purchasing brings such competitive advantages as frequent communication between partners of SC that allows achieving long-term mutual objectives and maintaining stable relationships with a limited number of suppliers. (Sarkis & Dou 2018.) There are two approaches to green purchasing: reactive (monitoring) and proactive (collaboration). In the table below, the main strategies of these approaches are listed.

TABLE 3. Categories of green purchasing strategies (Sarkis and Dou 2018.)

Reactive approach	Product content requirements/restrictions Product eco-labelling Supplier environmental questionnaires EMS for suppliers Supplier auditing
Proactive approach	Product stewardship Educational programs for suppliers about environmental issues Influence in legislation through cooperation with suppliers

5.1 Reactive approach

Reactive green purchasing includes such activities as a product standard (eco-labelling of suppliers' products), examination of a supplier's environmental records, regular questionnaires and audit of environmental characteristics made by a buyer or third party (Tachizawa, Gimenes & Sierra 2015, 1547-1548). Figure 6 illustrates that reactive approach practices described earlier have both low buyer level of effort in implementation and impact on customer behavior.

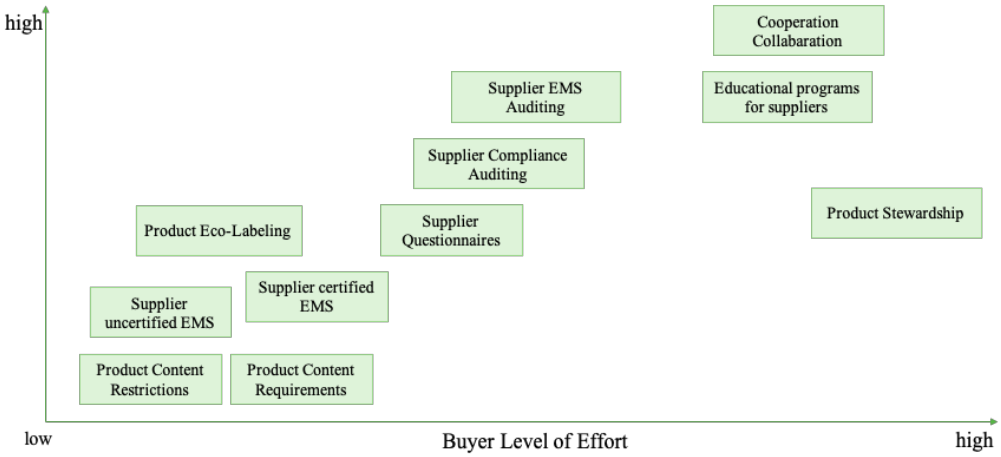

FIGURE 6. Impact of different green purchasing strategies in supplier behavior (adapted from Sarkis 2006, 34)

5.1.1 Product content requirements

In this strategy, companies create new environmental specifications for their suppliers. The product content requirements strategy is constantly used by companies because normally it does not involve additional cost, time and resources for it. However, suppliers generally need to spend money and time to meet buyers' requirements. An example of this strategy is the prohibition of CFCs in plastic packaging. (Sarkis & Dou 2018.)

5.1.2 Product eco-labelling

In this green purchasing strategy, a company requires its suppliers to have a third-party environmental certification label to ensure suppliers' environmental performance and knowledge. As in the product content requirements strategy, buying companies do not handle additional costs. Suppliers are required

to invest their time and money to obtain the labels. After adopting this strategy, suppliers mostly will receive a competitive advantage in the market and increase environmental and technological knowledge. (Sarkis & Dou 2018.)

5.1.3 Supplier environmental questionnaires

In this strategy, the buyer requires suppliers to present environmental information by answering the questionnaires that are generally created by skilled workers from purchasing and other departments. Ordinarily, questionnaires are based on different sources of information such as governmental standards, professional researches, and publications, reports, websites of leading organizations. A supplier obligates to collect and measure needed information through EMS or another system. (Sarkis & Dou 2018.)

Example questions that can be included in a survey include the following:

- What policies are created to control and monitor your SC regarding environmental issues?
- Does your company have an environmental policy statement?
- Has your company ever been cited for noncompliance of environmental regulations?
- What type of eco-packaging do you use?
- Does your company have a green transportation plan?
- What programs have you created/planned to improve resource efficiency?
- Has LCA of our product been administered by a certified testing organization?
- If you are supplying a final product for our organization, does your supplier have an environmental policy statement? (Arizona State University 2012.)

5.1.4 EMS for suppliers

A company requires suppliers to create and manage an EMS with international or local standards. The certification by a third party can lower the price for the buyer since it eliminates human, time and other resources. However, the costs needed for creation for such a working system for a supplier is rather high in terms of time and funds. (Sarkis & Dou 2018.)

5.1.5 Supplier compliance auditing

In this green purchasing strategy, buyers attempt to secure a supplier's compliance with environmental regulations through auditing which conducted by a firm itself or third party. The audits can be done in the purpose of monitoring and control of compliance with current regulations, but can also be used for developing improved technologies/processes and future collaboration with a supplier. (Sarkis & Dou 2018.)

The checklist of the auditor can contain the following questions:

- Does your company have certified EMS?
- Describe the facility location and characteristics.
- Describe corrective efforts taken on the facility and respective costs.
- List all environmental approvals and permits for your company.
- Certifications and permits for waste transportation.

5.2 Proactive approach

Proactive approach in green purchasing is a risk management tool that decreases information asymmetry. This approach is based on supplier training and collaborative development of environmentally friendly goods and processes which improving environmental performance. The proactive approach is essential not only to increase environmental performance but also to enhance sustainability. (Tachizawa, Gimenes & Sierra 2015, 1547-1548.) Figure 6 demonstrates that proactive approach practices described earlier have both high buyer level of effort in implementation and impact on customer behavior.

The proactive approach has a positive impact on green supplier development. This term means that buying company aims to help its supplier to reduce environmental impact and at the same time to maintain their economic performance. There are several steps in the implementation of supplier development:

1. Establishment of a team from different departments (e.g. purchasing, design, quality, R&D, operations, marketing departments) in a buying company.
2. Classifying and rating of suppliers and raw materials by using such tools as the supplier classification model or supplier evaluation sheets.
3. Identification of suppliers that require a future product or process development.
4. Creation of a joint team with supplier.

5. Selection of performance areas where the development is essential.
6. Implementation of collaborative efforts in performance improvement.
7. Monitoring of the existing environment requirement and supporting further product/process development. (Sarkis & Dou 2018.)

5.2.1 Product stewardship

Purchasing process and suppliers are a valuable part of SC. Consequently, it is essential to include them in an environmental plan to further waste reduction and effective resources consumption. In this strategy, companies intend to decrease the negative impact of products on the environment at all stage of the life cycle through techniques such as LCA and eco-design. The product stewardship requires close communication between companies. In most cases, the strategy requires a large time and money investments for buying companies and considerable changes in operations and/or components for sellers. (Sarkis & Dou 2018.)

5.2.2 Educational programs for suppliers

This green purchasing strategy includes buyers who train their suppliers concerning ecological problems to enhance environmental performance and to support the economic gains of suppliers. Education programs usually involve large knowledge, financial and human resources exchange from the buyer. (Sarkis & Dou 2018.)

Educational programs may include such activities as

- Organize awareness seminars and training about the benefits of GSCM and technologies or methods which could be used in implementation it;
- Explain for suppliers how to create own environment program: code of conduct, ethical guidelines;
- Share innovation or issues of suppliers in establishing or operating GSCM;
- Promote environment actions by discussing such topic as safety, health and environmental standards;
- Choose environmentally-friendly suppliers: conduct tender which is based on an evaluation of cost, quality and ethics of potential suppliers (Cosimato & Troisi 2015, 1542)

5.2.3 Influence of environmental legislation

Using the proactive approach, buying companies are able to help their suppliers to establish cleaner production. Indeed, in joint development, buying and supplying companies can make a change – improve manufacturing productivity and reduce waste and materials consumption by presenting innovating methods. (Sarkis & Dou 2018.)

By introducing these innovative environmental programs, companies in cooperation with suppliers sometimes are able to influence future governmental regulations. An example of this strategy is an establishment of carbon label program by Tesco PLC, one of main supermarkets of the United Kingdom, in 2007, which is now considered to be implemented in different countries all over the world such as Japan. This program involved the creation of carbon footprint labels to products. (Sarkis & Dou 2018.)

6 GREEN MANUFACTURING

Green manufacturing is one of the most essential GPs among GSCM activities. The impact of the current manufacturing processes and equipment can be quantified by LCA (Chapter 4). Green production incorporates designing, planning or optimization of processes that will require less energy and materials used in a production system and minimize possible negative environmental impact in a form of waste and emission. The aim of green manufacturing is to continuously develop industrial activities and products or services to prevent any form of environmental pollution. To sum up, green manufacturing initiatives aim to deliver eco-friendly products with minimum raw materials used and waste generated during production. (Cankaya & Sezen 2019, 101).

There are different initiatives that allow making an organization's production "eco-friendly". These practices are the establishment of EMS (ISO 14001) and the effective use of raw and substitution materials that will guarantee high quality of a product and reduce harm for the environment, the selection of environmentally conscious business technologies, the creation of environmentally friendly design for a product or process and other initiatives. (Lyons 2015, 79-80.)

6.1 Eco-design

Eco-design is a design of product or process that focuses on reducing/preventing of environmental impact before the implementation/production phase. Design-for-the-environment (DFE) or eco-design is a pollution prevention tool because 80% of the environmental impact made by the companies is determined at the design stage. It helps to limit costs associated with the end-of-life stage of a product such as reuse, reduce or utilization costs. There are different governmental and international regulations aimed to control environmental effect in eco-design such as ISO 14001, RoHS in the USA, Eco-Design Directive in the EU. (Sarkis & Dou 2018.)

There are different ways to enhance the environmental characteristics of eco-design. The features of environmental design are, for example, the minimizing of diversity of resources used, using components from known quality materials, using less harmful materials, and leasing of products for take-back and reuse, etc. (Sarkis & Dou 2018.)

There five major steps in the implementation of eco-design:

1. Measure and evaluate the current environmental impact of a product/process. One can use such characteristics as recyclability, reusability, maintainability.
2. Conduct market analysis.
3. Brainstorm new ideas within a team (e.g. through a creative workshop).
4. Select appropriate design strategy.
5. Design the product/process. (Sarkis & Dou 2018.)

6.1.1 Eco-design tools

In order to create proper eco-design, different tools are used:

The Requirement Matrix has a form of rows that show product system components and columns, which represent the stages of product life cycle stages of a product/process. By this matrix, for each stage the company can develop cost, legal, cultural, performance and environmental requirements. The Requirement Matrix is a simplest tool to decide on design of product/process. (Sarkis & Dou 2018.)

DFE Matrix is a simple and flexible five-by-five matrix where the life cycle stages are listed on the vertical axis and the environmental, health and safety (EHS) issues on the horizontal axis. This matrix is used to determine priority EHS issues. (Sarkis & Dou 2018.)

Readiness Assessment for Implementing DFE Strategies (RAILS) is a tool to illustrate the results of DFE strategies described earlier in an effective way. In order to implement RAILS, a company will need to take four steps:

1. LCA or DFE Matrix is created in order to find out the environmental profile of a new product, threats and opportunities for a company.
2. The Life Cycle Design Strategy Wheel (LiDS-wheel) is used to define appropriate environment options.
3. Creation of the House of Environment Quality (HoEQ) based on LiDS-wheel.
4. Improvement options are divided into short-, medium- and long-term realization. Design the product/process. (Sarkis & Dou 2018.)

Integrated Approach to Sustainable Product Development combines quality function deployment, LCA and Life Cycle Costing (LCC) to evaluate environmental, economic performance and customer satisfaction. The results of improvement options are calculated by a quantities analysis. (Sarkis & Dou 2018.)

Environmental-QFD (E-QFD) examines the relations of LCA and QFD to define the potential environmental impact of developing a product at all stages of the life cycle and to find out stakeholders' expectations accordingly and creates design alternatives. (Sarkis & Dou 2018.)

House of Ecology (HoE) arranges environmental requirements by the selected Best Available Techniques at a defined budget. The ranking is based on cost reduction and environmental characteristics improvement. (Sarkis & Dou 2018.)

Life Cycle Environment Cost Analysis (LCECA) is a mathematical model that is used to reduce the total costs (e.g. cost of eco-taxes, costs of waste disposal and control) by the implementation of environmental design alternatives at different stages of a product life cycle. This model includes break-even, sensitivity and risk analysis in managing and analyzing alternatives. (Sarkis & Dou 2018.)

More tools for implementation of eco-design are Green-QFD, Environmental Objective Deployment, Quality Function Deployment for Environment, Life Cycle or Environmentally Conscious Quality Function Deployment. (Sarkis & Dou 2018.)

6.2 Environmental Management System

Environmental Management System is a tool that assists organizations with identification, management, monitoring and controlling of their environmental problems (ISO 2015, 2). Certification of manufacturing system with EMS of the International Organization for Standardization (ISO) 14001 and a materials reduction program will allow a company to make the first steps towards green manufacturing. ISO standards were first developed in 1996 and state guidelines which are created to provide a structured approach in setting and achieving environmental objectives. EMS certificate guarantees that manufacturing systems will include cleaner production, environmental performance international standards and supplemental guidelines. It is possible to apply for ISO certification to a third party with accredited auditors or there is option to self-declare compliance. (Lyons 2015, 79.)

The latest version of ISO were published in 2015 and called ISO 14001:2015. ISO 14001:2015 does not state specific environmental performance criteria and suitable for any organization. ISO 14001:2015 defines the specifications for the EMS that an organization can use to improve its environmental performance. Compared to the previous standards, ISO 14001:2015 is focused on leadership and communication, lifecycle thinking regarding environmental issues. It also has a stronger influence on proactive green manufacturing initiatives. (ISO 2015, 2.)

According to the ISO 14001:2015 (2015, 8) in order to achieve the intended goals, including improving company's environmental performance, an organization needs to "establish, implement, maintain and continually improve an environmental management system including the processes needed and their interactions". In addition, the organization can consider the knowledge gained in" chapters named understanding the organization and its context and understanding the needs and expectations of interested parties of ISO 14001:2015 "when establishing and maintaining the environmental management system".

6.2.1 PDCA

In order to achieve continuous improvement, Plan, Do, Check, Act (PDCA) or Deming cycle is used. In the 1950s, W. Edward Deming introduced that business activities should be examined and measured to "identify sources of variations that cause products to deviate from customer requirements" (Arveson 1998.)

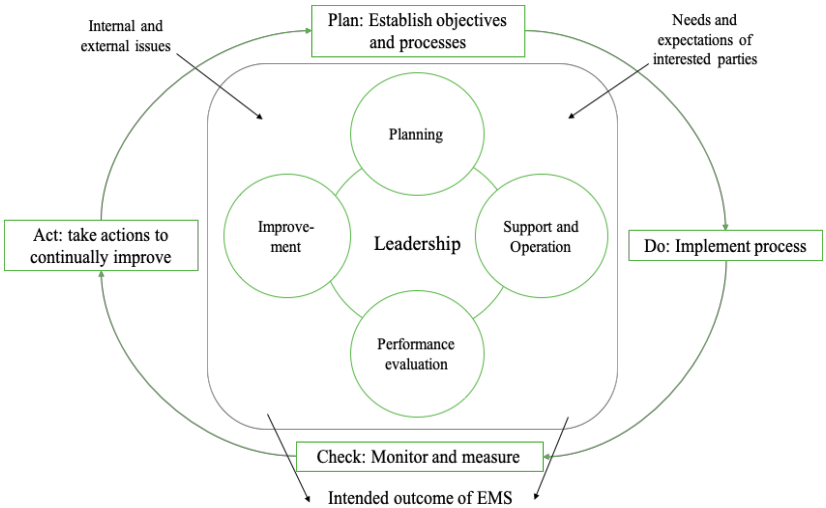

FIGURE 7. "Plan, Do, Check, Act" (adapted from ISO 2015, 7)

Deming has suggested that business activities could be placed in a continuous feedback circle (FIGURE 7) to identify and change elements that require additional improvement. The PDCA cycle consists of 4 parts:

- Plan: Assess or design business objectives and processes to improve.
- Do: Implement the plan and measure the performance.
- Check: Evaluate the measurements received and report the results.
- Act: Decide on additional changes to develop the process (Arveson
- 1998.)

The main benefits of the Deming cycle are “increased productivity and capacity, decreased cycle time, lower production costs, increased profits and fewer customer complains”. Indeed, this system will also allow reaching continuous development in manufacturing and other working areas. (Petersen 1999, 481-482.)

7 GREEN DISTRIBUTION AND LOGISTICS

Logistics and distribution management is a vital part of SC that covers the management and storage of materials and products. Expansion of distribution operations because of such modern practices as demand-driven sales and JIT created both social and environmental burdens. (Fahimnia, Bell, Hensher & Sarkis 2015, 4). For example, the global transportation sector has a significant influence on climate change contributing to 15% of global CO2 emissions. (Sarkis & Dou 2018.)

Green distribution and logistics activities include such processes as delivery and warehousing of materials, sale of final products to the customers along the SC. Nowadays there are six trends in green logistics: "autonomous vehicles, new materials, connected vehicles, collaborative consumption, electric drivetrain and efficient multimodal network". (Sarkis & Dou 2018.)

Greening of logistics and transportation of a company requires establishing specific environmental measures. It is essential to create such performance measures for a company since they will identify performance capabilities for reaching targets of an organization. The examples of business success indicators are transported dependability, customer service, low logistics costs, delivery flexibility and speed. (Fahimnia et al. 2015, 10.)

Green logistics can be analyzed from two sides. The first aspect is the strategic design level where logistics aims are to evaluate and select green logistics providers, transportation modes and deciding on distribution strategies. On the other hand, in tactical and operational level, green logistics is focusing on green routing, consolidation of delivery scheduling and efficient inventory management. (Fahimnia et al. 2015, 4-5.)

Moreover, existing green distribution practices can be divided into four groups: green transportation, green warehousing and inventory management, green facility and reverse logistics. Green transportation includes a selection of efficient transportation modes and routes. (Sarkis & Dou 2018.) These practices will be described in sub-chapters below.

7.1 Green transportation

Companies usually choose transportation vehicles based on product type, time of delivery, availability of transportation modes and budget. However, it is significant to consider the environmental performance of selected transportation mode. In order to choose effective transportation such tools as cost-benefit and multicriteria decision analysis, mathematical and system dynamics models can be employed. (Sarkis & Dou 2018.)

Moreover, effective transportation route is valuable green logistics practice. Travel route is optimized then travel distance of products and materials are minimized while meeting the delivery requirements. The benefits of such optimization are reduced energy consumption and pollution released. Software packages are usually employed to provide the most suitable route solutions by environmental effect inspection (detection level of emission) and traffic evaluation. (Sarkis & Dou 2018.)

7.2 Green warehousing and inventory management

Green warehousing and inventory management are one of the most significant processes in SC. Green warehousing creates an environmental impact in the form of energy used for lighting and cooling of the stock and gas or oil utilized for heating systems (Sarkis & Dou 2018). Carbon Trust (2002) have suggested such techniques as separation of "dispatch and intake areas from other areas of activity"; the opening of doors only when necessary; integration of barriers in areas where forklift trucks are regularly used; using time-controlled thermostats to reduce energy consumption. In addition, use of efficient fuel and lamps will allow saving energy used even further (Sarkis & Dou 2018).

In order to optimize the space used for warehousing, green packaging practice can be used. Green package is a low weight package produced with fewer materials that use minimum space and combines 3R principles - reuse, reduce and recycle. For example, trays and containers can be used and/or recycled which will "save GM over $15 million in packaging costs". (Sarkis & Dou 2018.)

Moreover, inventory management can not only cause carbon emissions but also require space and energy. For this reason, it is essential to determine economic order quantity and transportation levels based on mathematical models and planning. (Sarkis & Dou 2018.)

7.3 Green facility

The optimal number of warehousing centers and their location can improve logistics effectiveness and reduce environmental burden. Modern organizations aim to not only minimize economic costs but also consider environmental characteristics such as local ecosystem conditions and consumption, production patterns. To sum up, “the decision making involved in a facility location from a green logistics should stress the minimization of environmental impact from transportation and distribution centers, while improving customer service level and decreasing financial cost”. (Sarkis & Dou 2018.)

7.4 Reverse logistics

Modern companies have created a system of reclaiming of products at the end of their life-cycle and return them through the SC for further disposal, decomposition, re-use of key components. According to the Hawks (2014), reverse logistics is a set of planning and management activities which are connected to product or service after reaching of a final customer in order to optimize or make more efficient aftermarket activity. Strategic factors in reverse logistics are cost, quality, customer service, environmental and legislation concerns. On the other hand, operation factors to consider in reverse logistics are a cost-benefit analysis, transportation, warehousing, packaging, recycling and remanufacturing. (Lyons 2015, 87.)

There are different methods to implement reverse logistics in a company, depending on the reason for a product returned. Sarkis and Dou (2018) defined that simplest form of reverse logistics is the return of a product to the shelf, “more broadly it may include returns for reuse, repair or remanufacturing”. Reverse logistics has such functions as collection, distribution, sorting, and 4R - recovery, remanufacturing, recycling or disposal.

8 CONCLUSION

In this thesis, the author aimed to describe the framework of GSCM and its practices based on research and analysis of theoretical materials (books, standards, magazines and electronic articles) from various sources. GSCM differs from traditional SCM because it incorporates environmental thinking in every process of SC (Jaggermath & Khan 2015). There are four strategies to implement GSCM: risk-based strategy, efficiency-based strategy, innovation-based strategy and closed-loop strategy that are divided based on inter-organization commitment and level of investment in the GP (Simpson & Samson 2008).

There are 3 main parts of GSCM: green purchasing, green manufacturing, green distribution and logistics. Green purchasing is a process of obtaining materials and products from reliable suppliers who are meeting a company's objectives and specifications. (Zsidisin & Siferd 2001). Nowadays there are two approaches towards green purchasing: monitoring and collaboration. Monitoring (reactive approach) includes such practices as product content specification and eco-labelling, supplier environmental questionnaire as well as EMS for suppliers and supplier auditing. In turn, collaboration incorporates practices of product stewardship and education programs. (Sarkis & Dou 2018.)

Green manufacturing includes practices aiming to create or optimize existing processes to use fewer materials and energy in production and, at the same time, to minimize environmental burden (Cankaya & Sezen 2019, 101). The techniques used to implement green manufacturing are the establishment of EMS, the selection of eco-friendly business technologies and the creation of green design. (Lyons 2015, 79-80). Green design is an essential initiative since it allows eliminating 80% of negative environmental burden before manufacturing. Tools used to create effective eco-design are the Requirement and DFE Matrix, RAILS, E-QFD, HoE and other. (Sarkis & Dou 2018.)

Green logistics incorporates all the environmental initiatives in transportation, warehousing, and distribution processes. Green logistics initiatives are divided into 4 groups: green transportation, green warehousing and inventory management, green facility and reverse logistics. Reverse logistics is a process of obtaining of used products from a final customer in order to further dispose, reuse or remanufacture them. (Sarkis & Dou 2018.) Last but not least, the author has described types of pollution named wastewater, land pollution and air emissions and ways how to measure (LCA) and eliminate (6S) them. It was essential to emphasize what kind of impact business has on the environment and the importance of its elimination.

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APPENDIX 1

Benefits of GSCM

Environmental benefits	**Business benefits**
Waste reduction	Profitability incensement
Pollution reduction	Competitive advantage in the market
Emissions reduction	Production, operation and distribution costs reduction
Improved energy efficiency	Value of operation improvement
Efficient packaging	Customer service and retention improvement
Water conservation	Product and service differentiation incensement
Processing operations improvement	Environmental, social and market risk minimization
	Distribution efficiency improvement
	Inventory improvement
	Innovation and trustworthiness incensement
	Strong cooperation between company, suppliers and customers
	Closed-loop supply chain by reverse logistics
	Reputation development
	Payment for non-compliance penalties and fees minimization