

Using the Green Public Procurement policy as guide for green innovation in the flooring industry



Master thesis committee:

Chairman of committee: Dr. Robert M. Verburg

First supervisor: Dr. ir. A. (Ad) Straub

Second supervisor: Dr. L.M. Kamp (Linda)

Additional supervisor: Dr. Queena Qian

Bixuan Rao

4312783

SUMMARY

Sustainable development, after all these years development, has already been accepted as one of the themes of 21st century, especially after the reveal of some serious environmental problems, such as global warming, resource exhaustion, etc. Construction industry, although being considered as one of the traditional industries of which the development speed is slowing down, is currently still playing an important role in the society and economy system. Meanwhile, it is also an industry that relies heavily on resources and energy consumption, especially the construction manufacturing industry. As a result, the pursuit of sustainability within the construction industry seems to be inevitable.

In order to stimulate and push for the green transitioning in the construction industry in Europe, the European Commission issued the Green Public Procurement policy to motivate manufacturers of building products to develop green products and technologies. As a gesture of support, many member states quickly issued their own GPP policies which are more tailored for their specific situations. However, many challenges stand in the way toward fully implementation, and one of which is the shortage of qualified suppliers. Many existing literatures elaborate on the possibility of solving this challenge from the perspective of public authorities. This research, however, looks at this challenge from a different angle, the perspective of manufacturers of building products. This research studies into the flooring industry and intends to develop some suggestions for manufacturers who plan to develop green products based on the successful experiences of some frontrunners. To realize this objective, research questions are developed in this study:

- 1) What are the GPP requirements for flooring products in public construction projects and how are they evaluated?
- 2) What are the enablers and barriers during the development of green products? How do these factors get influenced by the GPP policy?
- 3) Given the enablers and barriers, how can manufacturers of building products adjust their product development strategies to meet the GPP criteria? What green attributes should be emphasized on during the green product development process?

A literature review was conducted to find answers for the first research question. The EU GPP criteria are made for general terms of building products with no specification for each category. Two sets of criteria are contained in the EU GPP criteria, the core criteria and the comprehensive criteria which are built on the former. The main

requirements of the core criteria are that products compete for public tenders should either be eco-labeled or provide detailed LCA reports to prove their environmental performance during life cycles, and if the products are wooden based, then the wooden materials are supposed to be responsibly sourced. The comprehensive criteria, based on the core criteria, add two more requirements regarding the recyclability of the products and the amount of recycled materials that should be contained in the products. In public tenders, the core criteria work as selection criteria for the qualification of suppliers, while the comprehensive criteria act as award criteria. Apart from the general EU GPP criteria, eco-label criteria can also be used as evaluation references. The eco-label criteria, comparing to the EU GPP criteria, are more detailed and specified. Three subgroups for the flooring products are made by the eco-label criteria, namely hard flooring, textile flooring, and wooden flooring. These criteria consider every stage and aspect in the life cycle of products, and only products fulfill all of them get to wear the labels.

Case studies were conducted to research into question 2 and 3. Three frontrunner companies in the flooring industry who have successful experiences in marketing green products were interviewed, in order to identify the enabler and barriers of green product development process as well as some recognizable green product attributes. Main findings on enablers and barriers are listed Table A. As for the influence of the GPP policy, interviewees claimed it to be limited, mostly because they developed green products before or along with the development of the GPP policy.

Enablers		Barriers	
Motivations	Success factors	Worries about future uncertainty	Practical difficulties
Concern for the sustainable development of the company	Partnership	High price perception of customers	Difficult to sell at competitive prices
Concern for the competitiveness of products	In-house knowledge base	Low functional performance perception of customers	Development cost
Concern for the image of the company	Government subsidies	Future uncertainty (policy change, market requirement change, etc.)	Need for extra knowledge and expertise
Market requirement			Loss of government subsidies

			Stringent public scrutiny
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Table A Enablers and barriers of green product development (based on data of flooring industry)

Some of the most mentioned green product attributes by the interviewees are:

- Toxin-free raw materials
- Containment of recycled contents in products
- Recyclability of products
- Reduction of production wastes
- Use of renewable energies
- Closed-loop water recycling systems.

Based on these findings, some recommendations are given for manufacturers of flooring products who plan to develop their own green products in the near future:

For enablers:

- Bring the plan of developing green products up to schedule to meet future market demand.
- Build stable and cooperative relationships with main raw material suppliers and lead clients.
- Start to cultivate in-house knowledge base for green product development.
- Look out for government subsidy plans and build projects based on that.

For barriers:

- Consider long term return on investment when setting prices for green products.
- Try various ways to gather the initial investment, such as loans, partner investments, government subsidies, etc.
- When choosing what green certificates to apply, consider the zone of influence of the certificates, the market area, and supplying sector of the focal company.

For green attributes:

- Use toxin-free materials in the products. If greener alternative is not available yet, then keeping the amount of toxic materials below safe limits is necessary.
- Contain certain amount of recycled materials in the products.
- The design of the products should enable recycling.
- LCA assessment report shall be provided.
- Use green packaging.

- Use renewable energy in production. If not possible yet, then energy saving plans shall be applied.
- Consider using water in closed loops. If not possible yet, then waste water should be processed before discharging to keep the amount of certain materials below required limits.
- Consider reutilizing production wastes and by products.

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1 INTRODUCTION

For a long time, construction has been one of the essential elements of society and economy. According to statistics, the volume of construction output is expected to reach \$15 trillion (around €13 trillion) worldwide annually by 2025, which provides 5-10% employment opportunities and accounts for 5-15% of GDP at national level (Global Construction Perspectives and Oxford Economics, 2013; UNEP SBCI, 2009). However, what cannot be neglected is that construction industry brings negative environmental impacts along with those benefits. From the perspective of environmental protection, construction sector is a major consumer of natural resources and energy and a massive producer of wastes, no matter solid, water, or air (Uttam, Balfors, & Faith-Ell, 2013). In the worldwide, according to reports, the manufacturing of building products consumes approximately 10% of the global energy supply (UNEP, 2011) and 40-50% of the total flow of raw materials in global economy (Roodman, D. M., Lenssen, N. K., & Peterson, 1995; UNEP, 2014). The in-use phase of buildings accounts for 30-40% of the total global greenhouse gas emission (Taipale, 2012; UNEP, 2007), and 12% of the global water use (Taipale, 2012; UNEP, 2011). Moreover, approximately 40% of solid waste streams are generated during building construction and demolition (UNEP, 2011). In Netherlands, the situation is not optimistic, either. With respect to national figures, construction sector accounts for 45% of energy consumption, 45% of CO₂ emission, 35% of production waste, and 25% of road transport (De Ridder, 2008; Lichtenberg, 2005).

In recent years, people's attention on pursuing sustainable development have been aroused by some serious environmental problems, such as energy crisis, depletion of non-renewable resources, and environmental pollution. Given the poor environmental performance, construction industry naturally becomes one of the targets of green transition for sustainable development, and building products and materials, as one of the essential elements of construction projects, get the most attention during the process. By using green building products and materials, a good foundation can be established for green buildings. For that, public authorities issued the Green Public Procurement (GPP) policy to guide the greening process of the public procurement of building products and materials.

Nevertheless, several barriers lie in the implementation of GPP policy, and lack of qualified suppliers is one of them. The GPP policy is supposed to stimulate manufacturers of building products to adopt greener design of products and production process which could ultimately lead to increase in resource and energy efficiency. However, although all policy documents have been well developed, the question of how manufacturers of building products can actually incorporate GPP into their product

strategies to enhance the environmental performance of their products still remains unclear. To gain more insights into this question, this study chooses to research on one of the branches of building product industry – the floor covering industry. By taking a close look into this particular industry, this research aims at identifying the enablers and barriers which manufacturers encounter during the process of green product development. Moreover, this research tries to establish the connection between these factors and manufacturers' product strategies and identify the influence of GPP policy on these factors. Last but not least, some of the most valued green attributes of sustainable flooring products will be identified in order to give manufacturers some clues when developing their own green product development plans.

1.1 RESEARCH BACKGROUND

To give an overview of this research, some background information is provided regarding several main concept, namely public construction, public procurement, Green Public Procurement, and the most useful tool in evaluating green products - life cycle assessment (LCA).

1.1.1 PUBLIC CONSTRUCTION

Public construction includes any matter relating to the construction, maintenance, rehabilitation, alteration, extension or demolition of any improvements on land by, or on behalf of, departments and public bodies. It usually encompasses design and construction practices, tendering processes, project delivery, and contract administration (*Project Development and Construction Management Act 1994*, 1994). The projects of public construction includes public buildings (e.g. municipal buildings, schools, hospitals), transport infrastructure (e.g. roads, railroads, bridges, pipelines, canals, ports, airports), and public spaces (e.g. public squares, parks, beaches). The spending on public construction every year is huge, thus the behavior change in public construction procurement can influence the whole building product market, which could signal the market transform into a greener one.

1.1.2 PUBLIC PROCUREMENT

Procurement is basically the purchase process of goods, services or works from external sources. It is important that the purchasing staff get goods, services or works at a fair cost without compromising the quality and quantity expectations in procurement process (Essig, 2011). Public procurement, as can be read from the literal meaning, is the procurement of goods or services on behalf of public authorities (Global Trade Negotiation Home Page, 2003). Public procurement is one of the major economic activities of government, thus a 275-page book was published in 1919 to regulate this activity, named Principles of Government

Purchasing (Thai, 2001). Ever since, public procurement has gone through multiple developments. In last 20 years, environmental changes have great impact on public procurement which finally leads to the emergence of Green Public Procurement.

1.1.3 GREEN PUBLIC PROCUREMENT (GPP)

The Green Public Procurement (GPP), as defined in the Communication (COM (2008) 400) "Public procurement for a better environment", is "a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured" (European Commission, 2008a). GPP focuses on public procurement because the purchasing power of public authorities makes it an important factor that has potential to influence the market. Public authorities in European Union (EU) spend approximately 16-17% of the EU Gross Domestic Products (GDP) on purchasing annually, goods including office equipment, building products, transport vehicles, and services (Tarantini, Loprieno, & Porta, 2011; Testa, Annunziata, Iraldo, & Frey, 2014; Testa, Iraldo, Frey, & Daddi, 2012). With its influence, GPP gives manufacturers incentives to redesign their products and production processes to meet requirements of environmental performance.

1.1.4 LIFE CYCLE ASSESSMENT

One useful method to develop GPP criteria as well as evaluate whether products meet GPP criteria is life cycle assessment (LCA). LCA is an approach to evaluate the environmental impacts associated through all stages of product's life from cradle to grave (United States Environmental Protection Agency, n.d.). The stages covered by LCA regarding building products are materials production stage (all upstream processes from cradle to gate, such as raw material supply and manufacturing), contribution in building construction process (such as products installation), in-use phase (such as maintenance and repair), and end-of-life process (such as recycling and disposal) (Tarantini et al., 2011). Obviously, the advantage of LCA is that it considers all phases of the product life cycle when assessing the environmental performance of products, and during which it helps identify phases that cause main environmental impacts. The disadvantages of LCA, however as pointed out by Sterner (2002), lie in the fact that it is energy and time consuming to conduct LCA, the present form of LCA is too complex, and input data for analysis is lacking (Sterner, 2002).

1.2 PROBLEM DEFINITION

As introduced earlier, the construction sector is always seen as a massive resource consumer and pollution generator. Along with the awakening of environmental

consciousness, a green revolution in construction sector is deemed to happen and the GPP policy is one of the methods. Although public authorities set high targets for the implementation of GPP, there still remain many barriers and problems blocking the full implementation in practice. According to Brammer and Walker (2011), there are four factors that are influential for the implementation of GPP: the perception of cost and benefits of GPP, the availability of green products and services, the organizational pressure, and the “familiarity” of GPP. The factor “familiarity” refers to the expertise and know-how of environmental criteria that some governmental procurement staffs do not obtain.

This research aims at contributing to the development of more qualified green product suppliers, and this goal is associated with the second barrier mentioned by Brammer and Walker (2011), namely the availability of green products and services. This research is going to address this problem by taking examples from several successful frontrunners in the flooring industry. By analyzing their experiences, this research can finally develop suggestions for manufacturers who plan to develop their own green products, mainly in two aspects: factors that affect the development decision and green product attributes which should be taken into consideration during the development process.

1.3 RESEARCH OBJECTIVES

The main research objective of this study is:

Make recommendations to manufacturers of flooring products on green product development corresponding to the GPP criteria and ultimately improve the environmental performance and competitiveness of their products.

In order to achieve the main research objective, several sub-objectives need to be established as well:

- 1) Specify the enablers and barriers manufacturers encounter during the development of green products, and how these factors influence their product strategy decisions.
- 2) Find out how the enablers and barriers are affected by the GPP policy.
- 3) Find out what attributes of green products are expected by the market.

By researching on the above objectives, suggestions will be offered to manufacturers of flooring products on combining GPP policy with product strategies, which will lead to

the emergence of more qualified green flooring product suppliers in the construction sector.

1.4 RESEARCH QUESTIONS

Based on the problem definition and research objectives, the following research questions are developed. The central research question is shown below:

How can manufactures of flooring products learn from frontrunners and make their green product development plans corresponding to the GPP criteria?

To answer this central research question, the following sub questions should be answered first:

- 1) What are the GPP requirements for flooring products in public construction projects and how are they evaluated?
- 2) What are the enablers and barriers during the development of green products? How do these factors get influenced by the GPP policy?
- 3) Given the enablers and barriers, how can manufacturers of building products adjust their product development strategies to meet the GPP criteria? What green attributes should be emphasized on during the green product development process?

1.5 RESEARCH METHOD

The main research objective of this study is to offer manufacturers of flooring products some suggestions on how to build their green product development plans corresponding to GPP criteria. By doing so, more qualified green flooring products will be available for construction projects, which can ultimately lead to healthier, safer, and more environmental friendly living spaces. Due to the limitation of existing literature regarding the main research objective, this study is exploratory in nature. Two research methods were used in this study, namely literature view and case study.

A literature view sets the theoretical foundation of this study. Through a literature view, relevant information collection and proposition development can be undertaken. Literatures were found through university library and academic websites, such as Science Direct and JSTOR, and google scholar. Policy documents were mainly found through websites of public authorities, such as European Commission, Dutch Public Procurement Expertise, and Netherlands Enterprise Agency. The criteria of choosing these documents and literature are the number of citation and information relevance.

Case study was applied in this research to find out detailed information about the enablers and barriers that influence manufacturers' decisions on green product development as well as some most valued green product attributes. Case study is a research method involving an up-close, in-depth, and detailed examination of a subject of study (the case) as well as its related contextual conditions (Yin, 2009). Usually, people choose case study as main research method when at least one of following three situations fits (Yin, 2009):

- When the research question is about “how” or “why” something happened.
- When researchers are dealing with behavioral events which they have no control over.
- When the focus of the research is a contemporary phenomenon.

For this study, the research question is '*how can manufactures of flooring products learn from frontrunners and make their green product development plans corresponding to the GPP criteria*', which fits the first situation. Moreover, case study provides benefits which outweigh other research methods in this study. For example, case study allows ordinary readers (not scholar or expert) to easily understand the research contents, results, and application, and it provides understandable explanations for analogous cases. Moreover, it is a perfect research method for individual researchers, and, sometimes, it enables researchers to discover special phenomena which were ignored by traditional statistical methods. Last but not least, case study not only focuses on phenomenon itself but also the reason caused the phenomenon. Therefore, case study was chosen for this research.

The research subjects chosen for case studies are manufactures of flooring industry who have successful experiences in the field of green product development. Since this research aims at identifying the enablers and barriers that may happen in the development process, frontrunners can speak from their past experiences to answer this question and even provide their solutions to tackle the barriers. Besides, these frontrunners have already marketed their green products and gained positive results, which makes them qualified to provide information about what attributes of green products are valued most in the market. Thus, by analyzing their experiences, this research can finally help other flooring product manufacturers to building their own green product development plans.

1.6 RESEARCH SCOPE

The building types can be roughly classified into residential buildings and non-residential buildings, and not all building types can be easily transformed into green buildings. The variation in usage pattern, energy requirements, construction

techniques, age, and ownership are factors that can influence the way realizing green buildings. Office buildings tend to be the most promising building type for realizing green buildings, since it is the most rated building type by various green building rating systems and accounts for significant share of non-residential floor space (UNEP, 2014). For example, in Europe, office buildings account for 23% of the non-residential floor space (BPIE, 2011). Therefore, the flooring product manufacturers chosen for case studies should have experiences in supplying products to public office building construction or renovation projects in Netherlands or EU wide.

1.7 CONSTRAINTS AND ASSUMPTIONS

Greening the construction supply chain can be done in many ways, and the GPP policy is just one of them. Implementing the GPP policy can give the market positive signals on producing environmental friendly products or researching on environmental innovations. As a matter of fact, no matter how eager public authorities are, there are many challenges standing in the way towards the full realization of GPP, such as lack of administration support, lack of environmental expertise, lack of awareness, and lack of qualified suppliers. Among all these challenges, this thesis focuses only on dealing with the shortage of qualified suppliers.

What makes this study different from others is that this research takes the angle from inspiring and helping more manufacturers to innovate green to enhance the implementation of GPP policy, unlike other researches tend to focus on the perspective of public authorities. However, due to the limitation of time and effort, this research only focuses on one branch of the building product industry – the flooring industry. This choice is made under the influence of many factors. First of all, flooring products are common building products widely used in construction projects, no matter it is new construction or renovation of existing buildings. Moreover, floor covering products have diverse categories which include carpet, area rugs, and resilient flooring such as linoleum or vinyl flooring. Materials commonly called flooring include wood flooring, ceramic tile, stone, terrazzo, and various seamless chemical floor coatings (World Floor Covering Association, n.d.). Due to the wide application range of floor covering products in buildings, their quality has direct influence on residents' health. Last but not least, there are clear GPP requirements for floor covering products in policy documents published by European Commission.

1.8 PROJECT DESIGN AND DOCUMENT OUTLINE

This thesis research is conducted in three parts, and the whole project outline is shown in Figure 1. The first part of this research consists of three chapters in which the background information and theoretical foundation of this research are provided. Chapter 3 explains the necessity of pursuing sustainability in the construction industry, chapter 4 provides relevant information about the GPP policy which is used to enable the necessity described in chapter 3, and chapter 5 proposes several possible enablers and barriers that manufacturers could encounter during the green product development process and provides the conceptual model of this research.

Based on the knowledge foundation formed in the first part, case studies were conducted in the second part to find out the actual influencing factors in green product development process. Chapter 7 describes the design and results of the case studies. Through interviews, the true enablers and barriers which manufacturers confronted when deciding to innovate green are identified, as well as how they dealt with them. The influence of the GPP policy in the whole process is found out, and some green product attributes which are most valued by the frontrunners are also revealed in the interview. Chapter 8 is about data analysis. Five categories are classified to make comparisons between the interview results, namely green certificates, green attributes, enablers of innovating green, barriers of innovating green, and GPP influence.

After analyzing all relevant information and data, conclusions, recommendation and reflection are provided in chapter 9 which is also part three. All of the research questions are answered in this chapter. Based on that, this research can finally make recommendation to manufacturers of flooring products who have plans to develop green products in the near future about the possible enablers and barriers they may encounter and some of the highly valued green product attributes they may take into consideration. Last but not least, a reflection about the whole research is provided to describe the contribution as well as advantages and shortages of this research.

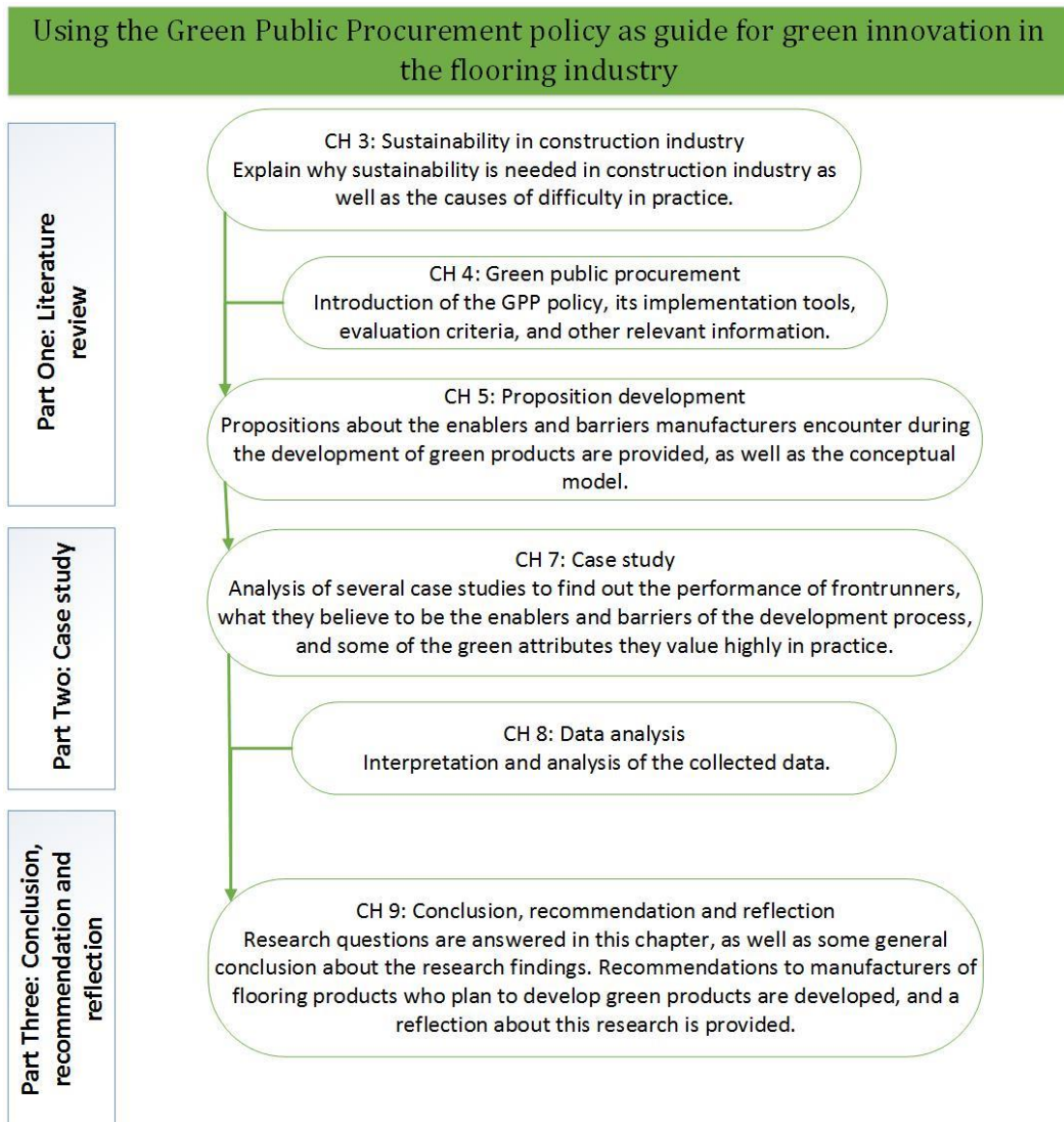


Figure 1 Project outline

PART ONE:

LITERATURE REVIEW

2 INTRODUCTION FOR PART ONE

The goal of this part is to build theoretical foundation for this research. By conducting a literature review, a more thorough image about the research problem and a knowledge base for further conducting case studies can be developed.

Chapter 3 aims at explaining the necessity of pursuing sustainability in construction industry. To achieve that, some general information on the construction industry and sustainability are first provided. By elaborating on the environmental performance of construction industry, the meaning and value of the concept of sustainable buildings can be understood.

Chapter 4 focuses solely on the Green Public Procurement policy, its concept, implementation tools, assessment criteria, and some relevant information. By digging into this concept and policy, this research can build the foundation to incorporate the GPP criteria into product development suggestions which this research aims at providing the manufacturers of flooring products with.

Chapter 5 proposes some possible enablers and barriers which manufacturers of flooring products may encounter during the green product development process. Five enablers and five barriers are extracted from literatures describing the influencing factor of green product development in general. Last but not least, a conceptual model linking all of the theoretical foundations is provided, which completes this whole literature review part.

3 SUSTAINABILITY IN THE CONSTRUCTION INDUSTRY

3.1 CONSTRUCTION INDUSTRY

The construction industry is one of the major consumers of energy and natural resources, which, according to Worldwatch Institute's State of the World 2012, consumes more than 33% of global resources (Taipale, 2012). Along with the appeal for sustainable development, construction industry becomes a natural target for this green revolution. Based on who finances or constructs the project, the construction industry can be generally divided into two sectors: public and private. Obviously, public construction projects are financed or constructed by public authorities for recreational, employment, and health and safety uses in the greater community, and it is the context in which this study will be conducted. The following part provides information on the special attributes of construction projects and building supply chain, which are important to understand the challenges to apply GPP in the construction sector.

3.1.1 ATTRIBUTES OF CONSTRUCTION PROJECTS

Over 59 years ago, Cox and Goodman (1956) described the construction industry in the article "Marketing of housebuilding materials" as:

The physical substance of a house is a pile of materials assembled from widely scattered sources. They undergo different kinds and degrees of processing in large numbers of places, require many types of handling over periods that vary greatly in length, and use the services of a multitude of people organized into many different sorts of business entity.

From this quote, an overview of the attributes which distinguish construction projects from other business projects can be extracted.

Uniqueness Cox and Thompson (1997) believe that construction projects are site-specific and project-based. In other words, construction projects are unique assembly of specific parameters. Each project has its own choice of duration, location, site geographical conditions, and environmental conditions, etc. (Dubois & Gadde, 2002; Olsson, 1998). Therefore, each construction project itself is inherently unique. However, from the point of view of materials and skills used, construction projects are not always unique, which leaves room for standardized solutions (Koskela, 2003).

Customization Another attribute of construction industry is that it is always the customized products that be produced. This attribute is actually the result of the uniqueness of construction projects. Each construction project is customized to the specific requirements of customers, the site location, and the geographical and

environmental condition of site, which makes the production of construction project a demand driven process (Vrijhoef & Ridder, 2007).

Structure complexity The management of construction industry is challenging due to the complexity of the building supply chain structure as well as the uniqueness of construction projects. As what can be seen from Figure 2, large number of stakeholders is involved in construction projects, such as public authorities, suppliers, contractors, subcontractors, design firms, real estate companies, and users, etc. Each one of them has different stakes and interests in the project, and coordination among all of them is difficult. Besides, the number of subcontractors is usually large, and the majority of them tend to be small and medium enterprises (SMEs), even in large construction projects, which worsens the situation (UNEP, 2014). A UNEP report in 2003 confirmed the dominant role of SMEs in construction industry. 90% of construction workers are employed by SMEs which have less than 10 people worldwide (UNEP, 2003). SMEs are also involved in manufacturing of building materials, especially in developing countries. There are 2.5 million construction SMEs in EU, occupying 90% of total construction enterprises, 16% of manufacturing and service companies, and 80% of construction turnovers (UNEP, 2003).

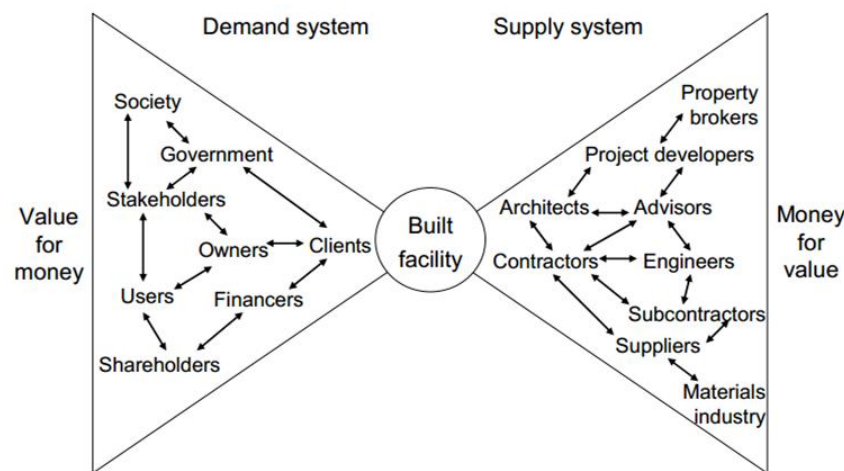


Figure 2 Demand and supply system in construction industry (Vrijhoef & Ridder, 2005)

Huge public expenditure Every year, public authorities in 25 member countries of European Union purchase goods and services to the value of €1,000 billion (ICLEI, 2006). A significant share of them is spent on construction projects, no matter it is the construction of new one or renovation of existing buildings, and sometimes it even exceeds 50% of annual expenditure (European Commission, 2008b). Take UK as an example, public construction spending accounts for 31% of total construction spending, excluding professional fees and value added tax (Building.co.UK, 2006). The huge public

expenditure makes it possible for public authorities to influence the construction market to their favorable direction – green products and technology.

3.1.2 *BUILDING SUPPLY CHAIN*

Supply chain is a series of activities concerning the planning and controlling of raw materials, components and final products from suppliers to end users (Stevens, 1989). The supply chain perspective provides a useful way to analyze the construction process (Ofori, 2000). The building supply chain can be seen as a process of strategic management of information flow, activities, tasks, and various networks of organizations and companies who are involved in the process from extraction of raw materials to the eventual demolition of the building, and disposal of its components (Akintoye, McIntosh, & Fitzgerald, 2000; Ofori, 2000). Usually, the construction supply chain only exists for the duration of one project, but if maintenance service is part of the contract, the duration will theoretically extend to the whole life of the building (Reed, 1999).

Building supply chain can exist in many forms and vary largely in the complexity and diversity (A. Cox, 1999). A simplified building supply chain is shown in Figure 3. As can be seen from the figure, the whole building supply chain consists of five phases: concept definition, design, construction, in use, and end of life. During the concept definition phase, the initial idea and scope of a building is established, while the design phase translates all the ideas into detailed building design. The construction phase is the operation on-site phase. For simplicity, the procuring process is counted to occur in this phase, but actually, it may happen through the whole delivery and management process (UNEP, 2014). The operation and maintenance of a building happens in the in-use phase, and the end-of-life phase describes the time point when then building is to be demolished or renovated significantly, either way, it is the end of the using life of a building (European Commission, 2008b; UNEP, 2014).

Meanwhile, the UNEP (2014) report, “Greening the building supply chain”, divides the whole building supply chain into two parts, namely the upstream and downstream supply chain. The upstream supply chain encompasses the first three phases, i.e. concept definition, design and construction in which the procurement of building products is included. These three phases address, what so called, the major three subsystems in building supply chain according to Voordijk, Haan, & Joosten (2000), which are manufacturing of building products, construction and design. These three subsystems are certainly the core of construction projects in which multiple actors are involved. The upstream supply chain is usually characterized as highly fragmented and non-integration between elements because of the presence of relatively small and local actors (comparing to international standards) (Dainty, Millett, & Briscoe, 2001; UNEP, 2014). A study about the structure of private sector

contracting firms in UK shows that very small sized firms are the majority in construction sector. Firms with three or less employees account for 83% of those small firms, and if using the standard hiring 24 or less workers to define small companies, they would account for 98% of the total (Dainty et al., 2001). Even large construction projects rely on small and medium enterprises as material suppliers or designers. The interaction complexity of these participants might be one of the biggest barriers to green the building supply chain (UNEP, 2014). The downstream supply chain covers the latter two phases which are the in-use and end-of-life phases. During these two phases, buildings are managed, marketed, and maintained by small landlord, corporate property owners and public housing authorities (UNEP, 2014).

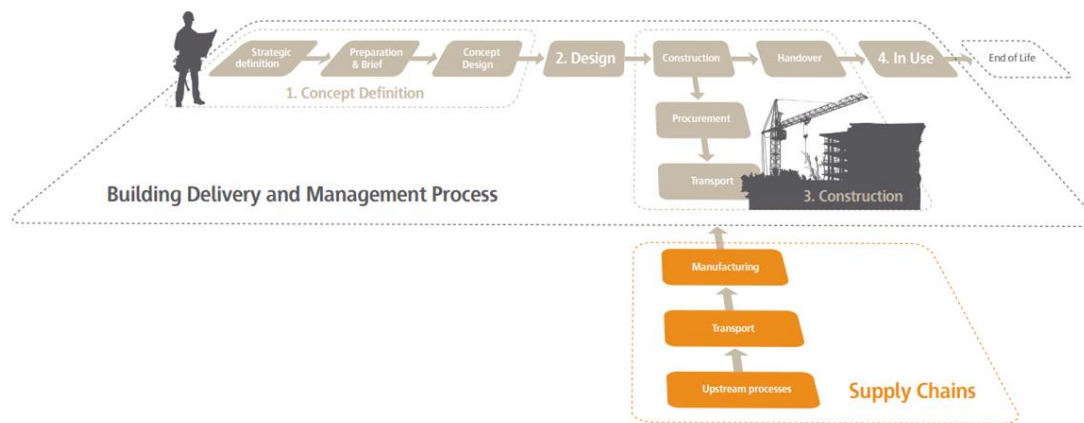


Figure 3 Simplified construction supply chain (UNEP, 2014)

3.2 SUSTAINABILITY

Concept definition

The concept of “sustainability” was employed to describe an economy “in equilibrium with basic ecological support systems” in 1970’s (Stivers, 1976). Not until 1987 did the Brundtland report give a classic definition to sustainable development which is accepted and used widely - “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” (WCED, 1987). In other words, sustainable development provides good quality of life for everyone, not only for people who are living but also for generations to come. Sustainable development combines the concern for the carrying capacity of natural systems with the social, political, and economic challenges faced by humanity. It requires people to combine immediate and long-term objectives, local and global action, and to see the economy, environment and society as a

whole ("Sustainable development," 2015). The process of sustainable development must remain flexible, because what works for one scenario may not work for another, or they may work for different reasons. Nevertheless, no matter how flexible the process is, there are three basic elements which provide the foundation for sustainable development, namely economic, environmental, and social aspects (Flint & Houser, 2001; Mebratu, 1998). The three basic elements are interrelated, and changes happen in any one dimension can affect the other two. The relationship among the three dimensions is shown in Figure 4 below.

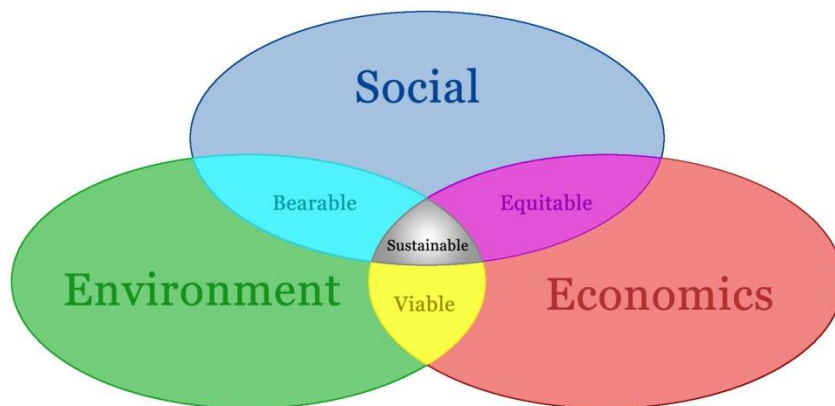


Figure 4 sustainability Venn diagram (Uren, Parkin, & Sommer, 2003)

Economic aspect

The economic aspect of sustainability emphasizes on economically sustainable system which uses its resources efficiently and responsibly, so it can constantly produce goods and services to make profits, keep government and external debts under control, and avoid situations which could hurt agriculture and industrial production (Mebratu, 1998). Meanwhile, the economic sustainability requires economic development plans to protect and/or enhance the quantities and qualities of natural resources, as well as other resources, such as manufactured resources, human resources, and social resources (Flint & Houser, 2001; Mebratu, 1998; Uren et al., 2003).

Environmental aspect

An environmentally sustainable system should have the ability to keep a stable resource base and avoid over-exploitation of non-renewable resources or environmental sink functions. Meanwhile, when depleting non-renewable resources, it is important to

make sure that the investment is made in adequate substitutes (Mebratu, 1998). From a perspective of environmental sustainability, both of the human population and resource demand should be limited to certain degree, and it is important to maintain biodiversity and integrity of ecosystem (Flint & Houser, 2001; Mebratu, 1998). In business, environmental sustainability means making responsible decisions that will reduce the negative impacts on environment. It is not just minimization of wastes, but also it emphasizes the importance of developing process which can lead the whole business toward full sustainability in the future (SmallBizConnect, n.d.). The construction sector has great potential of developing environmental sustainability, since it gives great burden to the environment with huge consumption of natural resources and energy and generation of large amounts of wastes.

Social aspect

A socially sustainable system emphasizes the fairness in distribution and opportunities. It should provide people with adequate and equal accesses to social services including employment, health, education, natural resources, gender equity and political participation and accountability (Flint & Houser, 2001; Mebratu, 1998). There are three priorities that should be addresses in social sustainability. The first one is poverty reduction, and it is the primary objective of sustainable development. Poverty can be caused by unequal distribution of land and other resources and assets (WCED, 1987). The second one is social investment which could supply the economy with healthy and educated workforce (Torjman, 2000). The last one is safe and caring communities. It is believed that the human well-being is the responsibility of all individuals and sectors, and they should take care of each other's welfare. By engaging in communities, citizens can find positive solutions to negative problems. Meanwhile, communities can also provide positive impacts to citizens, for example, enhancing citizens' accomplishment regarding culture and art (Torjman, 2000).

3.3 SUSTAINABILITY IN THE CONSTRUCTION INDUSTRY

3.3.1 BENEFITS BROUGHT BY THE CONSTRUCTION INDUSTRY

As one of the traditional industries, construction industry is definitely one of the pillars of economy and society, especially for developing countries where the demand for infrastructure is still very high. Benefits brought by construction industry come from both economic and social aspects. In terms of economic benefits, the construction sector accounts for 10% of gross world product, and the output of construction industry is expected to reach US\$15 trillion worldwide annually by 2025 (Taipale, 2012; UNEP, 2014). As for social benefits, the construction industry generates 5-10% of employment

at national level, including jobs of management and maintenance (Taipale, 2012). For example, the construction industry generates 3 million jobs in UK which represents 8% of national workforce, and more importantly, over 60% of these workers are low-skilled labors who have limited employment opportunities. Besides, the construction industry also plays important role in the urbanization process, especially in developing countries. If calculating based on current rate of urbanization, researchers predict that there will be 1.4 billion more people live in cities in 2030, and 1.3 billion of them have needs for houses, services, and employment, which all needs buildings to realize (Taipale, 2012).

3.3.2 SUSTAINABILITY ISSUES WITHIN THE CONSTRUCTION SECTOR

The importance of construction industry to economy and society cannot justify its poor environmental performance. Main environmental and social impacts of buildings and construction are presented in the Table 1.

Main environmental and social impacts of buildings and construction
◆ raw material extraction and consumption; related resource depletion
◆ land use change, including clearing of existing flora
◆ noise pollution
◆ energy use and associated emissions of greenhouse gases ^a
◆ other indoor and outdoor emissions
◆ aesthetic degradation
◆ water use and wastewater generation
◆ increased transport needs (depending on siting)
◆ various effects of transport of building materials, locally and globally
◆ waste generation
◆ opportunities for corruption
◆ disruption of communities, including through inappropriate design and materials
◆ health risks on worksites and for building occupants
a. Particularly the “Kyoto gases”: CO ₂ , CH ₄ , N ₂ O, HFCs, PFCs and SF ₆

Table 1 Main environmental and social impacts of buildings and construction (UNEP, 2003)

Among all of these environmental impacts, the most significant ones are resource and energy consumption and greenhouse gas (GHG) emission. It is almost common knowledge that the construction industry is a massive resource consumer, and it is responsible for 40% of natural resource consumption worldwide, including 25% of wood harvest (UNEP, 2003, 2014). The mining and quarry of building materials account for large amounts of pollution and waste generation, as well as considerable amount of

land use (UNEP, 2003). However, the demand for these materials is constantly growing these years. The demand for steel is expected to grow 80% between 2010 and 2030, and the production of cement is predicted to increase by 43-72% between 2006 and 2050 (McKinsey & Company, 2011; UNEP, 2014). Some metals widely used in construction projects may even face the problem of shortage in the middle of 21st century, such as copper and zinc (UNEP, 2003). The water consumption is also significant in construction industry. The water use in buildings accounts for 12% of global water demand, and this data does not even cover the water consumption in construction and building products manufacturing activities. What is more, the construction water demand rate is constantly growing, which is expected to grow to over 20% of the world water demand by 2030 (UNEP, 2014). If keeping up with this high rate of resource consumption, challenges of future resource availability may actually happen instead of being a threat.

The energy consumption in the construction sector is significant also, and it usually comes with the GHG emission which is responsible of the climate change worldwide. Around 25-40% of produced energy is used in construction and operation process, while manufacturing of building products accounts for 10% of global energy consumption (UNEP SBCI, 2009; UNEP, 2011). For some countries, the number even goes up to 50%. This estimation does not count for embodied energy which is used to describe how much energy consumed producing a particular building product, and the transformation of raw materials into building products actually has quite high energy demand (UNEP, 2003). With this large amount for energy use, construction industry contributes to 30-40% of CO₂ emission (Taipale, 2012). Manufacturing activities of building products are major sources of CO₂ emission, mainly through burning of fossil fuels and breakdown of raw materials (UNEP, 2003). Yet, what should really be worried about is the growth rate of CO₂ emission. Between the year of 1971 and 2004, CO₂ emission grew at a rate of 2.5% per year for commercial buildings and 1.7% per year for residential buildings, including through the use of electricity (Levine, Ürge-Vorsatz, Blok, & Geng, 2007). Besides, the construction sector is also responsible for other non-CO₂ GHG emission, such as halocarbons, CFCs, HCFCs, and hydrofluorocarbons (HFCs), due to their application in cooling and refrigeration systems (UNEP SBCI, 2009).

When talking about social sustainability, construction industry has poor performance also. Construction jobs are usually considered as low-status, low-paid and hazardous employment (UNEP, 2003). Thus, the main social sustainability concern in construction industry is about the health, safety and education issues of workforce (Valdes - Vasquez & Klotz, 2012). Many jobs in construction industry are unregistered and hazardous (UNEP, 2003). According to report, 600 workers die each year because of

asbestos-related ailments, 40% of them have muscular-skeletal problems, and 30% have dermatitis due to contact with cement. Besides, over 50000 workers die in construction accidents annually worldwide (UNEP, 2003). To improve the social sustainability performance, more attention should be paid to job security in construction industry, especially when using casual labor and subcontracts.

3.4 SUSTAINABLE BUILDINGS

Given the poor environmental and social performance of the construction industry, the 'Roadmap to a Resource Efficient Europe' published by the European Commission states its ambition to transform the building sector into a greener one. According to the roadmap, the renovation and construction of buildings and infrastructure will reach high resource efficiency levels by the end of 2020, and the life cycle assessment will be widely applied. New buildings will reach nearly zero-energy and high material efficient, and policies for building renovation will also be available. Moreover, over 70% of non-hazardous construction waste will be recycled or reused (Europe Regional Network of WGBC, n.d.). certainly, this road map gives a clear start of the transitioning, yet the sustainable buildings should not only about resource efficiency but also about high performance in social, economic, and environmental dimensions through their whole life cycles (Europe Regional Network of WGBC, n.d.).

Apart from the availability of green technologies and products, the cost of constructing sustainable buildings appears to be one of the obstacles in practice. Normally, the initial costs of sustainable buildings are higher than conventional buildings due to novel technologies and products. However, if considering the costs of the whole life cycle of buildings, sustainable buildings tend to have better performance than conventional ones, since they usually require lower operation and maintenance costs (Davis Langdon, 2006). There are also arguments stating that green buildings do not necessarily cost more with proper strategies and combinations of technologies (Davis Langdon, 2006). With the right mix of green technologies, green buildings can cost the same or even less comparing to conventional buildings. For example, using energy saving lightening system could increase the initial installation cost, but it saves money on energy use during the in-use phase.

Other than the dispute about the development cost, green buildings can provide building owners with benefits in many different ways. Sustainability is one of the future development directions, thus sustainable buildings, after development, will have higher future capital value and reduced risk of obsolescence which means they are investments with great potential (Davis Langdon, 2006). By providing residents with healthier and

more comfortable spaces, higher lease rates can be required. Last but not least, sustainable buildings require less operation and maintenance work during in-use phase, which saves costs for building owners both in monetary and non-monetary terms (Davis Langdon, 2006).

In practice, five rating systems are commonly used for rating the performance of green buildings: BREEAM (Building Research Establishment's Environmental Assessment Method), CASBEE (Comprehensive Assessment System for Building Environmental Efficiency), GBTool, Green Globes™ U.S, LEED® (Leadership in Energy and Environmental Design) (Fowler & Rauch, 2006). Different specialized sustainable building design knowledge is required to comply with different rating systems.

BREEAM was first launched by a former British government department named Building Research Establishment in 1990, and it is the longest established sustainable/green building rating system in the world (BREEAM, n.d.). It is used by over 50 countries in the world, including EU member states, such as Netherlands, Germany, Spain, and Norway and so on. It is annually updated, and a certificated BREEAM assessment report is usually delivered by a licensed organization if applied.

CASBEE is a relatively new sustainable building rating system developed for Japanese market (Fowler & Rauch, 2006). The idea of CASBEE is to create a rating system that is simple and applicable to wide range of building types, and takes into consideration of issues that is peculiar to Japan and Asian (CASBEE, n.d.). The system requires quantifiable sustainable design achievement assessed by trained architects who passed the CASBEE assessor examination (Fowler & Rauch, 2006).

GBTool is an international sustainable building rating system. GBTool is applicable to all but tenant building out and operation and maintenance system. It encompasses both qualitative and quantitative methods to evaluate the sustainable design performance of buildings, yet it tends to require more expertise to conduct than other rating systems (Fowler & Rauch, 2006).

Green Globes™ U.S is the newest rating system among the five, and it is adapted from Green Global Canada in 2004 (Fowler & Rauch, 2006). It is developing tools to address tenant build out, major renovation, and operation and maintenance applications. Similar to other rating systems, the construction information is assessed by a third party that has professionals trained and approved by Green Building Initiative and Green Globes (Fowler & Rauch, 2006).

LEED is developed by the U.S. Green Building Council to help operators and owners act environmental responsible and resource efficiently during the construction process, and it also helps to recognize best-in-class green building strategies and practices (USGBC, n.d.). LEED is the most widely used green building rating system by U.S. Federal and States agencies. For now, LEED has been applied to 7000 projects in United States and 30 other countries, since it is flexible enough to cover all building types and works throughout the whole building lifecycle (USGBC, 2015).

3.5 CONCLUSION

The construction industry is one of the traditional industries and relies heavily on resources and energy consumption. Meanwhile, it is also one of the footstones of society and economy, not only because it provides people with houses to live in and work but also because it creates financial benefits and employment opportunities. However, some serious environmental problems have raised people's awareness of the importance of environment protection and sustainable development. Therefore, there is a conflict between the nature of construction industry and people's will to protect environment. To solve this problem, the concept of sustainable building is brought up. Sustainable buildings emphasize the importance of achieving resource and energy efficiency in the construction and in-use phases, which offers a clear guidance of the development direction of the construction industry. Furthermore, people grow to realize the necessity of greening the whole building supply chain, because it can not only increase the availability of green products and technologies, but also it is the method to ultimately improve the environmental performance of this industry. However, given the unique characteristics of the construction industry and the complexity of the building supply chain, the greening process is deem to be a challenge in practice.

4 GREEN PUBLIC PROCUREMENT

4.1 GREEN PUBLIC PROCUREMENT

In order to enhance the performance of environment protection, the European Union introduced the Green Public Procurement policy to European wide at the end of 1990's (Temmerman & Habets, 2013). The Green Public Procurement (GPP), as defined by European Commission, is "a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured" (European Commission, 2008a). Public authorities are major consumers in Europe, and they spend two trillion euros which is equivalent to 19% of the EU Gross Domestic Products (GDP) on purchasing annually, goods including office equipment, building products, transport vehicles, and services (Tarantini et al., 2011; Testa et al., 2014, 2012; "What is GPP," n.d.). By choosing products with lower impact on environment, public authorities can actually contribute to sustainable development and environment protection. The significant purchasing power of public authorities also makes it possible for them use policies like GPP to signal the market about the future trend, thus giving manufacturers a real incentive to develop green technologies and products, especially industries in which public authorities occupy large shares of the market ("What is GPP," n.d.).

Many initiatives are adopted to stimulate the implementation of inserting environmental criteria in public tender procedures. The EC tries to provide guidance on GPP implementation through Commission communication and policy papers which state that GPP should be included in different stages of tendering process, and the Court of Justice of European Union accepted environmental criteria as part of the assessment criteria of awarding public contracts (Temmerman & Habets, 2013). However, despite of the encouragement and clear reference in legislation, the GPP policy is still a volunteering tool which member states of EU can decide to what degree they implement it, and different countries have slightly different GPP criteria (Temmerman & Habets, 2013).

4.2 IMPLEMENTATION TOOLS

Mainly two methods are used in EU to evaluate the environmental performance of products and the compliance to the GPP criteria: life cycle assessment (LCA) and eco-label program.

4.2.1 LIFE CYCLE ASSESSMENT

LCA is one of the most useful methods to develop GPP criteria as well as evaluate the environmental performance of products. It evaluates the environmental impacts associated through all stages of product's life, from cradle to grave (Dangelico & Pujari, 2010; United States Environmental Protection Agency, n.d.). The stages covered by LCA regarding building products are materials production stage (all upstream processes from cradle to gate, such as raw material supply and manufacturing), contribution in building construction process (such as products installation), in-use phase (such as maintenance and repair), and end-of-life process (such as recycling and disposal) (Tarantini et al., 2011). Companies tend to use LCA to evaluate the performance improvement of green products comparing to conventional ones (Dangelico & Pujari, 2010). Three key elements need to be considered when conducting LCA ("Glossary," 2015):

- 1) Identify and quantify the environmental loads involved, such as energy consumed or waste generated.
- 2) Evaluate the potential environmental impacts of these loads.
- 3) Evaluate options for reducing these environmental impacts.

Obviously, the advantage of LCA is that it considers all phases of the life cycle when assessing the environmental performance of products, and during which it helps identify phases that cause main environmental impacts. The disadvantages of LCA, as pointed out by Sterner (2002), lie in the fact that it is energy and time consuming to assess all stages of products. The present form of LCA is too complex and input data for analysis is lacking (Sterner, 2002). Therefore, the environmental performance assessment of certain types of products only measures one stage of the whole life cycle in practice (Dangelico & Pujari, 2010). For example, for energy based products, the assessment is usually expressed in terms of energy saving or pollution reduction during the in-use stage (Dangelico & Pujari, 2010). Even for some material based products, the assessment can be expressed in result of a single stage, for example, the percentage of recycled materials used in the production process. When LCA is used to assess only one single stage of the whole life cycle of products, it is usually the stage which leads to the greatest environmental impact that is evaluated (Dangelico & Pujari, 2010).

4.2.2 ECO-LABEL PROGRAM

The second assessment tool, the eco-label program, is set up by the EU in 1992 to help consumers to identify products and services which have lower negative impacts on environment through their life cycles (European Commission, 2004). Today, the eco-label program covers 28 products and services including textile, paper, cleaning

products, electronic equipment, coverings, furniture, gardening, household appliance, lubricants ("Product groups and criteria," n.d.). It is a tool for developing GPP criteria, verifying the compliance of products and services with these standards, and award points for environmental characteristics (European Commission, 2004). Multi-criteria labels are the most common types of eco-labels used in GPP. They consider all environmental impacts of products and services through the whole life cycle, from raw material extraction, through production and distribution, in-use phase, to final disposal or recycle phase (European Commission, 2004). Different criteria are established for different product groups.

There are two ways to use eco-label criteria (European Commission, 2004):

- 1) To help procurement staff to make specifications about the characteristics of the products or services they want to purchase.
- 2) To check the compliance of products and services with specifications and the labels can act as proofs of qualification.

Yet, conditions must be met before using eco-label as technical specifications ("Ecolabel and Green Public Procurement," 2015; European Commission, 2004):

- 1) Procurement staff cannot require products carry eco-labels, yet they can demand the products to meet certain criteria under specific eco-labels.
- 2) The eco-label criteria used shall only refer to the characteristics of products or services. Eco-label criteria which are related to the general management practice of companies should not be applied.
- 3) The requirements of eco-labels should be based on scientific evidence.
- 4) The eco-label is adopted with the participation of all stakeholders and accessible for all interested parties.

In general, the eco-label program makes it easier for procurement staff without much environmental expertise to buy green products. Moreover, it is widely adopted by the EU member states and European Economic Area countries with transparency and non-discrimination, which makes it a suitable tool to better implement the GPP policy in public procurement projects.

4.3 ACTORS INVOLVED

Main actors involved in public procurement process are public authorities, developers, contractors, and manufacturers of building products. Relationship of these four actors

can be found in Figure 5. Other relevant actors like transportation service providers and construction design companies are omitted for the sake of simplification.

As described in the previous chapter, the whole building supply chain is divided into five stages, namely concept definition, design, construction, in-use, and end of life. Theoretically, the construction activities would not be started until most of the design works have been completed; however, in practice, designers or contractors tend to finish some of the design works, for example choosing materials & service providers, during the construction stage. Therefore, the procurement activities in public construction projects usually happen during the construction stage.

The procurement process starts with developers issuing a request for qualification to potential contractors. Only qualified contractors receive Invitation to Tender (ITT) or equivalent. With that, qualified contractors can submit a bid with cost later. Developers later award the best offer, usually based on predetermined criteria and can be largely influenced by cost. The relationship between developers and contractors will then be formalized by contracts (UNEP, 2014).

A lead contractor is usually appointed by the developer to manage the most of the activities, usually through a competitive tendering process. As modern buildings are becoming increasingly complex, it becomes increasingly difficult for single stakeholders to possess all required skills and resources for their work, thus they tend to subcontract some works (e.g. roofing and cladding) to specialized subcontractors, which in some cases also including materials & service providers (UNEP, 2014). Normally, if not specified by developers, lead contractors will select materials & service providers according to design specifications only. If the developer has requirements, as in this case, the GPP criteria, then the lead contractor is supposed to consider these requirements along with the design specifications during the selection process.

The influence of public authorities during the procurement process is conducted through regulation and fiscal policies. The relevant public authorities have the right to evaluate and approve the building planning and permit application submitted by developers. Besides, it is also within public authorities' power to control the land-use planning, implement specific conditions on the size, density and use of buildings, and enforce local building codes which relate to specific building types. The fees public authorities impose on developers also have significant influence on the decision making in the design process (UNEP, 2014).

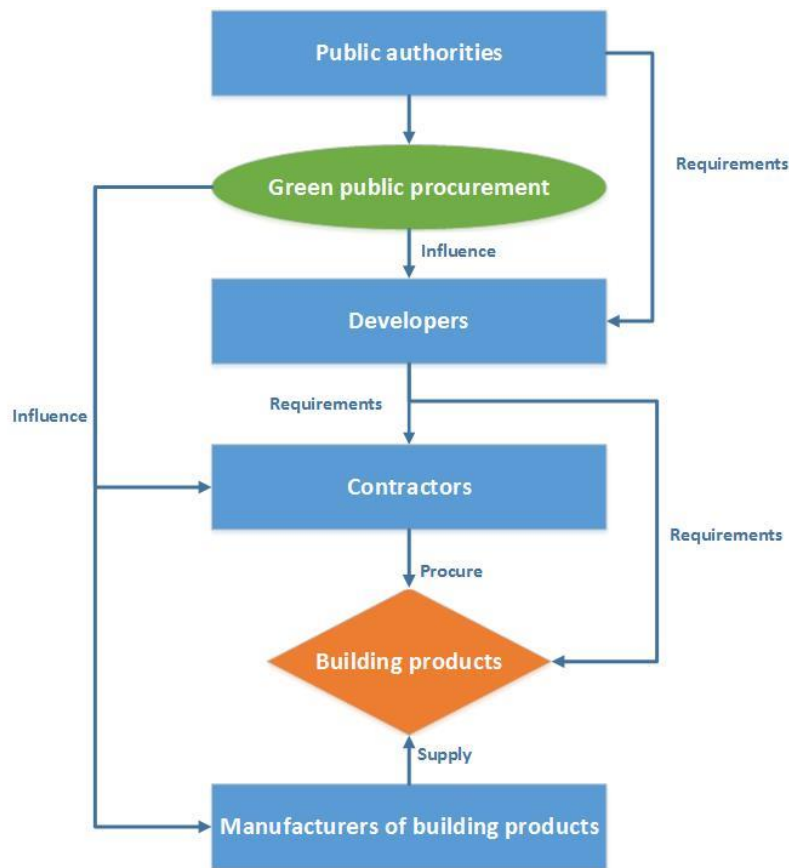


Figure 5 Relationship among main actors

4.4 GPP CRITERIA

The concept of GPP is to provide clear, reasonable and verifiable procurement criteria for goods and services by using LCA and other scientific tools ("Background and approach," 2015). In order to avoid distortion to the single market rule and reduction to the EU-wide competition, the European Commission proposed to create a common set of GPP criteria which can be used across Member States, and the national GPP criteria of Member States should be similar to the EU one ("Background and approach," 2015). Besides, the research subject of this study, the manufacturers of flooring products, may not only do business in Netherlands but also in other Member States. For these reasons, the GPP criteria chosen for this study is the EU standard one.

From 2008 to now, EC has developed more than 20 GPP criteria. The selection of sectors involved in GPP implementation is based on multi-criteria analysis, and the selection criteria encompass environmental, political, and economical aspects ("Background and approach," 2015). The development of EU GPP criteria is based on the empirical evidence using LCA, existing eco-label program, and information provided by stakeholders of selected industry, society and Member States ("Background and

approach,” 2015). The main criteria resources for this study are the EU GPP criteria for Office Buildings (mainly using the 2011 version since the newest one is still under revision) and the Eco-label program for wooden floor coverings, hard coverings, and textile floor coverings.

4.4.1 EU GPP CRITERIA

The EU GPP criteria can be further classified into Selection Criteria, Technical Specifications, Award Criteria and Contract Performance Clauses. Two levels in each criteria group are applied: the core criteria and comprehensive criteria. The core criteria are used by any member states to address the key environmental impacts in procurement process, while the comprehensive criteria are for those who want to buy the best products on the market (European Commission, 2011).

The EU GPP criteria for office buildings regarding construction materials are listed in Table 2. As can be read from the table, the criteria document not only specifies the product requirements but also the verification methods for manufacturers to prove the qualification. The comprehensive criteria are literally more “comprehensive” than the core criteria since it has more focuses which also means more efforts and costs are required to comply with. Therefore, the comprehensive criteria usually act as award criteria, while the core criteria are actually the selection criteria. Therefore, manufacturers who comply with the core criteria are qualified to attend public tenders from the GPP point of view.

Core criteria	Comprehensive criteria
Use of construction materials complying with certain environmental criteria At least 60-80% of construction materials used in the construction or major renovation of high environmental performance buildings should comply with at least one of the following criteria: 1) Eco-labelled products (labels Type I or Type III in accordance to ISO 14024 or ISO 14025 respectively) shall be selected. 2) If point 1 is not possible, materials that provide a clear and transparent information on the product environmental performance based on LCA information in accordance with ISO 14024 should be selected Verification: Bidders must provide a list of all: a) the Eco-labelled products used in the building, including their name, the name of their manufacturer and the	Use of construction materials complying with certain environmental criteria At least 60-80% of construction materials used in the construction or major renovation of high environmental performance buildings should comply with at least one of the following criteria: 1) Eco-labelled products (labels Type I or Type III in accordance to ISO 14024 or ISO 14025 respectively) shall be selected. 2) If point 1 is not possible, materials that provide a clear and transparent information on the product environmental performance based on LCA information in accordance with ISO 14024 should be selected Verification: Bidders must provide a list of all: a) the Eco-labelled products used in the building, including their name, the name of their manufacturer and the

Eco-label they have been awarded with, as well as a description of their common function at building level (i.e. description of the product category). Moreover, the applicant shall provide copies of certificates corresponding to the Eco-labels awarded for all of these products. b) The LCA assessment of the materials along with the name of the manufacturer and the description of the function shall be provided	Eco-label they have been awarded with, as well as a description of their common function at building level (i.e. description of the product category). Moreover, the applicant shall provide copies of certificates corresponding to the Eco-labels awarded for all of these products. b) The LCA assessment of the materials along with the name of the manufacturer and the description of the function shall be provided
	Use of construction recycled and reused materials The preparation for re-use, recycling and other material recovery, including backfilling operations using waste to substitute other materials, of non-hazardous construction and demolition waste excluding naturally occurring material defined in category 17 05 04 in the list of waste of the Directive 2008/98/EC on waste shall be increased to a minimum of > 80% by weight. Verification: Bidders must provide a detailed description of the methodology to calculate the estimated material recovery potential of the demolition waste, once the building completes its service life. Material recovery potentials should not be hypothetical but based on existing technologies, economic viability and applicable industry standards. In the description bidders must: ● Identify the potentially recyclable or reusable materials ● Explain how these materials could be identified and collected during the demolition processes ● Foresee which will be the most probable and appropriate recycling process Finally, bidders must calculate the percentage in weight that the recovered materials represent in relation to the total amount of materials and products used in the building.
	Use of building materials with recycled and reused content At least 30-50% in cost of the building components installed in the building, will be formed by products containing at least 20% recycled or reused materials. Verification: Bidders must provide a list of all the products used in the building which contain recycled materials, including their name, the name of their manufacturer and the percentage and origins of the recycled content, as well as a description of their common

	function at building level (i.e. description of the product category). Moreover, bidders must provide copies of the certificates or declarations corresponding to the recycled content of products.
Responsible sourcing of wood and wood-based materials At least 60-80% of the wood and wood-based materials shall be responsibly sourced materials. Verification: Certification schemes that can certify this requirement such as FSC, PEFC, or any equivalent means of proof (accepted by the respective competent body).	Responsible sourcing of wood and wood-based materials At least 60-80% of the wood and wood-based materials shall be responsibly sourced materials. Verification: Certification schemes that can certify this requirement such as FSC, PEFC, or any equivalent means of proof (accepted by the respective competent body).

Table 2 EU GPP criteria regarding building materials (European Commission, 2011)

4.4.2 ECO-LABEL CRITERIA

Eco-labels are one of the most important tools used by EC to implement GPP - to develop specifications or criteria and to check products and services for compliance with those criteria ("Eco-labels," n.d.). The eco-label program covers a wide range of product categories with the intention to minimize the negative environmental impacts of products through their whole life cycle. Due to different characteristics of each product group, different eco-label criteria are tailored for each of them and they are revised every four years on average to keep up with the latest technical innovations ("Product groups and criteria," n.d.). As for floor covering products, the eco-label program classifies them into three categories: wooden floor coverings, hard floor coverings, and textile floor coverings. For each category, there is a set of tailored eco-label criteria specifying requirements that need to be met during each stage of the production process, including raw material selection & extraction, production process, waste management, emission during in-use phase, fitness for use, packaging, consumer information, and eco-label information. Only products comply with all the requirements can be certified with eco-labels. More detailed information about the floor covering eco-label criteria is provided in Appendix A.

4.5 BENEFITS OF IMPLEMENTING GPP

GPP policy has a list of positive impacts including environmental, economical, and political benefits. Study reveals significant reduction in the greenhouse gas emission after the adoption of GPP policy in seven European countries during the year between 2006 and 2007 for ten groups analyzed, namely Austria, Denmark, Finland, Germany, Great Britain, the Netherlands and Sweden (Testa et al., 2014). The Vienna city, for example, saved over 100,000 tons of CO₂ between 2004 and 2007 through its EcoBuy

Programme (City of Vienna, 2008). Some studies even predict that if the GPP policy can be widely adopted, huge amount of money and CO₂ will be saved. For example, according to the European Commission, 3 million tons of CO₂ saving and 10% reduction of energy consumption in public sector will be achieved in Netherlands alone if all Dutch public authorities apply GPP criteria in their procurement activities ("Benefits of GPP," 2015). If the central government of United Kingdom adopts the GPP policy, 40.7 million pounds (£47.2 million) will be saved, according to a cost-benefit analysis which monetizes all of the potential impacts (Department for Environment Food and Rural Affairs, 2010). Moreover, the GPP policy have positive impacts on deforestation as wood products are required to be sourced from legally harvested and sustainably managed forests. By choosing greener products, efficiency can be achieved in water, resource and energy use as well as reduction in pollution because of limitations of use of chemical and hazardous substances ("Benefits of GPP," 2015).

Apart from all these environmental benefits, the GPP policy brings social and economic benefits as well. From the social benefits point of view, the GPP policy improves the quality of people's life by delivering cleaner products and setting higher environmental performance standards for products and services. As for the economic benefits, the GPP policy gives industries a real incentive to innovate green technologies and products, and it also provides opportunities for SMEs to market their innovative solutions and products. Moreover, the adoption of the GPP policy could attract new entrants to the green market which could increase the competition and lead to reduction in the prices of green products ("Benefits of GPP," n.d.). Last but not least, the GPP policy can, actually, save money and resources for public authorities as well as the society if they start to purchase and use, for example, energy-efficient products ("Benefits of GPP," 2015).

4.6 BARRIERS OF IMPLEMENTING GPP

To date, the advantages of applying the GPP policy to public procurement activities is becoming obvious, yet there still exist many challenges in the implementation process. The first challenge would be lack of political support, or more precisely, lack of management support. Reasons may be high level management personnel do not have a high awareness of the importance of applying the GPP policy or their high attention to the GPP policy is not detected by the lower level procurement staff for one, and operational guideline and training regarding the GPP policy is lacking for two (Testa et al., 2012). The second barrier is that the GPP policy is considered to be more costly comparing to conventional procurement. Indeed, if only considers purchasing price when choosing between conventional products and green products, green products tend to have higher initial prices, thus appearing to be less desirable. However, if considers

the whole life-cycle of products, green products tend to be less costly because of energy saving, less operation, maintenance, and disposal costs. Actually, the GPP policy has positive impacts on cutting the overall cost of organization purchasing in general (PwC Sustainability, 2009). Moreover, the lack of information about the real environmental impacts of building products and the lack of legal expertise to apply the environmental criteria make it hard for purchasing staff to identify green products during procurement. There are only limited established environmental criteria for products and services, and public authorities have difficulties to access clear criteria to combine the environmental performance with their tenders. Besides, challenges like shortage of qualified green product suppliers and the lack of cooperation between authorities also make the implementation of the GPP policy a rough task ("Benefits of GPP," 2015; Testa et al., 2012).

4.7 CURRENT LEVEL OF GPP IMPLEMENTATION

Currently, according to a recent OECD study, 24 out of 34 OECD (Organization for Economic Co-operation and Development) countries have introduced environmental requirements into technical specifications during public procurement, while 18 countries have applied them as award criteria. Standard definition of GPP has been developed in more than half of the OECD countries, yet only six of them have officially defined GPP in the law, namely Denmark, France, Italy, Japan, Luxembourg and Slovenia (Uttam et al., 2013). As for using the GPP policy as an incentive to stimulate innovation, there are no explicit principles can be used as guidelines in the policy documents, though possibilities are provided by the European public procurement rules. However, in practice, most of the contracting authorities lack the knowledge and experiences to explore these possibilities. Thus, the effect of the GPP policy on green innovation stimulation still remains unclear.

Netherlands adopts the code of practice of GPP. The Dutch central government set ambitious goal to achieve 100% of green procurement by the year of 2010. Under this guidance, municipalities and provinces set their targets at 75% and 50% of GPP implementation respectively in 2010 and 100% by the end of 2015 (NL Agency, 2010). According to a report published in June 2011, all of the targets set by Dutch public authorities have been met that 99.8% of sustainable procurement has been achieved at national level, 96% at province level, and 86-90% at municipality level ("Taking stock of green public procurement in Europe," 2011). Therefore, Netherlands is classified as one of the frontrunners in the implementation of the GPP policy along with 14 other countries by UNEP in one of its global review reports. However, when talking about green innovation stimulation, Netherlands is not considered as one of the leading

countries (UNEP, 2013). The GPP policy is supposed to be a real incentive for manufacturers to innovate green, yet, the question of how to combine the requirements of the GPP policy with the product development still remains challenging in practice. Besides, the Dutch public procurement system is highly decentralized, and the lack of a single national agency to coordinate the public procurement in national level may also stand as one of the barriers on green innovation stimulation (*Netherlands major responsible institution for procurement on the national level*, 2010; UNEP, 2013).

4.8 CONCLUSION

The significant purchasing power of public authorities makes them major consumers in many industries, which gives them the power to influence the market to their favorable directions. To realize sustainability, public authorities issued the GPP policy to motivate green purchasing and green innovation. Similar to other industries, the GPP policy is a signal, an opportunity as well as a challenge for manufacturers in construction industry, since good combinations of the GPP requirements with product attributes open the window of doing business with public authorities.

The EU GPP criteria of building products are the main evaluation references used in this research. The EU GPP criteria consist of core criteria and comprehensive criteria. The core criteria are the minimum criteria, and any supplier who complies with them is in theory qualified to participate in public tenders. The main idea of core criteria is that manufacturers who want to participate in public tenders should either provide LCA assessment reports for their green products or wear eco-labels. These two choices are also the main implementation tools for public authorities to exercise the GPP policy in practice, and they both evaluate the environmental performance of products through their whole life cycle. Thus, for manufacturers who plan to develop their green products and do business with public authorities should try to make comprehensive improvements on the environmental performance of their life cycle instead of focusing on one or two attributes. The comprehensive criteria are built on the core criteria but have more requirements. In theory, potential tenders who comply with the comprehensive criteria should get more credits in competition, yet the results of public tenders are also affected by many other factors, such as price, service, etc.

No matter what, the GPP policy is a voluntary policy instead of a mandatory one, thus public authorities are usually considered to be responsible for motivating manufacturers to comply with it. As a result, most of the researches on the implementation of the GPP policy take the angle from the public authorities to elaborate on how to increase the implementation rate. Certainly, public authorities can use its political resources and

identity as clients to stimulate the implementation of the GPP policy. However, there also exist many other actors in public procurement process who have influence on the actual results of the GPP policy implementation, such as contractors and manufacturers. Therefore, when considering the implementation of the GPP policy, angles from other relevant actors can also be taken instead of thinking them as purely passive participants.

5 PROPOSITION DEVELOPMENT

The literature review provides some information about the background and relevant information of this study. Most of the existing GPP related literatures emphasizes on issues such as importance of GPP application, obstacles that hinder the uptake the GPP, policy implementation tools, and the impacts of public authorities and procurement staff (Testa et al., 2014). Limited literatures focus on the green innovation stimulation effect of GPP policy and take the angle from manufacturers of building products to research on the GPP implementation as they are often seen as passive-participation partners. Besides, GPP criteria are usually composed of minimum requirements and award criteria, which give spaces for manufacturers to choose to what degree they are willing to comply with GPP criteria. These facts make it meaningful and interesting to study factors that influence the choice of manufacturers about green product development, both enablers and barriers, and how GPP influence those factors and ultimately influence their product strategies. Before interviews, several propositions about the enablers and barriers are developed based on literature of green innovation and product development. Both the enablers and barriers can be further divided into external and internal factors.

5.1 ENABLERS

External factors

External factors that stimulate companies to go green are pressures or requirements coming from outside companies, and they may not necessarily benefit companies. The first enabler that pushes companies to green their products is the need to comply with regulations (Dangelico & Pujari, 2010). This could also be one of the essential reasons for supplier of building products to develop greener products. The GPP criteria set the minimum requirements about building products, and any company that wants to win public tenders should at least meet those requirements.

The second enabler is the need to meet the market expectation. The social and environmental expectations of stakeholders have changed the market. Companies are expected to develop green products to attract, satisfy, and retain customers (Dangelico & Pujari, 2010). Besides, the size of green market is growing and it will get bigger and bigger in the future, which makes it a cannot-miss opportunity for companies to develop new markets (Dangelico & Pujari, 2010).

Internal factors

Internal factors for companies to go green are those that originate from companies themselves and meet the needs of companies' development. There are three main internal enablers. First of all, companies adopt greener product strategies because of their ecological responsibility (Dangelico & Pujari, 2010). For example, companies use renewable energy or recycled materials to promote their environmental concepts. Usually, the ecological responsibility in new product development is derived from environmental orientation of companies with the potential market success (Dangelico & Pujari, 2010). Take a step further, sometimes it is the personal commitment of the top management which later spreads in the entire company from top to bottom (Dangelico & Pujari, 2010).

The second internal factor is the goal to enhance the competitiveness of their products and the image of their companies (Dangelico & Pujari, 2010). In recent years, an increasing number of consumers have realized the impact of their purchasing behaviors on ecological problems, and they tackle this situation by considering more about environmental issues when purchasing, such as preferences for eco-packaging or purchasing ecologically compatible products only (Laroche, Bergeron, & Barbaro-Forleo, 2001). Besides, evidence shows that some consumers are willing to pay more for greener products, and the number is still growing (Laroche et al., 2001). Thus, it is a competitive advantage for products to be labeled as green. Meanwhile, green products also help companies to build an environmental friendly image and reputation which can bring intangible benefits in the long run.

The third factor considers the sustainable development of the company (Wanke weekly, 2014). There are many uncertainties in the future regarding the development of the company, but the green trend is certainly happening and growing. The green trend is not decided by governments or companies. Instead, it happens because the planet cannot support the high rate of resource consumption and waste generation any more. Companies need to go green if they do not want to get obsolete in the future (Wanke weekly, 2014).

5.2 BARRIERS

External factors

The first factor that blocks companies from going green is the difficulty of selling green products at competitive prices (Dangelico & Pujari, 2010). Comparing to conventional products, green products usually require heavier initial investments because of the

involvement of new technologies or more expensive raw materials. As a result, green products tend to have higher initial prices which increase the difficulty for them to compete with conventional products both in the market and in public tenders in which economic factors have significant swaying power (UNEP, 2014). Besides, the lack of customers' awareness of the benefits of green products can also be a contributor to this barrier. The economic and environmental benefits of green products usually happen in the long run, and without seeing that, customers can be unwilling to pay higher prices for those greener designs (Dangelico & Pujari, 2010).

Subsidies are financial aids used by public authorities to promote economic, social, or environmental policies, for example, supporting companies to develop green technologies or products in this case. Sometimes, government subsidies can be an actual incentive for companies to follow the green path, and some new green ventures and companies are even founded on government subsidies (Dangelico & Pujari, 2010). Even for large companies, government subsidies can be a source of financial investment. Therefore, the loss of government subsidies could be one of the factors which concerns companies when they consider developing green products.

The stringent and various public scrutiny of verifying the green nature of sustainable products can be another obstacle for companies to go green (Dangelico & Pujari, 2010). To market a product as a green product, companies need proof to convince their customers, which makes the existence of various green certificates meaningful. However, it is both time and energy consuming for companies to complete the scrutiny, and some companies may find this situation uncomfortable to deal with.

Internal factors

The two main internal reasons which block companies to go green are high cost and the need for extra knowledge and expertise. Although green products provide lower overall costs to consumers and society, their initial developing costs tend to be much higher than conventional products (Dangelico & Pujari, 2010). These costs can come from the adoption of new production procedures, new equipment, and new raw materials. These costs also cover the training fee of employees to get extra environmental protection related knowledge as well as environmental policies and regulations, which poses the second concern. With greener product design, employees need to gain extra expertise and knowledge (UNEP, 2014). Other than environmental protection related knowledge and policies, employees also need to master environmental performance assessment tools and corresponding marketing skills.

5.3 CONCEPTUAL MODEL

Based on the literature review and propositions proposed, a conceptual model of this research is developed, as shown in Figure 6. As described in the literature review, the poor environmental performance of the construction industry requires a green revolution in this sector to realize the balance between economy and environment, thus resulting in the concept of green buildings. To actually materialize the green building concept, green building products, being the foundation and essential elements, need to be available first, and in this case, the green flooring products are under discussion. The availability of green building products, however, depends on the manufacturers' actions. Therefore, given the significant influence of public procurement, public authorities issued the GPP policy to stimulate manufacturers of building products to develop green products. Under this situation, manufacturers of flooring products are facing two options: developing green products or sticking to the current product designs. For each option, there are various factors to support it, and the final decisions are actually the results of all these factors. In this research, five enablers are proposed to support the development of green products as well as five barriers are proposed to against it. With consideration and trade-off of all these factors, manufacturers can reach their final decisions about product development strategies. This research aims at clarifying some of the concerns that manufacturers may have during the decision making process and providing some insights of how frontrunners dealt with those concerns. Furthermore, this research also focuses on finding out the green product attributes most valued by frontrunners and how can other manufacturers learn from it and develop their own green products with attributes that are in compliance with GPP policy.

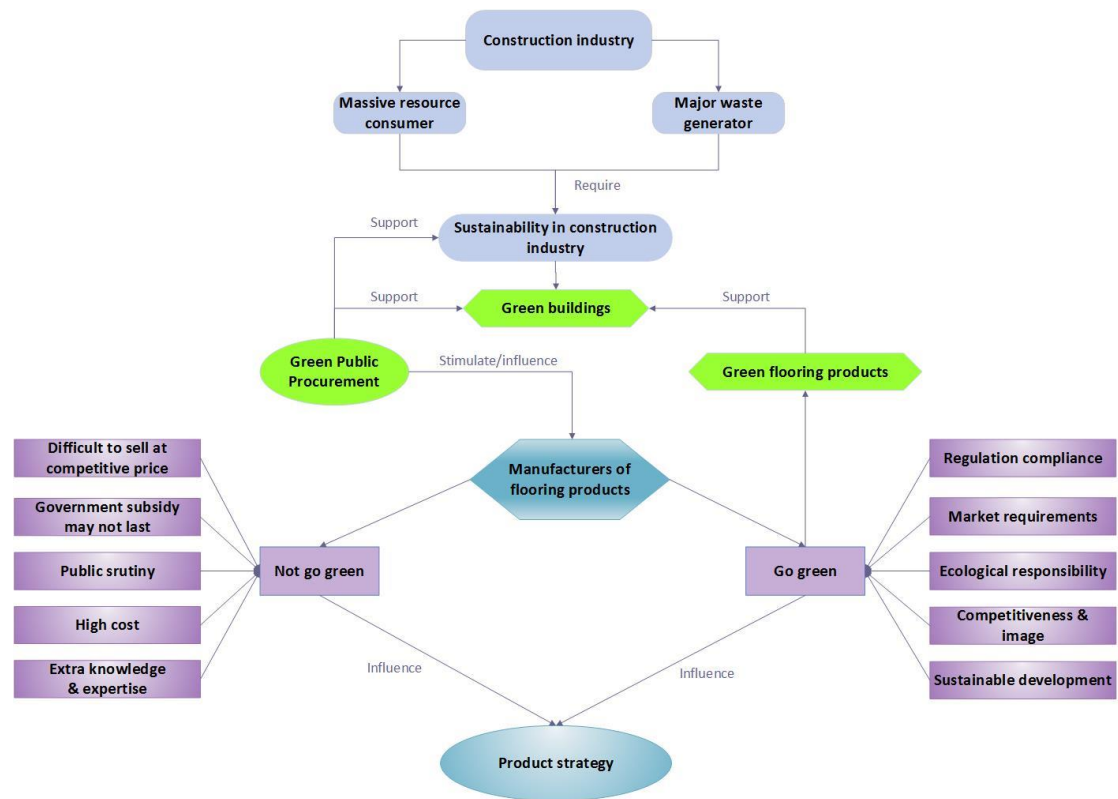


Figure 6 Conceptual model

PART TWO:

CASE STUDY

6 INTRODUCTION FOR PART TWO

After literature reviews, the second part of this research is about case studies. Two chapters, chapter 7 and 8, are included in this part. Chapter 7 first describes the research design of the case studies. Three frontrunners in the flooring industry who provide green flooring products are chosen for this research according to two basic selection criteria. The data collection method chosen for the case studies is interview, and the question list is outlined in this chapter to provide a clear overview of the structure of the interview. The results of these interviews are documented in this chapter case by case, and the interview notes can be found in Appendix B.

Chapter 8 is data analysis about the interview results. The whole analysis and comparison is divided into five categories: green certificates, green attributes, enablers for innovating green, barriers for innovating green, and GPP influence. Through comparisons in each category, patterns and differences of the green product development experiences among the three companies can be detected. Moreover, the analysis also establishes a more clear foundation for further developing conclusions and recommendations.

7 CASE STUDIES

Case study is applied in this research to find out the enablers and barriers that frontrunner manufacturers of flooring products encountered when considering producing green products and the influence of GPP policy on these factors. Due to the limitation of existing literatures, this research is exploratory in nature which makes case study suit this research well, since it usually provides in-depth information about specific research subjects.

In this part of the study, the last two research questions will be addressed:

- What are the enablers and barriers during the development of green products? How are these factors influenced by the GPP policy?
- Given the enablers and barriers, how can manufacturers of building products adjust their product development strategies to meet the GPP criteria? What green attributes should be emphasized on during the green product development process?

7.1 RESEARCH DESIGN

7.1.1 CASE SELECTION

The ultimate goal of this case study is to make recommendations to manufacturers of flooring products on how to start their own green product development projects, especially on what factors and green product attributes they should take into consideration during the process. To achieve this goal, this research is designed to use the successful examples of frontrunners to establish the foundation for recommendation. Frontrunners who have successfully marketed their green products have firsthand knowledge of the enablers and barriers of the development of green products as well as some highly valued green product attributes. Under these considerations, three companies are chosen for the case studies, namely Mosa, Desso, and Interface. Two main criteria are applied in the selection process:

- The first selection criterion is the market areas of the company. This study aims to connect EU GPP policy with product development strategies of the company, thus the candidate company shall at least operate in EU wide (or even globally) and have experiences in public tenders.
- The candidate company shall have certain achievements in the field of green product development. The definition of achievement is subjective to some degree,

and the criteria for that used in this case study are certificates, awards, and reputation in the industry.

Mosa is a Dutch tile manufacturer with 130 years of history which sells products to four continents ("About Mosa," n.d.). Mosa tiles are used both in private homes and public buildings, such as schools, banks, train stations, and office buildings, etc. One of the newly finished projects is the tile supply to the new Delft train station which opened in February 2015 ("Station with pillars in delft blue," n.d.). Mosa applies the cradle to cradle theory to its product designs and production activities and gets its entire tile collection certified as Cradle to Cradle® Silver ("About Mosa," n.d.).

Desso is a global carpet tile manufacturer which operates in over 100 countries (Desso, 2014). Desso carpets can be found in offices, banks, public buildings and universities, etc. Its customers include both business companies and public authorities, for example, Dutch Ministry of Safety & Justice. In terms of sustainability and green products, Desso follows cradle to cradle philosophy. In 2010, Desso managed to get its carpet backing certified as Cradle to Cradle® Silver and 97% of its raw materials evaluated as Green (optimal) and Yellow (tolerable) according to Cradle to Cradle® evaluation (Desso, 2014).

Interface is one of the largest modal carpet tile manufacturers in the world and well known for its leading position in green flooring product development. Interface started green product development back in 1990's and has established relatively complement system to implement sustainability to product designs, production activities, customer services, and business models. Interface bears various design awards, eco-awards, and green certificates. Moreover, Interface works closely with both business companies and public authorities, such as Ministry of Foreign Affairs and municipalities ("European case studies," n.d.).

7.1.2 DATA COLLECTION

Among many other data collection methods, interview is chosen for this study as it is appropriate for exploratory researches. The main idea is to interview respondents to get information on issues of interest (Sekaran, 2006). Because it is already known what kind of information is needed, structured interview is preferred in this study, which means a question list should be developed before the interview.

Moreover, this structured interview will be conducted in face-to-face setting because of the advantages it brings with. Face-to-face setting enables the interviewer to adapt the prepared questions if needed to, clarify interviewees' doubts to make sure they understand the questions properly, and pick up nonverbal information from

respondents. Certainly, face-to-face interview has its drawbacks, such as geographical limitation, interviewer's bias, and the fact that sometimes interviewees might feel uneasy in this specific setting (Sekaran, 2006). Nevertheless, these drawbacks do not make big obstacles in this case. The research subjects chosen for this case study are all flooring product manufacturers with offices in Netherlands, and the number of respondents is not large, thus the disadvantage of geographic limitation is controllable. Meanwhile, disadvantages regarding interviewer's bias and interviewees feeling uneasy in the face-to-face setting can be reduced by well-prepared question list and good communication before and through the interview process.

To conduct the interview, the first step is to go through the website contents of targeted manufacturers to collect relevant information. Based on collected information, research objectives and questions, the second step is to develop interview question list. Questions like what factors make them want to develop green products and what risks they have to bear should be included. The third step is to choose respondents. The potential respondents of floor covering manufacturers should have good knowledge of product attributes, both market and contractors' preferences, and have influence on product strategy development. Hence, managers from marketing department and production department are targeted. The following steps are arranging the interviews, collecting data, and analyzing data.

These interviews are supposed to give an overview of the current GPP implementation situation in the chosen companies, including enablers and barriers they have encountered during the process. Besides, how these factors have influence on manufacturers' choice on product strategy development and how they are affected by GPP policy should also be identified.

7.1.3 INTERVIEW DESIGN

The whole interview consists of 11 questions in total to address the questions of availability and proof of green products, green attributes, enablers and barriers of developing green products, GPP compliance, and future plans. Because of the exploratory nature of this research, 7 questions are open questions.

The interview is started with two closed questions and one open question:

- Does your company currently offer green floor covering products? What are they?
- What is the turnover of your company for green products comparing to that for conventional products?
- To what extent do public and private sector organizations demand for green products?

These open questions aim at warming up the interviewees for the later questions. The first question is designed to address both the type and proof of green products, and the second one aims at finding out the proportion of green products in each candidate company. The third question is an open question to give a general impression of the demand performance of both public and private sector, and more importantly, whether public sector outweighs private sector in green product procurement.

After the three warming-up questions, there follows another open question:

- Why do you believe your products are green products? What are the environmental performance improvements of these green products over conventional products?

This question is designed to address the specific green attributes of their sustainable products. Interviewees are expected to give specific numbers to prove the improvements of their products. For example, the new green products contain 50% of recycled materials and have realized 15% of reduction in energy consumption.

Two open questions are designed to find out the enablers and barriers frontrunners encountered during the development process:

- What factors make your company decided to develop green products? (to address enablers)
- What kinds of risks did your company consider during the decision making process? (to address barriers)

During the interview, interviewees are expected to not only provide the enablers and barriers they encountered but also the solutions they used to tackle the barriers. Besides, the current states of the original enablers and barriers are also expected to be provided in these two questions.

After identifying the enablers and barriers, the following two questions are designed to find out the influence of GPP policy on these factors:

- What do you know about Green Public Procurement policy?
- Does this policy have influence on your decision about developing green products? (Does it change your decision about developing green products?) What factor has been changed by it? (changes of enablers or barriers)

Before the case studies, five enablers and five barriers of the green product development process are proposed. The following closed question asks interviewees to rank the influence of these enablers and barriers according to their experiences. The ranking

results of this question are supposed to provide some complements to the enablers and barriers interviewees provided in former questions.

- There is a list of enablers and barriers developed from existing literatures, please prioritize them according to your experience. (Please use 12345 to mark them. 1 stands for most important and 5 stands for least influential. If you have other enablers or barriers, please add them into the list.)

Enablers (drivers for you to go green):	Barriers:
● Regulation compliance ● Market requirements ● Ecological responsibility (your company want to achieve ecological goal) ● Competitiveness & image ● Sustainable development (sustainable development is the trend that your company could get obsolete if not following)	● Difficult to sell at competitive prices ● Government subsidy may not last ● Stringent public scrutiny to verify green products ● Development cost ● Extra knowledge & expertise needed

After identifying enablers, barriers, and the influence of GPP on those factors, the following closed question is designed to provide a general impression about the GPP compliance level of the interviewee companies:

- The EU GPP criteria require 60-80% of building products used in public construction projects to be either eco-labeled or assessed by LCA method to provide clear information about the environmental performance. Besides, the comprehensive criteria require more than 80% of the building product materials to be recycled or reuse possible. 30-50% of building products used should contain at least 20% of recycled materials. If the products are wooden based, at least 60-80% of the wood and wood-based materials shall be responsibly sourced materials (Certification schemes that can certify this requirement such as FSC, PEFC, or any equivalent means of proof). To what degree do your products comply with these requirements?

The interview is ended with an open question regarding the future plans of interviewee companies:

- What does your company plan to do in the future to improve the environmental performance of your products? (The key environmental performance indicator that needs to be improved)

With the knowledge of what improvements they have done, this question provides information about development direction of the interviewee companies as well as some indications about the green product attributes that they highly valued.

7.2 CASE STUDY RESULTS

7.2.1 CASE ONE: MOSA

Introduction

Mosa is a Dutch tile manufacturer with 130 years of history which constantly proposes distinctive tile concepts for walls, floors, facades and terraces. 6 million square meters of tiles are sold by Mosa to 30 countries annually ("About Mosa," n.d.). Apart from its attention on aesthetic design and high-level quality, Mosa wants to contribute to the construction industry for both today and tomorrow by pursuing sustainable development during design and production processes. It is believed by Mosa that the buildings in the future will only use green building materials which are not only accounted for design and quality but also safety to residents during in-use phase ("Sustainability," n.d.). This belief has been driving Mosa into putting sustainability as core value when developing new products, which makes Mosa the first tile company in the world that are able to certify its entire tile collection for Cradle to Cradle® Silver ("Cradle to Cradle®," n.d.). Other than that, Mosa has also achieved its ISO 14001 certificate, EPD, Dubokeur and its entry in the National Environmental Database.

EPD is short for Environmental Product Declaration, and it is an independently verified and registered report that uses LCA method to measure the environmental impacts of products through their whole life cycle ("Why EPDs?," n.d.). It is currently written down in the new European standard project named "Sustainability of buildings", and can be used as proof of environmental claims in public tenders ("Why EPDs?," n.d.). Dubokeur, however, is a product label published by Dutch Institute for Building Biology and Ecology (NIBE). It also uses LCA to evaluate the environmental performance of products and expresses negative impacts in a single number, namely the shadow cost. Products are compared with other alternative applicants within the same product group, such as ceramic tiles or natural stone in general, and the best one gets wearing the Dubokeur ("Sustainability," n.d.).

The interviewee in this case study is the manager of the Sustainable Department: Dorien van der Weele. The Sustainable Department of Mosa is established to specifically deal with green product and sustainability related issues, thus the interviewee, being the manager of this department, should have good answers for the interview questions.

Availability of green products

The whole collection of Mosa floor tiles are claimed to be green. Mosa applies the cradle to cradle principle throughout the whole design and production process, including raw material selection, energy use, water management, recycling, and social aspects. Moreover, all Mosa tile products have externally validated LCA results to support their green nature, and those results are published on EPD (Environmental Product Declaration) and MRPI (Environmentally Relevant Product Information) websites.

Comparing to conventional tiles, Mosa tiles are improved in many aspects:

- 1) Raw materials: The traditional ceramic tiles contain certain toxic components (like lead, cadmium, and mercury) in the glazes and pigments which only account for 2-5% of the total weight of the end products but contribute a lot to the final appearance of the tiles, which makes them important components in traditional tiles. For the sake for sustainability, Mosa excluded all these toxic components in their tile designs.
- 2) Energy & water management: For now, 30% of the energy used by Mosa is green energy, and they are still working on sourcing an alternative for natural gas ("Cradle to Cradle®," n.d.). Until then, Mosa is currently working on how to optimize the energy use and lower down the consumption, and they have reduced the CO₂ emission by 48% in past ten years ("Cradle to Cradle®," n.d.). As for water management, Mosa factories are using water in closed loops, which results in 60% less water requirement than before. The plan is to realize zero discharge of waste water to municipal sewers through reutilization and evaporation.
- 3) Recycling & waste management: Mosa dedicated a lot of effort to find out how to work in the optimal way. They manage to recycle most of their production waste now, and they are going achieve full recycle by the middle of this year. All the recycled wastes are brought back to the production processes. Besides, some secondary materials, for example the byproducts from stone industry, are also used in their production processes. On average, Mosa floor tiles contain 21% of recycled materials. Moreover, Mosa established their "Take Back" system in 2012 which aims at recycling and remanufacturing used tiles to helps reduce landfill wastes, yet this system only recycles Mosa tiles currently because of the strict criteria of the tile contents ("Sustainability," n.d.).

Actual enablers and barriers experienced by the company

When talking about the enablers and barriers which affected their decision making process, the interviewee claims that the most important driver that made Mosa decide to develop green products in the first place was the sustainable development concern

for the company. The management team believes that there will be no room in the market for non-sustainable building materials in the long run, and with the rise of customers' environmental awareness, green products will get more weight in the future market demand. Thus, it is better for Mosa to be among the first ones and pioneer than stick to the old way and get left behind. Besides, the green nature of sustainable products is a competitive advantage over conventional products and a selling point to customers. It is also a good way to build the environmental friendly image of a company which can benefit the company potentially. As a company which is located in the city center and in the middle of a residential neighborhood, it is important for Mosa to treat carefully with many emission limits, such as fine dust, noise, CO₂ and so on. Therefore, it is in the interest of Mosa to green their production activities as well as products to comply with or even go beyond the environmental regulations.

One of the major concerns that Mosa was worried about when first considering developing green products is that customers may perceive their products to be expensive. Most green products in the market are charging for higher prices because of higher initial investment, both in technology and raw materials. With this perception, some customer may exclude green products as option due to budget cause. Besides, Mosa also worried that customers may think green products as having lower functional performance than conventional products, which will decrease their trust in green products. Other factors, such as development cost and the need for extra knowledge and expertise, were considered as less important. Mosa believes employees will quickly be familiar with the green procedures after the first research and study, and this cost will be diminished as the production scale expands.

Ranking results of the hypothetical enablers and barriers

Regarding the hypothetical enablers and barriers proposed in this thesis, as shown in Table 3, Mosa gave their opinions by ranking them according to their actual influences. 1 stands for the most influential factor and 5 stands for the least.

Enablers	Conformity	Barriers	Conformity
Regulation compliance	5	Difficult to sell at competitive prices	1
Market requirements	3	Government subsidy may not last	Not applicable
Ecological responsibility (your company want to achieve ecological goal)	4	Public scrutiny to verify green products	4
Competitiveness &	2	Development cost	2

image			
Sustainable development (sustainable development is the trend that your company could get obsolete if not following)	1	Extra knowledge & expertise needed	3

Table 3 Mosa's perception of the conformity of propositions

As can be read from the table, the most influential enabler, according to Mosa, is their concern for the sustainable development of the company, which is also suggested by Mosa during open questions. Surprisingly, compliance with regulation is the least influential driver for Mosa. This sequencing shows that Mosa is more self-motivated than passively cooperated when talking about green product development. As for barriers, the most influential one is "difficult to sell at competitive prices" which is in align with the first barrier proposed by Mosa during open questions – customers may perceive green products to be expensive. According to Mosa, they do not obtain any government subsidy at all, so whether government subsidy lasts or not is irrelevant. Initial cost and the need for extra knowledge and expertise did existed, yet Mosa did not consider them as very influential barriers. As the production scale expands, the initial financial and knowledge investment will be diminished. Also, both development and knowledge cost were not considered as very high in the first place, which is also the reason why the prices of Mosa green tiles did not increase much. Last but not least, Mosa was so devoted to developing green tiles that they would not be scared off by stringent public scrutiny, thus they considered it to be the least influential barrier.

GPP influence

When Mosa got their first green tile certificate in 2010, Netherlands was developing guidelines for green procurement. For that reason, Mosa expected large demand from the public sector, yet it did not happen. This first disappointment made Mosa believe that the GPP policy would not benefit their company much, so they stopped putting GPP as one of the major concerns. Therefore, Mosa claims they have limited knowledge of the GPP policy. "The GPP policy does not have obvious influence on our decision, and we will just continue our development plans." said by the manager of Sustainable Department. Even though, Mosa also believes, if being well implemented, the GPP policy can increase the customer awareness of green products in both public and private sectors.

GPP criteria compliance and future development plan

1. *The EU GPP criteria require 60-80% of building products used in public construction projects to be either eco-labeled or assessed by LCA method to provide clear information about the environmental performance.*

Although Mosa green tiles do not obtain any eco-labels due to the variety reason, all of their tile products are evaluated using LCA method and manage to achieve cradle to cradle design.

2. *The comprehensive criteria require more than 80% of the building product materials to be recycled or reuse possible. 30-50% of building products used should contain at least 20% of recycled materials.*

All of Mosa tiles are recycle or reuse possible. As for actual containment of recycled materials in practice, the floor tiles contain 21% of the recycled contents on average, some even contain up to 45% of recycled materials.

For the future, Mosa will put most of their efforts on energy management. The energy consumption during the production process is huge because tiles need high temperature to make. Although Mosa expressed their willingness of switching to renewable energies, the quantity and quality of currently available renewable energies are not ideal. Therefore, the only thing Mosa can do now is to save energy by using them efficiently, and Mosa wishes to make some progresses on this matter.

7.2.2 CASE TWO: DESSO

Introduction

Desso is a global flooring company which specializes in carpets, carpet tiles and sport pitches. Desso is active in more than 100 countries and its products are widely used in corporate offices, education, healthcare, government, homes, hotels, cruise liners and airlines (Desso, 2014). With 80 years of professional experience in flooring industry, Desso reached 181 million euros of carpet turnover and 202 million euros of Group turnover in 2013 (Desso, 2014). Desso believes the importance of safe and healthy indoor environment to people, and based on that, they developed three pillars to guide their innovation strategies: creativity, functionality, and cradle to cradle design. Desso built its entire sustainable development program based on cradle to cradle philosophy and circular economy (Desso, 2014). The cradle to cradle philosophy sets five criteria for companies to achieve in order to be certified: material health, material reutilization, renewable energy & carbon management, water stewardship, and social fairness. Based on the performance compliance of products to these five criteria, there are five certification levels accordingly: basic, bronze, silver, gold, and platinum ("Get cradle to

cradle certified," n.d.). For now, Desso has managed to get most of its products certified from basic to gold as some products are more difficult to be greened than others, and they plan to achieve 100% of Cradle to Cradle® in 2020. Other than Cradle to Cradle® certificates, Desso also possesses EPD reports and GUT labels to verify the green nature of their products. The GUT label is short for "Gemeinschaft umweltfreundlicher Teppichboden" which means environmental friendly carpets in German. It is an institution founded by some leading European carpet manufacturers in order to continuously improve the environmental and customer protection aspects throughout the whole life cycle of textile flooring products ("GUT Carpets tested for a better living environment," n.d.).

The interviewee in this case study is the manager of Corporate Social Responsibility (CSR) Department: Nicole Schaffroth. The CSR Department has similar functionalities to the Sustainable Department of Mosa. Employees in this department do environmental performance analysis of their products and give suggestions to the company about how to practice sustainability in their daily production activities.

Availability of green products

Desso started to embrace the cradle to cradle philosophy in 2008, and they have made great progresses in this area. For now, Desso offers Cradle to Cradle® Silver certified carpets as well as some Cradle to Cradle® Bronze certified ones. In total, Desso managed to achieve Cradle to Cradle® certification for 90% of their carpet tiles. Desso emphasizes its goal to be greening of its whole company and all products, instead of having several niche green products on the market. With their sustainability road map, they plan to achieve 100% of Cradle to Cradle® in 2020.

Following strictly to cradle to cradle philosophy, Desso improved its products in five aspects:

- 1) **Raw material selection:** the foundation of achieving Cradle to Cradle® is the material health. Desso knows every material in their products down to very low limit (around 100 ppm). They believe that if the products are going to be recycled, then the materials need to be healthy and safe, otherwise the recycling would be an accumulation of toxic substances, which is not good for human health. To achieve that, they ask their raw material suppliers for lists of substances and later send it to EPEA (Environmental Protection Encouragement Agency) for evaluation. Only materials deemed to be qualified will be used to produce Desso carpets. Desso claims their products do not contain any known toxic substances, and they will

continue their plan to find out other substances that may be harmful for human health in the future.

- 2) Energy management: Desso uses renewable energy in production process according to cradle to cradle philosophy, mainly solar energy and wind energy. The use of renewable energy has reduced 50% of carbon footprint in these years. About energy saving, Desso speaks frankly that efficiency is not one of the requirements of cradle to cradle philosophy, thus it is not their priority concern, yet they still manage to save 2% of energy annually in response to the energy saving appeal of government.
- 3) Recycling & waste management: Desso recycles most of its factory wastes. Desso established a "Take Back" program for their products as a part of the recycling plan. Carpets are recycled using their innovative separation technique called Refinity®, which separates the yarn and other fibers from the backing. After an additional purification stage, the yarn (with the required purity) is returned to the yarn manufacturer for the production of new yarn, while other non-recyclable fractions will be used as secondary fuel in the cement industry. In more details, over 50% of Desso commercial carpets are made of ECONYL® yarn which is regenerated from nylon, and the new DESSO SoundMaster® carpet contains 80% of recycled materials (Desso, 2014).

Actual enablers and barriers experienced by the company

Desso is one of the frontrunners of pursuing sustainability in flooring industry. The opportunity came suddenly when the former CEO of Desso watching a documentary on TV about the cradle to cradle philosophy. He was so impressed by the concept that he decided to introduce it to his company. Therefore, after discussion, Desso started to research and implement the cradle to cradle philosophy within the whole company. Apart from the CEO's commitment, the decision of innovating green was also made due to marketing concerns. Green products can help building ecologically responsible image of the company, and it is also believed to be the representation of the future market demand. Besides, innovating green is also a method to increase the competitiveness of products, because the healthy and safe nature of green products can be appealing to customers who value life quality. Last but not least, from the economic perspective, Desso believes green products are profitable in the long run.

Other than all these motivations, Desso also possesses resources that are necessary for this green transitioning. First of all, Desso has employees who have related knowledge of cradle to cradle philosophy, which formed the in-house knowledge base of the implementation. Secondly, Desso has good partnership with their raw material suppliers

who are willing to cooperate and provide necessary knowledge and techniques to realize the program. Finally, Desso got government subsidies to finance the project.

However, when first decided to start the program, Desso also had many concerns. The redesign of the products usually brings doubts about quality, which may influence customers' perception and trust of these new products. Besides, redesign takes time, the uncertainties lie in the future increase the risk of failing in the new product development. Besides, there were also concerns about product prices. As the development cost is so high, the prices of the products will be increased accordingly. Although many customers claim they do not mind the higher prices in the market research, the initial market share of these new products was still small. Nevertheless, these barriers and concerns did not stop Desso from following the cradle to cradle path, and they actually make some achievements in this field now.

Ranking results of the hypothetical enablers and barriers

Desso also expressed their opinion about the hypothetical enablers and barriers proposed in this thesis by ranking them according to their actual influences, as can be seen from Table 4. 1 stands for the most influential factor and 5 stands for the least.

Enablers	Conformity	Barriers	Conformity
Regulation compliance	5	Difficult to sell at competitive prices	2
Market requirements	2	Government subsidy may not last	5
Ecological responsibility (your company want to achieve ecological goal)	3	Public scrutiny to verify green products	1
Competitiveness & image	1	Development cost	3
Sustainable development (sustainable development is the trend that your company could get obsolete if not following)	4	Extra knowledge & expertise needed	4

Table 4 Desso's perception of the conformity of propositions

As can be read from the table, Desso made their decision about innovating green mainly based on marketing concerns. The top two enablers that Desso think match most to the reality are competitiveness & image and market requirement. Desso believes the green

products are the future market demand, and they are profitable in long run. It is also a good way to advertise itself as an ecologically responsible company, which could increase customers' trust and loyalty. After that, there comes ecological responsibility and sustainable development concern of the company, and the least influential enabler is regulation compliance. As for barriers, Desso finds the public scrutiny is the most difficult barrier to deal with, basically because there are too many different evaluation systems to comply with and some criteria appear to be unreasonable to Desso. The second influential barrier comes from the fact that the development cost for new products increased the total production cost, thus selling at competitive prices is hard to achieve. The three less influential barriers are development cost, extra knowledge requirement, and government subsidy. As mentioned before, Desso has good relationships with raw material suppliers and government, which solves these three barriers to certain degree. Apart from all the proposed barriers, Desso finds the long life cycle of floor covering products a concern for them. The typical duration of carpets is 15 years, and this long life cycle makes it hard for Desso to calculate both the economical and environmental impacts, which increases the difficulty for them to make future product improvement plans.

GPP influence

Desso participated in many public construction projects, and there are many public authorities/government departments lie on their customer lists, such as Provincie Noord-Brabant, Rijkswaterstaat, and Belastingdienst. However, the interviewee claims to have limited knowledge of the GPP policy, "Usually our marketing people would come to us sustainability people for advice when come across with sustainability related issues in public tenders, but they have not done that yet." Therefore, obviously, Desso claims that GPP has little influence on their decision of innovating green. Nevertheless, the interviewee does believe the existence of GPP policy has positive effects on increasing customer awareness and motivating manufacturers to innovate green. Meanwhile, Desso is working on getting the Cradle to Cradle® certification into public procurement criteria with a working group, because they believe the government is not providing efficient and right criteria to distinguish them from other conventional manufacturers.

GPP criteria compliance and future development plan

1. *The EU GPP criteria require 60-80% of building products used in public construction projects to be either eco-labeled or assessed by LCA method to provide clear information about the environmental performance.*

Not all Desso products are assessed by LCA now, only around 50% of them are evaluated, but the number is still increasing as they are working on that.

2. *The comprehensive criteria require more than 80% of the building product materials to be recycled or reuse possible. 30-50% of building products used should contain at least 20% of recycled materials.*

Desso has achieved making 60% of their products recycled or reuse possible and 30% of them contain more than 20% of recycled materials.

As for future plans, Desso will continue following their roadmap to realize their ambitions, such as increasing the use of renewable energies, bringing certified products to higher levels, continuing detecting potential harmful substances in raw materials, etc. Desso do not have plans to apply for EU eco-labels in the near future since they already bear several certificates to prove the green nature of their products, and they prefer to follow their own philosophy in the green product development process.

7.2.3 CASE THREE: INTERFACE

Introduction

Interface began its life in 1973 when its founder, Ray Anderson saw the potential of flexible floor covering products in the modern office environment ("Where we have come from," n.d.). Because of the office building boom in 1970s, Interface achieved 11 million dollars in 1978 for the first time and went public in 1983 ("Where we have come from," n.d.). Through acquisitions, Interface has become a world leader in the field of modular carpet tiles. For now, Interface has production locations on four continents and offices in over 100 countries.

As a manufacturer of carpet tiles and one of the leaders in the field of sustainability, Interface bears many awards to prove its achievement, such as the European Business Awards for the Environment 2014-2015 (for its recycling of discarded fishing nets as raw materials), the Guardian Sustainable Business Award 2014 (for its excellence in carbon and energy management), MaterialPREIS 2013 (for Urban Retreat's strong design credentials and the integrated approach to sustainability) and so on ("Onze prijzen," n.d.). Meanwhile, Interface bears EPD reports, Dubokeur, GUT label to prove its environmental performance to customers. As mentioned before, EPD report contains lists of materials used in their products and the possible impacts to the environment at each stage of product life cycle ("Why EPDs?," n.d.), Dubokeur is awarded to the best environmentally performed product in the candidate product group, and GUT is a label for eco-friendly carpets.

The interviewee of this interview is the head of Sustainable Department of Interface: Geanne van Arkel. Similar to the other two companies, Interface also established their separate Sustainable Department to do analysis and evaluation of the environmental performance of their products and guide their green product development plans.

Availability of green products

Interface started to embrace sustainability in 1994, and it becomes more of a company mission than just a project after all these years. Interface believes that everything they do, no matter it is making a product, developing a process, or creating a new business model, should be aligned with this mission. Through years of effort, Interface claims all of their products are as sustainable as possible now, yet they will never deny that there is room for improvement. To provide full information about the environmental performance of their products, Interface chooses to disclose all related information through Environmental Product Declaration (EPD) system. Although the EPD is only a declaration of the environmental performance of products instead of comparative standards, customers can use it to make the comparison between products. Besides, Interface also focuses on how their products can contribute to green buildings, such as BREEAM and LEED. As for green labels, Interface thinks there are too many eco-labels on the market now and the different standards of them makes it time and energy consuming to fully fulfill. Therefore, Interface only bears limited number of labels, such as GUT and Dubokeur.

Specifically, Interface improved its products in the following aspects:

- 1) Raw material selection: Interface started program to phase out harmful materials and replace them with safer and healthier ones back to 1990's. For now, Interface claims no harmful contents, at least to their best knowledge, are contained in their products. Taking a step further, Interface is now focusing on using recycled or bio-based contents in their raw materials, and they have made some achievements on this matter. Globally, 49% of their raw materials are recycled or bio-based, and some products are even made 100% from recycled nylon yarn.
- 2) Energy & water management: Interface invested a lot to improve the efficiency of energy and water consumption during production process. They plan to achieve zero fossil energy consumption and zero negative impact to the environment by the end of 2020, and they name this plan Missio Zero. For now, interface has started to use renewable energy in their production processes, mainly the bio-gas made from fish wastes. Globally, they have achieved 40% of renewable energy use on average. Besides, to increase the water use efficiency, Interface adopted closed water loop

system in their factories. For example, the European factory in Scherpenzeel is now not only producing in closed water loop but also using renewable energies. As a result, the carbon footprint has been reduced by 90% comparing to the state in 1996.

- 3) Recycling & waste management: Interface uses recycled contents in its carpet tiles, and some of the products are even made 100% from recycle materials. To realize that and to reduce the amount of landfill wastes, Interface set up ReEntry® system to recycle as much end-of-life products as possible. As for now, 49% of the raw materials of Interface come from recycled or bio-based materials.
- 4) Social responsibility: Interface believes social aspects of sustainability should be valued equally in the development of green products. Therefore, Interface set up a website to named Humanspace to research on social aspects. Interface tries to fulfill its social responsibility through working with low skill labors. For example, Interface works with people from low skill labor market to clean old carpets, so these carpets can be given a second or even a third life. Interface is also working with fishermen in Philippine who collect fishing nets, and these fishing nets later can be made into carpet tiles again. Besides, interface develops new business models in which they provide more service to their clients than just selling products, such as helping them to create inspiring environment, advising them about maintenance, teaching them to reuse or clean old carpet tiles, etc.

Actual enablers and barriers experienced by the company

Back in 1990's, some clients of Interface who focused on green business asked Interface about their plan for environment protection and green products. Interface responded that they were following legislation, and this answer, however, is not satisfying to their clients. Later, the founder of Interface, Ray Anderson, found it is important and strategically wise to begin embracing sustainability, after reading a book about the potential great effects of the union of ecology and economy. Therefore, the sustainable development project was kicked off within Interface. It can be concluded that the initial enablers for Interface to go green is the result of both market demand and top-management commitment. As a matter of fact, the market demand was only a lead which triggered the sustainability thinking of Interface. It is the consideration about the future of the company that really enabled the transforming.

However, after years of practice, the interviewee also acknowledged that there are more benefits and motivation for them to continue this path. First of all, the green products are actually bringing them economic savings, in contrast to what people usually believe. Besides, it is a good driver of innovations for their production process and business

models. Thirdly, it stimulates the engagement of people both within and outside of the company, such as suppliers, clients, and other cooperators. Last but not least, sustainability commitment makes Interface turn into a healthier and more comfortable organization to work in.

As for worries, Interface admitted that some of their stakeholders expressed deeply concerns about the future of the company when they first brought this project up. The project plan is too ambitious and novel for stakeholders to put their faith in, and they doubted about the market response. However, there were still stakeholders shared the same vision of Interface that they were willing to invest in this project. Actually, some of their suppliers now find it was wise to participate in the project because they are now the leading suppliers of 100% recycled materials.

It is admitted that the initial development costs of these new products are high, and it was once a problem that needed to be handled. However, because of the investments received from stakeholders and government subsidies, Interface solved it successfully. For now, Interface claims that they are actually saving money through the sustainability project. The need for extra knowledge and expertise was also a barrier once. When Interface decided to go green, there were not many companies that were pursuing sustainability, which makes it hard for Interface to borrow experiences from successful examples or find partners who have good knowledge on the matter. Interface itself, however, did not obtain any employee with sustainability expertise either. Therefore, with no other means, Interface hired a team of sustainability experts to help them build the development plan in the end.

Ranking results of the hypothetical enablers and barriers

Regarding the hypothetical enablers and barriers proposed in this thesis, the ranking results of Interface are shown in Table 5. 1 stands for the most important factor and 5 represents the least.

Enablers	Conformity	Barriers	Conformity
Regulation compliance	5	Difficult to sell at competitive prices	4
Market requirements	3	Government subsidy may not last	5
Ecological responsibility (your company want to achieve ecological goal)	2	Public scrutiny to verify green products	3
Competitiveness &	4	Development cost	2

image			
Sustainable development (sustainable development is the trend that your company could get obsolete if not following)	1	Extra knowledge & expertise needed	1

Table 5 Interface's perception of the conformity of propositions

In consistent with the actually story, Interface considers the most influential enabler to be the sustainable concern for the company: the management team worried that the company would get obsolete in the future if they did not go green. Other than that, Interface also values their role in the ecological and social responsibility. The business concerns of this decision, market requirements, competitiveness and image concern are valued third and fourth influential factors. The regulation compliance is considered as least influential factor because Interface believed they fulfilled the legislation requirements already. The most influential barrier, according to Interface, is the need for extra knowledge and expertise. Given the time and situation when Interface decided to start the project, there was no explicit solution for their goals, which makes the development plan explorative in nature. The second influential barrier is the development cost which exists whenever a company wants to innovate, and the third and fourth influential barriers are considered to be public scrutiny and selling at competitive prices. Interface believes that even though new solutions tend to be followed by high investments, prices are not always the issue if the new solutions are valuable enough. Also, Interface claims that they have wide price range. Although they cannot offer the lowest price point in the market due to quality concern, they actually find their sustainable products are lower priced than old ones, because sustainable carpets tend to use fewer materials. Therefore, products with the least negative impact on the environment also have the lowest prices in their range. For example, the recycled nylon they are using is more expensive than conventional one, yet by using special method to mix with other materials, clients do not have to pay more in the end. Thus, Interface does not believe sustainable products should cost more. The last concern is government subsidy. As the project goes, it started to save money and finance itself, so the government subsidy does not matter much later.

GPP influence

Interface supplies their products to construction projects of schools, hotels, and office buildings for municipalities and ministries. Interface claims that they did receive requirements for green products in public tenders, though the requirements may not be

very explicit. Contracting authorities usually evaluate the total cost of products during the whole life cycle, so suppliers who provide products with reliable quality and sustainability get more credits. However, Interface also admits that there are many other factors that have influence on the tender awarding process, and price is always a strong factor.

Regarding the influence of GPP on their decision making about green product development, Interface considers it to be limited. It is simply because when Interface started to consider the potential of sustainability, the GPP policy was not developed yet. After the success Interface experienced on sustainable solutions, Interface will continue following this path no matter what. However, Interface also believes GPP policy is a good stimulus for industry innovation toward sustainability, and it helps improve the customer awareness of green products. Meanwhile, Interface also believes that the GPP policy should be more challenging instead of keeping at minimum level, and it should be more performance based and include carbon footprint into criteria.

GPP criteria compliance and future development plan

3. *The EU GPP criteria require 60-80% of building products used in public construction projects to be either eco-labeled or assessed by LCA method to provide clear information about the environmental performance.*

All of Interface products are assessed by LCA method, and they have EPD reports to verify on that. Also, the EPD reports are accessible for anyone who is interested in the environmental performance of their products, and all necessary information is included in reports.

4. *The comprehensive criteria require more than 80% of the building product materials to be recycled or reuse possible. 30-50% of building products used should contain at least 20% of recycled materials.*

For now, 85% of Interface products are recycled or reused possible, and globally, 49% of their raw Materials are recycled or bio-based on average.

As for the future, Interface will continue to work on realizing Mission Zero which aims at realizing fully sustainability by the end of 2020. Fully sustainability means they want to achieve the equilibrium in which their products and production process do not affect environment in negative way. Besides, Interface plans to continue improving the performance of their products through radical innovation and constantly improve all green attributes in the future.

8 DATA ANALYSIS

8.1 GREEN CERTIFICATES

To verify the green nature of their products, companies usually bear various green certificates, so do the three companies participated in this research. As can be read from Table 6, some similarities are shared by all three companies on choosing green certificates. Among all four certificates listed below, EPD is the only certificate possessed by all three companies. The reason why they all choose EPD may be that it is merely an information declaration report instead of a judgement standard. The EPD report does not offer any comparison between alternative products, yet it offers full information of the life-cycle environment impacts of products. This special nature of EPD makes it universal useful in different occasions.

Apart from the EPD reports, the cradle to cradle philosophy is also applied by all three companies, yet only Mosa and Desso possess the Cradle to Cradle® certificates. Mosa has its whole floor tiles collection certified as Cradle to Cradle® Silver, while Desso gets 90% of its products certified from Cradle to Cradle® Basic to Gold. Dubokeur is a Dutch green certificate which only awards the best product among the alternative applicants. Among the three companies, Mosa and Interface bear Dubokeur, while Desso claims that they did not apply for it because it is limited to Netherlands. As for the GUT label, it is a green certificate exclusively for carpets, and both Desso and Interface bear it.

When asked about intention to apply for more European or international eco-labels, only Mosa expressed their interests in more information. Neither Desso nor Interface has plans to apply for eco-labels in the near future, because they find it time consuming to fulfill all the different requirements of different eco-labels. Besides, the EU GPP criteria give manufacturers the option to choose from either being eco-labeled or LCA assessed. This option actually affects their interests in eco-labels to some degree. Since all three companies possess certificates to prove their products are LCA evaluated, they do not find it necessary or motivated to apply for eco-labels.

Green certificates	Mosa	Desso	Interface
EPD	✓	✓	✓
Cradle to Cradle®	100% Silver	90% Basic to Gold	
Dubokeur	✓		✓
GUT	Not applicable	✓	✓

Intention to apply for eco-labels	Interested	Not interested	Not interested
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Table 6 Green certificates

8.2 GREEN ATTRIBUTES

All three companies participated in this research offer green products. When talking about the improvements of these products over conventional products, the three companies share a lot in common, and all of the improvements they mentioned are listed down in Table 7.

Containing zero (known) toxic contents or keep them at fairly low levels in raw materials seems to be one of the base lines for green products. This cannot be surprising since safety is definitely one of the priorities for users and flooring products are one of the building products that have direct contact with users inside buildings. In addition, the purity of the raw materials affects the recyclability of the products. If toxic contents are contained in raw materials and products, then the recycling of these materials will be an accumulation of toxins which will do no good to either environment or human health. Thus, all three companies claim their products are toxin free and they are continuing the process of phasing out potential toxic contents.

Taking a step further, green products should not only contain no toxic contents but also contain certain degrees of recycled materials, and this is also one of the requirements written down in the comprehensive criteria of EU GPP policy. According to the criterion, 30-50% of building products used in public construction projects should contain more than 20% of recycled materials. Regarding this requirement, on average, Mosa floor tiles contain 21% of recycled contents, 30% of Desso products contain more than 20% of recycled contents, and Interface products contain 49% of recycled or bio-based materials. The advantage of Interface on this attribute is not only brought by their early commitment, but also their recycling plans on other materials (e.g. waste fishing nets from Philippine) apart from their own products. Nevertheless, these numbers only represent average levels, and each firm has products containing high percentage of recycled materials as well as low percentage ones, so it is up to the public authorities to choose which products they want to use.

Using renewable energy in the production process is another bullet point of green products in order to reduce the carbon footprint and address the problem of resource exhaustion. Both Desso and Interface use renewable energy in their production process. Desso mainly uses solar and wind energy, and Interface uses bio-gas. The bio-gas used by Interface is made from fish wastes which are connected to one of their recycling

plans in Philippine. Interface works with Philippine local fishermen on collecting waste fish nets as raw materials to make carpets and fish wastes to make bio-gas, and it is also considered as one of their policies to address the social aspect of sustainability. Different from the other two companies, Mosa is still searching for appropriate renewable energy to replace natural gas, and until then, Mosa will continue their energy saving plan. Mosa explains that ceramic tiles need very high temperature to make, which means the quality of the energy is crucial. Currently, Mosa finds it very hard to find a renewable energy available on the market that is both economic efficient and effective enough to provide the high temperature needed. Nevertheless, Mosa claims that they use 30% of green energy in their production process, yet they do not specify what kind of green energy exactly. Through their energy management plans, Mosa, Desso and Interface manage to save carbon footprint by 48%, 46%, and 90% respectively.

Regarding the water management, both Mosa and Interface claim they have realized using water in closed loop in some of their factories, and they are trying to increase the number of factories adopting this method. For example, one of the Interface facilities which is located in Scherpenzeel is operating 100% in closed water loop (zero fresh water consumption) and renewable energy (both electricity and gas) since January 2014. Although Desso does not specify whether they have adopted the closed-loop water system or not, they managed to increase the use of recycled water from 11% in 2008 to 20% in 2013 (Desso, 2014).

Recycling, no matter it is containing recycled contents in products or the recyclability of products, is one of the highlights of green products. All three companies value this green attribute highly, and they have set up take-back systems to recycle their products and put them into reuse or remanufacturing. The comprehensive GPP criteria require 80% of building products used in public construction project to be recycled or reused possible, and all three firms claim offering such products. Mosa, among all three of them, has the best performance on this attribute that their entire collection of floor tiles is recyclable, yet their take-back system only recycles their own products due to quality concern. Interface, however, has a lower percentage of recyclable products, 85%, yet their take-back system collects both their own products and other materials. Desso is a little left behind on this attribute, and only 60% of their products are recyclable. Similar situation happens when comparing the percentage of products that are LCA assessed. Both Mosa and Interface have all of their products assessed by LCA method (with the proof of EPD reports and Dubokeur), while Desso only manages to get 50% of their products assessed by LCA method currently.

Green attributes	Mosa	Desso	Interface
No toxic content in raw materials	✓	✓	✓
Containing recycled materials in products (on average)	21%	>20%	49%
Renewable energy	Not specified	Solar & wind energy	Bio-gas
Reduction in carbon footprint	48%	46%	90%
Water recycling in closed loop	✓	Not specified	✓
Take-back system	✓	✓	✓
Products are recycled or reused possible	100%	60%	85%
Products assessed by LCA method	100%	50%	100%

Table 7 Green attributes of sustainable products

8.3 ENABLERS FOR INNOVATING GREEN

When asked about what factors motivated them to go green, all three companies share similar stories. Table 8 shows both the enablers suggested by the interviewees (highlighted with orange color) and the propositions developed in this research.

The first enabler, top-management commitment, is mentioned both by Desso and Interface. After leaders of the company became aware of the issue, either through clients or documentations, they proposed plans of going green and pushed for them to pass. The top-management commitment is usually an important incentive for companies to make big changes, yet it also requires the top-management team to have proper and right visions about the future to enable successful changes. Therefore, to some degree, this enabler can be seen as a result of the top-management team's vision about the sustainable development or the ecological responsibility of the company. In this case, it is believed by the management teams of the participant companies that the green products represent the future demand trend and they will get obsolete if they do not follow, so it is better for them to be frontrunners than laggards.

Another enabler mentioned by the interviewees is the partnership between the focal company and raw material suppliers and lead clients. The value of the partnership with raw material suppliers in green product development mainly lies in the collaborations and assistances that happen during the process. One single company usually does not

possess all of the resources and knowledge needed to develop green products. At the minimum, the focal company will need purer and healthier raw materials to realize their greener product designs. If the desired materials are not currently available on the market, then the focal company will need the participation of their raw material suppliers to research together and develop the necessary materials. An example can be found in the experiences of Interface. Due to the early commitment, it was hard to find qualified suppliers on the market who provide necessary materials with both fair quality and prices. To solve that, some of the raw material suppliers decided to join in the collaborative researches with Interface to develop greener materials. Other than raw materials, suppliers can also provide the focal company with necessary information, knowledge and technologies that they lack of. The partnership with lead clients, different from that with raw material suppliers, can provide the focal company with novel solutions and ideas. Some lead clients are even willing to try out new products for companies and give feedbacks to help improve the performance of the products. Desso mentioned one example that one of their clients from public sector tried out one of their green carpets which are still in development, and it helped a lot for Desso to understand how the new products performed in practice. Therefore, stable and healthy partnership with suppliers and clients are considered to be essential for green product development.

The third enabler mentioned by the interviewees is the in-house knowledge base. Given the fact that sustainability has become one of the focal topics these years, more and more people possess related knowledge and expertise, which forms good basis for companies to conduct the green transitioning. Both Mosa and Desso benefited from the in-house knowledge base and did not consider the knowledge investment to be high. In contrast, due to the early commitment, Interface started the green product development plan without enough in-house knowledge base, which, according to them, largely increased their knowledge investment because they had to hire a team of sustainable experts to help them get through it.

Government subsidy is also mentioned as one of the enablers for green product development. Government subsidy is a kind of financial support given by the government to companies who have proper projects. In this case, only Desso and Interface claim they received subsidies during the development process while Mosa claims otherwise. Nevertheless, for companies with certain size, such as the three companies participated in this research, government subsidies only make up a small portion of the development cost, thus they have limited influence on their decision making process. For some small-sized companies, however, especially for some

start-ups which are built on subsidies, government subsidies have significant influence on the final decisions.

Before the case study, several hypothetical enablers are developed from literatures, and the interviewees are asked to rank the influence of these enablers according to their experiences. As can be read from the data, Mosa and Desso are more market committed than self-motivated, because they both ranked market related factors, competitiveness & image and market requirements, as top-three influential enablers. Both Mosa and Desso started the project in 2008. At that time, the theory of sustainability was relatively mature, and more and more people had realized the potential of green products and possess the knowledge and expertise to practice sustainability. It was also around the time when public authorities promoted sustainability more, such as making GPP policy to incorporate environmental regulations into public procurement activities. Thus, Mosa and Desso are more like frontrunners who saw the market signal than real pioneers. Naturally, they do not rank ecological responsibility very high, around 3 or 4. In contrast, Interface ranked the self-motivated factors, sustainable development concern of company and ecological responsibility, as top-two influential factors. This result is reasonable because, as introduced before, Interface started the project in 1990's when sustainability was still a relatively new and exploratory field for most companies, and they chose to be one of the pioneers in this field. What is common for three companies is that they all rank regulation compliance as the least influential enabler, and they all believe they have achieved far more than what environmental regulations require.

Enablers	Conformity to facts		
	Mosa	Desso	Interface
Top-management commitment		✓	✓
Partnership	✓	✓	✓
In-house knowledge base	✓	✓	
Government subsidy		✓	✓
Sustainable development concern for the company	1	4	1
Ecological responsibility of the company	4	3	2
Competiveness & image concern	2	1	4

Market requirement	3	2	3
Regulation compliance	5	5	5

Table 8 Enablers for green product development

8.4 BARRIERS FOR INNOVATING GREEN

As can be seen from Table 9, interviewees have relatively diffuse opinions about the barriers that may hinder or increase the difficulty of innovating green. The orange highlighted factors are suggested by interviewees, and the rest factors are propositions developed in this study.

Mosa mentions that the most worrying factor for them is that customers may perceive green products to be expensive, which may lead to customers' pre-exclusion without actual knowledge of the product due to budget cause. Mosa and Desso share the same concern about customers' perceptions of green products having lower functional performance. Green flooring products tend to use less material to achieve sustainability in its life cycle, which may raise customers' doubts about the quality of the products. Besides, both Desso and Interface had worries about the future uncertainties, such as market response and regulation uncertainty, because, after all, developing green products is not a small investment.

Regarding the hypothetical barriers, Mosa and Desso still share more similarities than they with Interface. The development cost and difficulty to sell at competitive prices are considered to be top three barriers by Mosa and Desso, while the need for extra knowledge and expertise is considered less influential. In contrast, Interface ranked the need for extra knowledge and expertise to be the most influential barrier and development cost to be second. This result is again consistent with the timing and motivation of the sustainable projects started by the three firms. Comparing to Interface, Desso and Mosa started the projects in more mature conditions, thus the most influential barriers for them are the market related factors. Interface, however, started the project in 1990's when there were not many successful examples that could be borrowed experience from, nor did many suppliers of them have knowledge or experiences, thus the need for extra knowledge was more challenging for Interface than for the other two companies. The last proposed barrier, loss of government subsidy, is considered as the least influential one by both Desso and Interface, while Mosa claims this barrier is not applicable to them because they did not receive any subsidies at all. As explained earlier, for companies with certain size, the government subsidies only make up a small portion of development costs, and both Desso and Interface claim that most

of their investments came from the company budgets or stakeholders. Thus, the loss the government subsidy is not a determined barrier.

	Conformity to facts		
Barriers	Mosa	Desso	Interface
High price perception of customers	✓		
Lower functional performance perception of customers	✓	✓	
Uncertainty about the future		✓	✓
Difficult to sell at competitive prices	1	2	4
Development cost	2	3	2
The needs of extra knowledge and expertise	3	4	1
Public scrutiny to verify green products	4	1	3
Government subsidy may not last	Not applicable	5	5

Table 9 Barriers of green product development

8.5 GPP INFLUENCE

The interview results about the GPP influence are very different from what was expected. According to a report published in June 2011, the Dutch public authorities have achieved 99.8% of sustainable procurement at national level, 96% at province level, and 86-90% at municipality level (NL Agency, 2010). All three companies claim they engaged in public tenders before. However, all three companies claim have limited knowledge of the GPP policy or its requirements. Interface verified that products with reasonable quality and sustainable attributes score higher comprehensively, yet price factor still has the decisive influence in public tenders. Although all three companies claim the green attributes did not increase the prices, they still cannot be considered to be among the lowest price offers on the market. Mosa claims that the reason why they did not focus on GPP policy was the disappointment with the public demand when they first marketed their green tiles. They expected lots of public demands, yet it did not happen. However, this result is understandable because the timing when they started to market their green products is also when Netherlands started to implement GPP policy.

The fact that GPP policy is a voluntary policy instead of mandatory one makes it take longer time to be effective during implementation.

No matter what, all three companies believe that GPP policy can bring positive impacts to the market and construction industry. It is a signal of the government's attitude, and it is also stimulation for building material manufacturers to innovate green. Besides, it can, to some degree, change the customers' perception about green products. However, after reading the EU GPP criteria, all three companies agree that the current GPP criteria are not tough enough to distinguish companies who really dedicate to green products with others who only want to meet the minimum requirements. Also, they find the current GPP criteria are incomplete, because, for example, the carbon footprint is not addressed in the criteria. To make the situation more favorable to them, Desso claims that they have joined a working group which is actively seeking ways to get government accept cradle to cradle philosophy and certification as one of the assessment criteria in tenders.

PART THREE:

CONCLUSION, RECOMMENDATION & REFLECTION

9 CONCLUSIONS, RECOMMENDATIONS AND REFLECTION

9.1 CONCLUSIONS

Environment protection and sustainability have already become two of the many themes in the 21st century. More and more people have realized the absurdity of developing economy first and protecting environment later. Thus, many actions have been taken to change the old developing strategy. To live in harmony with environment, the green concept has been introduced to many industry philosophies and product designs. However, due to various reasons, green products still only make up a small portion in the market share.

The construction industry is always seen as one of the major consumers of resources and generators of wastes. In order to green the building supply chain as well as stimulate green innovations in building industry, the European Commission issued Green Public Procurement policy to specify the criteria for products used in public construction projects. In the last few years, GPP policy has been actively implemented throughout the whole European Union. Based on the EC GPP policy documents, member countries issued their own GPP criteria which are more in line with their specific situations.

National governments tend to set ambitious goals for the GPP implementation, yet the goals are proven to be hard to achieve later in practice due to various barriers. This research is built on the intention to solve one of the barriers – the lack of qualified suppliers. The solution to this barrier is to stimulate manufacturers of building products to innovate green, which is also one of the intentions of GPP policy. However, it is not clear that why and how manufacturers should start to improve the environmental performance of their products, especially for small-sized companies.

This research specifically focuses on one branch of the building product industry, the flooring industry, and aims at making suggestions to other flooring product manufacturers on what factors and green product attributes they need to pay attention on during the development process. To achieve this goal, this research interviewed three frontrunners in the flooring industry who have successfully marketed their green products. The successful experiences of these frontrunners make them qualified to provide information on the enablers and barriers of the green product development, especially on how they dealt with all the barriers as well as the subsequent effects of the barriers. More importantly, because they have already marketed their green products, they shall have the first-hand knowledge of the market responses of these products as

well as some highly valued green product attributes. Information like these can be valuable references for other manufacturers who plan to develop green products, thus fulfilling the goal of this research.

This whole research can be divided into two sections: the literature review and the case studies. The literature review is first conducted to get some in-depth understandings about the research topic as well as answer the first research question.

RQ1: What are the GPP requirements for building products in public construction projects and how are they evaluated?

The EU GPP criteria for building products consist of two parts: the core criteria and the comprehensive criteria. The core criteria are the minimum standards, and any supplier who complies with the core criteria is qualified to participate in public tenders in theory. The main requirement of the core criteria is that tenders must provide detailed information about the environmental performance of the products through the whole life cycle, and this can be done through either wearing eco-labels or providing LCA assessment reports. If the product is wooden based, then there is one more criterion requiring that the wood materials must be responsively sourced. The comprehensive criteria, however, have more focuses and act as award criteria, which means, in theory, suppliers who comply with them can get more credits in tendering process. Comparing to the core criteria, the comprehensive criteria add requirements about recyclability. This recyclability requirement does not only require the product itself to be recyclable but also certain percentage of recycled contents must be contained in the product materials. This requirement has many side effects in practice. For example, healthier materials should be used in the first place to enable the recycling, and using recycled contents as raw materials can reduce the landfill wastes. The compliance with these criteria is checked through detailed documents and corresponding certifications. Overall, all interviewees consider the EU GPP criteria to be a good stimulation for manufacturers to innovate green. Meanwhile, they also believe the current EU GPP core criteria are not strong or stringent enough to distinguish manufacturers who really made important achievements on green product development from other manufacturers who only want to meet the minimum criteria. Last but not least, according to interviewees, there exist some variances between the GPP criteria and the philosophy they used in practice. For example, the one philosophy they all apply in their green product development process, the cradle to cradle philosophy, is not mentioned in the GPP criteria, which makes them find the current GPP criteria not sufficient enough. Therefore, they are actively participating in a working group which aims at getting the cradle to cradle philosophy publicly recognized and admitted.

Other than the EU GPP criteria, eco-label criteria can also be used as evaluation criteria as well as proof of the green nature of products. The eco-label criteria classify the floor covering industry into three categories: hard flooring, wooden flooring, and textile flooring. There are separate assessment criteria for each one of the category, and these criteria, comparing to the EU GPP criteria, are more specific and operable. However, the specification of these criteria also makes them tedious for manufacturers to comply with. Besides, manufacturers have different emphases on the green product designs during the process, yet these emphases may not be well valued in the eco-label criteria, which could result in manufacturers' unwillingness to apply for the labels. For example, Desso mentioned that they find some evaluation criteria to be unreasonable to comply with. Moreover, the variety of eco-labels makes it hard for some international flooring companies to choose which label to apply for. There is a non-exhaustive list of existing EU and international eco-labels published by EC which includes 13 EU eco-labels, 8 international eco-labels, and 9 sectoral eco-labels.

The second part of the study is conducted through case studies. This research takes the examples of three frontrunners in the flooring industry to develop suggestions for other manufacturers who have not developed their own green products on factors and product attributes that need to be put attention on, thus answering the last two research questions.

RQ2: What are the enablers and barriers during the development of green products? How are these factors influenced by the GPP policy?

Different companies met different enablers and barriers in their experiences, but they do share some similarities. All of the enablers mentioned in this research can be divided into two categories: motivations and success factors. The most mentioned and recognized motivation is the concern for the sustainable development of the company. This concern is based on the vision and belief about the future market: green products represent the future demand, and companies will get obsolete if they do not follow the trend. It may be brought up by different people in different ways, such as commitment of the top-management and reminder from customers, but no matter what, it is the basic motivation for companies to go green. Happening with or as a result of this motivation, there are more market related motivations, such as concerns about competitiveness of products, public image of company, and market requirement.

Other enablers mentioned by interviewees, partnership, in-house knowledge base, and government subsidies, act as success factors in the green product development process. Whether or not the focal company possesses in-house knowledge base decides the

knowledge investment they have to put into the project. For companies like Interface which started to develop sustainable projects in early days, the knowledge investment is much higher than companies which started the project in recent years. When the focal company does not possess the needed in-house knowledge base, the value of partnership will be enhanced. Partners can not only provide qualified materials or equipment but also knowledge and expertise which the focal company lacks of. Besides, the collaborative researches happen between partners can increase the chance of success, especially when there are not many successful examples to borrow experiences from. Nevertheless, sustainable projects cannot be finished by a company alone. The requirements about raw materials and production process ask companies to have stable and cooperative relationships with suppliers and partners. The influence of government subsidies, however, depends on the size of the firm and its financial strength. Desso and Interface claim that they received government subsidies, yet neither of them considers it to be an influential enabler because their financial investments mainly came from company budgets and stakeholders. For relatively small sized companies with less financial strength, the influence of government subsidies may be higher.

Similar, the barriers of innovating green can also be classified into two categories: worries about uncertainty and practical difficulties. The worries about uncertainty include customers' perception of green products having high prices and low functional performance, and uncertainty about the future. Customers tend to think green products have higher prices because of healthier better raw materials and higher development costs. This perception may block some customers from knowing the products before excluding them as choices due to budget cause. In fact, all three companies claim that the prices of green products did not increase, and some product lines even have lower prices than before. As for the functional performance of new products, interface claims that the green carpet tiles indeed use less material, but it does not affect the quality and functional performance of the products. The worries about future uncertainty basically come from the possibility of changing policy and future market requirements, for example, what green attributes will be valued more in the future market.

The second category is practical difficulties, including difficulty to sell at competitive price, development cost, the need for extra knowledge and expertise, public scrutiny, and loss of government subsidy. This category is proposed by the author to test for conformity, and interviewees have rather diffused answers for this question. Nevertheless, there are more similarities between later committed companies, namely Desso and Mosa, than they with early committed company, namely Interface. The later committed companies worried more about the difficulty to sell at competitive price and

development cost, while the early committed companies like Interface consider the need for extra knowledge to be more challenging. This situation happens because the theory of sustainability has developed further in the past few years, and there are more successful examples to borrow experiences from also. The difficulty of obtaining extra knowledge, as a barrier, has been largely reduced nowadays. However, no matter when do companies start green product development projects, the development cost will always be a concern. The public scrutiny is considered as one of the practical difficulties basically because there lack of a universal standard to check for the green nature of products, and the closest one may be the EPD report which only states all the environmental impacts during the life cycle without any judgmental conclusion. The last factor, loss of government subsidies, can hardly be considered as a practical barrier for companies participated in this study because they are companies with certain size and financial strengths. For companies with relatively small size and weaker financial strength, the loss of government subsidies can actually be a practical difficulty in practice.

As for the influences of GPP policy on these enablers and barriers, the motivation and worry related factors can be more affected than practical ones. The GPP policy is a signal about the attitude of government regarding the future market. It will stimulate manufacturers, to some degree, to innovate green to cater to the future market demand. It can also help to change the perception of customers towards green products which can reduce the market uncertainties for manufacturers. These influences can later affect practical factors in some ways. For example, suppliers of the focal company may be more motivated to join in the collaborative research on new green products now. No matter what, all interviewed companies believe the GPP policy can have positive impacts on the green transitioning of building material industry.

RQ3: Given the enablers and barriers, how can manufacturers of building products adjust their product strategies to meet the GPP criteria? Which green attributes should be emphasized on during the green product development process?

What can be certainly deducted from the research is that the green products are the future trend, and companies should take it into consideration when making product development strategies. As for what kind of attributes should the new green products possess, several basic attributes are mentioned by the interviewees, including toxin-free raw materials, containment of recycled contents in products, the recyclability of products, reduction of production wastes, the use of renewable energies, and closed-loop water recycling systems. These green attributes, however, can be further classified into two categories: green product attributes and green production attributes.

The green product attributes consist of the first three attributes, namely toxin-free raw materials, containment of recycled contents in products, and the recyclability of products. Using toxin-free raw materials in production process is the bottom line for products to be considered as green. Any toxic substances listed in relevant EU Directives or national regulations should not be contained in the products or be limited to the safe amount. Taking a step further, green products should contain certain amount of recycled contents. The EU GPP criteria regarding this attribute require 20% of recycled contents contained in products. Besides, the product design should enable recycling or remanufacturing after disposal, and this attribute is associated with reduction in landfill wastes also.

The latter three attributes, reduction of production wastes, the use of renewable energies, and closed-loop water recycling systems, are green production attributes since they are associated with elements of production process. The use of renewable energy and water recycling are actually award points. The eco-label criteria only ask for reduction in energy consumption, yet all three interviewed companies claim they use green or renewable energies to certain degree in their production processes, such as solar energy, wind energy, and bio-gas. Both energy saving and use of renewable energies can help reducing the carbon footprint in products and production processes, so it is up to manufacturers to choose which method to use. As for water consumption in production process, eco-label criteria only ask for waste water being processed to keep toxic contents below certain limits before discharging. However, both Mosa and Interface claim that they have realized using water in closed loops and they are on the way to realize zero discharge of waste water to municipal sewers. Therefore, it is again up to manufacturers to decide to what degree they want to green their production activities.

9.2 RECOMMENDATIONS

The intention of this research is to solve one of the barriers standing on the way of implementing GPP policy, namely the shortage of qualified green building product suppliers. Due to the complexity of the building product market, this research decides to target specifically on the flooring industry. Through literature view and case studies, this research is finally going to make suggestions to flooring product manufacturers who have not yet developed their own green products on how to start the process. More specifically, this research aims at clarifying some of the factors that may affect manufacturers' decisions, both enablers and barriers, and providing some insights on the green product attributes they should consider during the development process. To achieve these goals, three frontrunners in the flooring industry are interviewed by the researcher, and several enablers and barriers during the development process as well as some of the most valued green attributes are identified.

Enablers:

- For the sake of long term development, companies should consider bringing the plan of developing green products up to schedule. It is both a preparation for the possible future market demand and a way to enhance the performance and quality of their products. Besides, by offering green products, companies can build ecological responsible images in public which can later benefit them in monetary and non-monetary terms. For example, it helps saving money from publicity if a company is well-known for selling green products.
- It is important for the focal company who wants to develop green products and realize sustainability to have stable and cooperative relationships with their suppliers and lead clients. Healthy raw materials are the footstones of green products, thus having cooperative relationship with suppliers who provide qualified products with reasonable prices is important. If the needed materials are not currently available on the market or available but pricy, then the former stable relationships between the focal company and suppliers can help facilitate joint researches to develop the needed materials. Besides, suppliers can also provide the focal company with resources and expertise which they lack of. Stable and positive relationships with lead client can bring the focal company with novel solutions or feedbacks after tryouts which can help them to further improve the performance of their products.
- The focal company should start to cultivate the in-house knowledge base if they have plans to develop green products. By setting up a project team or department, the focal company can gain more knowledge about the project before investment.

Either hiring new staff with sustainability expertise or sending employees to further education can do the trick. Besides, it is also important to raise the awareness of the whole company to join in the green transitioning, which can enable the emergence of brilliant employees and ideas.

- For companies with small size or weak financial strength, government subsidies could be a good support for the development plan. Whether or not a company can get government subsidy depends on what project they have on hand. Companies with the intention could watch out for government programs or news which may implicate what kind of projects they should go for.

Suggestions to overcome barriers:

- The interview results reveal that it is not certainty for green products having higher prices than conventional products, though they may not be among the lowest price range. Competitive prices are achievable if companies accept long term return on investment, because, if looking into the future, the initial development costs will diminish as the production scale expands. Different from the common perception, all three companies participate in this research claim that the green products development projects are not burdens but actually are saving them money.
- There are many ways to solve the initial development cost, such as loan, searching for partnership, government subsidy, etc. Companies can choose whatever methods suit their situation. For companies with certain size and financial ability, the initial development cost can be raised from stakeholders as well.
- As for public scrutiny and green certificates, it depends on the market area of the focal company and its main supplying sector, namely public sector or private sector. One of the universal solutions is applying for EPD (Environmental Product Declaration) which uses the LCA method to evaluate the environmental performance of the product through its whole life cycle. The EPD report discloses all relevant information online for interested parties to check, and the international system enables the verification of all EPD reports. Other than that, international companies who mainly work within the European Union can consider applying for EU eco-labels or other eco-labels that have greater influence within Europe, such as Nordic Swan (Nordic countries), Blue Angel (Germany), Dubokeur (Netherlands), etc. Last but not least, the Cradle to Cradle® certification is also a good choice since there are successful companies who bear it can be used as references.

Green attributes:

The attributes of green products can be classified into two categories: green attributes of products and green attributes of production process.

Product attributes:

- Toxin-free raw material is one of the base lines for green products. Companies which intend to develop green products should try to phase out all harmful substances in raw materials and replace them with safer alternatives. If some substances are not replaceable now, then they should be kept below safe limits to avoid health damage to users. Taking a step further, if certain amount of recycled contents is contained in the green products, as suggested by the EU GPP comprehensive criteria, it will be a good highlight to show the green achievements of manufacturers as well as a competitive advantage in public tenders.
- Green products shall be designed to be recycled or reused possible. This attribute is associated with healthy raw material as well as reduction of landfill wastes. Only if the raw materials do not contain any harmful substances, the recycling will not be an accumulation of toxins. Besides, collecting end-of-life products to put them into remanufacturing can be an effective way to reduce the landfill wastes. If having the ability, companies shall consider setting up take-back systems to recycle its own products or products of other companies as well.
- Companies which provide green products shall also provide the corresponding LCA assessment reports to verify all the improvements of the new products over conventional ones. It is not only compliance to the GPP criteria but also proof of the green nature of the products. Considering the accessibility and simplicity of understanding, companies shall consider applying for some corresponding eco-labels or disclosing the evaluation reports on certain platform for public to check, e.g. the EPD system.
- Green packaging is an attributes mentioned by the EU eco-label criteria. Using degradable, reusable, or other green packaging materials can also help reduce the negative impacts to the environment during the life cycle of product. Companies may also consider recycling the packaging materials of their products to help reduce the landfill wastes. Besides, green packaging is an easily noticeable attributes for customers to catch the green nature of the products as well as a demonstration of the green attitude of companies.

Production process attributes:

- To reduce the carbon footprint of green products, companies shall reduce the energy consumption during the production process. By making actionable energy saving plans or introducing energy saving equipment, companies can achieve certain amount of energy saving per year. If taking a step further, companies with abilities shall consider using renewable energies to gradually replace fossil energies, and this is proven to be operable in practice. One example can be found from the interview results of Interface – one of their facilities located in Netherlands has realized fully using renewable energy in its daily production activities.
- Regarding the water management, processing waste water to keep toxic substances below safe level before discharging is the minimum requirement. Companies which want to make achievements on sustainability shall consider developing complete and reasonable water recycling system to reduce the amount of waste water as well as the fresh water consumption during production process. Some frontrunner companies have achieved using water in closed loops which have potentials to realize zero discharge of waste water.
- Companies shall try to reutilize production wastes and byproducts to reduce the amount of landfill wastes. Some production wastes or byproducts, if cannot be reutilized by the company itself, may be useful in other industries, e.g. Mosa uses byproducts in stone industry in its production process. Therefore, collaboration with relevant manufacturing companies may be a good way to reutilize the production waste and byproducts.

9.3 REFLECTION

This research aims at providing flooring product manufacturers who have plans to develop green products with some useful information and suggestions on influencing factors as well as green product attributes which they shall consider during the process. Through both literature review and case studies, all of the research questions proposed in this research are answered. In order to maximize the output of this research, a reflection on the research is provided. Some critical remarks are demonstrated as follows.

- To achieve the research objective, three frontrunners in the flooring industry who provide green products were interviewed to gather necessary information for the suggestion development. This choice has its pros and cons. As frontrunners who have actually marketed their products, they have actual experiences of the enablers and barriers during the development and firsthand knowledge of the market

responses, which is a match to the research questions. However, comparing the SMEs in the flooring industry, the three companies chosen in this research are all companies with certain sizes and strong financial strengths. The yearly turnover of Desso was 202 million Euros in 2013, and that of Interface is almost 1 billion Euros. The “deep pockets” of the three companies may influence the way they consider the enablers and barriers of green product development economically. For example, none of the interviewees consider the government subsidies to be an influential enabler or the loss of it to be an important barrier. However, there do exist startup firms which are built on government subsidies or some of the small companies which depend on government subsidies to start the projects. For them, the government subsidies can be more important than it shows in the research results. Moreover, the GPP policy, either as enabler or motivation, does not show its importance in their decision making process, because they started to develop green products before or at the same time of the development of the GPP policy. However, for companies who plan to develop green products now, the GPP policy may have greater influence on their decisions and strategy development. The “deep pockets” and former experiences of these frontrunners also affect the green attributes they provide to some degree. Two interviewees claim that their companies are currently trying to replace the fossil energies with renewable energies, while the eco-label criteria only ask for energy saving. The same situation can be found when asking about water management system that two companies claim that they have realized using water in closed loops. For companies with weaker financial strengths, these attributes may be hard to achieve in the early days of the development projects. Furthermore, being frontrunners that have certain reputation on the market may also influence their perception about eco-labels. Only Mosa expresses their interests in applying for eco-labels in the near future, while the other two companies claim they currently have no relevant plans. However, for companies which are less known to the market, wearing corresponding eco-labels is a good way to demonstrate the green nature of their products to clients, especially the EU eco-labels which are also the entry tickets to public tenders.

- Another shortage of the case studies would be that no manufacturers of wooden flooring products are involved. Three companies participated in the research: Desso and Interface are manufacturers of textile flooring products, and Mosa is a manufacturer of hard flooring products. Nevertheless, because the final conclusions are rather generous without digging into technicalities, the absence of manufacturers of wooden flooring products shall have limited influence on the applicability of these results to the flooring industry.

- Due to the limitation of existing literature, the propositions proposed in this study are developed based on theories of the influencing factors of green product development in general instead of factors tailored for building products. The construction industry does have many unique attributes, so it is possible that differences exist between the influencing factors of green building product development and green product development in general, which may be an interesting topic for future research.
- The conceptual model developed in this research is not only a summary of the literature review but also a guideline for the case studies. In turn, the case studies and the interviews also add more elements and information to the conceptual model. Some new influencing factors of green product development surfaced during the interviews, such as partnership, in-house knowledge base, government subsidies, and customer perceptions, etc. Meanwhile, some originally proposed enablers appear to be less important than expected to be, mainly refers to ecological responsibility and regulation compliance. Although two of the interviewees actually ranked the ecological responsibility as a top-three influential enabler, the interview contents do not show equivalent result. The regulation compliance, however, can be underestimated because of the choice of interviewees. Moreover, the classification of the enablers and barriers also changes from merely internal or external to more specific categories: motivations (enabler), success factors (enabler), worries about future uncertainty (barrier), and practical difficulties (barrier).

Nevertheless, this research yields reasonable results for the research purpose. For the research community and the subject of management of technology, the contribution of this research mainly exists in the supplement findings of the influencing factors of green innovation and green product development. Some of the green attributes identified during this research show the recent progress and achievement in the field of green product development. Moreover, with its exploratory nature, this research sets the foundation for further research on the connection between the Green Public Procurement policy and green innovation. For companies and business practice, this research provides successful experiences of frontrunners in the field of green flooring product development that can be used as reference or even guide for other manufacturers to develop or improve their own green products. For public authorities, this research gives an overview of the green attributes that are valued and achieved by the frontrunners in the building product industry, which can be helpful for the further development of the GPP policy.

9.4 FUTURE RESEARCH

Based on the reflection of the whole research, it is possible to develop some suggestions for future research.

- To establish a reference for manufacturers who have not yet developed green products, this research collects data only from frontrunners in the flooring industry, and this choice brings some limitations as suggested in the reflection. Future research can extend the scope to include both frontrunners and laggards to compare the enablers and barriers experienced by each of them. By specifically using the publish date of the GPP policy to choose frontrunners and laggards, the comparing results can be more persuasive on showing the actual influence of the GPP policy on green innovation stimulation.
- As implicated by Figure 2, the “demand and supply system in construction industry”, multiple actors and stakeholders are included in construction projects. Most of these actors are SMEs which make the whole supply chain structure of the construction industry very complex. Researches have already shown that this complexity of supply chain structure has negative influence on the implementation of the GPP policy. Future research can focus more on the relationships between these actors, to what way exactly do these relationships affect the implementation of the GPP policy, and how can the supply chain structure be improved to neutralize the negative influence.
- Although the GPP policy is currently a voluntary tool, doing a compliance cost analysis of the GPP policy to measure the cost for a conventional building product turning into a GPP requirement qualified product can still be interesting and meaningful. The development cost of green products tends to be high and this research can help manufacturers to understand where the budgets will be spent on and how much could it be before starting the project.

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APPENDIX A: ECO-LABEL CRITERIA

WOODEN FLOOR COVERINGS

Wooden floor coverings encompass all wood- and plant- based coverings: wood and timber coverings, laminate floorings, cork coverings, bamboo floorings which contain more than 90% of wood, wood powder, wood/plant based materials (European Parliament, 2010). To reduce the energy consumption, limit the use of dangerous substance, and reduce the discharge of toxic wastes to environment, the following criteria should be complied with.

All wood, bamboo, and cork raw materials should come from forests that are managed sustainably. All wood materials should be well documented and come from legal resources. If recycled wood materials are used, several compounds in the materials should comply with certain criteria, such as arsenic, cadmium, copper, lead and so on. Besides, wood floorings should not be impregnated or treated with any hazardous substances recommended by WHO classification of pesticides. Last but not least, wood flooring products shall not contain genetically modified wood (European Parliament, 2010).

No dangerous substances, as laid down in Council Directive 67/548/EEC, shall be contained in wooden products. No wood products should contain halogenated organic binding agents, aziridin, polyaziridins, and other substances containing lead, cadmium, chrome (VI), mercury and their compounds, arsenic, boron, copper, and organic tin (European Parliament, 2010).

In the production process, a scoring point is calculated for the process energy consumption and it should comply with following criteria: wood and bamboo floorings <10.5, laminated floorings <12.5, cork coverings <9. As for waste management, a well prepared document about procedures adopted for the recovery of by-products shall be submitted by applicants (European Parliament, 2010).

In the in-use phase, the release of dangerous substance is strictly limited. In general, the release of formaldehyde from wood floor covering products should be no more than 0.05mg/m³. The release of other Volatile organic compounds should comply with the criteria shown in Table 10.

Substance	Requirement (after 3 days)
Total organic compounds within the retention range C6 — C16 (TVOC)	0.25 mg/m ³ air

Total organic compounds within the retention range > C16 — C22 (TSVOC)	0,03 mg/m ³ air
Total VOC without LCI (*)	0,05 mg/m ³ air
(*) LCI = lowest concentration of interest; see ‘Health risk assessment process for emissions of volatile organic compounds (VOC) from building products’ (Federal Environmental Agency).	

Table 10 Eco-label criteria for Volatile organic compounds (European Parliament, 2010)

The packaging of wood floor coverings should be made out of recycled material and be reusable itself. The products should be fit for use and clear customer information about use method, maintenance, recycle or disposal method and eco-label information should be written on the packaging or in the manual.

HARD COVERINGS

Hard coverings, for external or internal use, include natural stones, agglomerated stones, concrete paving units, terrazzo tiles, ceramic tiles, and clay tiles (European Parliament, 2009b). The whole criteria are composed of ten sections, from the raw material extraction to waste management to information appearing on the eco-labels, and each of them has specified requirements that need to be met.

As for the raw material extraction, a matrix of six indicators is used to evaluate environmental performance of the process, including water recycle ratio, quarry impact ratio, natural resource waste, air quality, water quality, and noise. The extraction processes need to be scored according to these indicators and only processes scored higher than 19 points pass the evaluation (European Parliament, 2009b).

In the raw material selection, the absence of dangerous raw materials is required for all hard flooring products, which is listed in the Council Directive 67/548/EEC (2) (Dangerous Substances Directive). For glazed tiles, the content of lead, cadmium and antimony is specifically limited. Besides, no asbestos should be contained in raw materials for natural and processed products, and the use of polyester resins should not exceed 10% of the total weight of raw materials (European Parliament, 2009b).

Finishing operations for natural products should be made complying with requirements shown in Table 11.

Parameter	Limit
PM10 emission	< 150 µg/N m3
Styrene emission	< 210 mg/N m3
Water recycling ratio	>=90%
Suspended solid emission to water	< 40 mg/l
Cd emission to water	< 0,015 mg/l.
Cr(VI) emission to water	< 0,15 mg/l
Fe emission to water	< 1,5 mg/l
Pb emission to water	< 0,15 mg/l

Table 11 Finishing operation requirements for natural products (European Parliament, 2009b)

Building materials are required to comply with multiple environmental performance indicators in production process, including energy consumption, water use, emission to air, emission to water, and cement use. The energy consumption for agglomerated stones and terrazzo tiles should be calculated as process energy requirement (PER) with the limitation of 1.6 MJ/kg and 1.3 MJ/kg respectively. For ceramic tiles and clay tiles,

energy consumption should be expressed in energy requirement for firing (ERF) with the limitation of 3.5 MJ/kg. The fresh water consumption in manufacturing stage is limited to 1 Liters per kilogram of products, while the recycle ratio of waste water shall be no less than 90%. As for air emission, different requirements apply to agglomerated stones, ceramic tiles, clay tiles, terrazzo tiles and concrete paving units, as can be seen from Table 12.

	Agglomerated stones	Ceramic tiles	Clay tiles	Terrazzo tiles and concrete paving unit
Particulate matter (dust) (mg/m ²)	300	200	1000	300
Nitrogen oxides (as NO _x) (mg/m ²)	1200	2500	12000	2000
Fluorides (as HF) (mg/m ²)		200	800	
Styrene (mg/m ²)	2000			
Sulphur dioxide (SO ₂) (mg/m ²)	850		8000	1500
Sulphur dioxide (SO ₂) Sulphur content in raw material ≤ 0,25 % (mg/m ²)		1500		
Sulphur dioxide (SO ₂) Sulphur content in raw material > 0,25 % (mg/m ²)		5000		

Table 12 Air emission requirements (European Parliament, 2009b)

The water emission in production product shall comply with the requirements in Table 13.

Parameter	Limit
Suspended solid emission to water	40 mg/l
Cd emission to water	0.015 mg/l
Cr(VI) emission to water	0.15 mg/l
Fe emission to water (i)	1.5 mg/l
Pb emission to water	0.15 mg/l

Table 13 Water emission requirements (European Parliament, 2009b)

If cement is used in production process, then the production process should use no more than 3800 MJ/t of process energy requirement, and the emission of dust, SO₂, and NO_x should be limited to 65g/t, 350g/t, and 900g/t respectively.

The waste management criteria require manufacturers of building products to have a system for handling wastes generated in production process, and the system should at

least includes procedures for separating and using recyclable materials, recycling materials for other use, and disposal of hazardous materials. Besides, applicants should provide reports specify waste management from quarry to finishing operation, in which the recycle and reuse of by-products should be clearly elaborated. In general, at least 85% of the totally wastes generated in the process should be recovered according to Council Directive 75/442/EEC (European Parliament, 2009b).

The only eco-label criterion listed in the use phase is for glazed tiles about the release of dangerous substance. In order to avoid the negative impacts of hazardous substance both in the use and end-of-life phases, the contents of Pb and Cd should be limited to 80 mg/m² and 7 mg/m² respectively (European Parliament, 2009b).

As for packaging, the paperboard used should be made out of 70% of recycled materials. Moreover, the fitness for use should be clearly specified, such as suitable for wall covering or floor covering or both. Relevant user information, such as the purpose, general and technical use method, maintenance, disposal or recycle method, and eco-label information should all be specified on the covering or in the instruction books (European Parliament, 2009b).

TEXTILE FLOOR COVERINGS

Textile floor coverings are floor coverings made of woven, knitted, or needle tufted fabric, excluding loose mat and rugs. Similar to the other two product groups, the eco-label criteria for textile floor coverings also comprise raw materials, production process, in-use phase, fitness for use, and customer information (European Parliament, 2009a).

The raw materials used for the production of textile flooring products should not contain substances listed in Council Directive 67/548/EEC. Only when the fibers used to make textile flooring products are of recycled origin, the eco-label criteria regarding chemical substances do not apply, otherwise, there is a list of requirements need to be complied with, especially for wool treatment as shown in Table 14.

Limit	Substances
Total sum content < 0.5 ppm	γ -hexachlorocyclohexane (lindane), α -hexachlorocyclohexane, β -hexachlorocyclohexane, δ -hexachlorocyclohexane, aldrin, dieldrin, endrin, p,p'-DDT, p,p'-DDD, Cyhalothrin, Cybermethrin, Deltamethrin, Fenvalerate, Flumethrin
Total sum content < 2 ppm	Propetamphos, Diazinon, Dichlofenthion, Fenchlorphos, Chlorpyrifos, Chlorfenvinphos, Ethion, Pirimiphos-Methyl, Diflubenzuron, Triflumuron, Dicyclanil

Table 14 Eco-label criteria for wool treatment (European Parliament, 2009a)

As for polyamide fibers, the limitation is for the emission of N_2O , which the annual emission amount should not exceed 10g/kg of polyamide-6 produced and 50g/kg of polyamide-6.6 produced. The amount of antimony in polyester fibers shall be no more than 260 ppm, and the emission of VOCs should not exceed 1.2g/kg of polyester produced in annual terms. No lead-based pigments should be used in the production of Polypropylene, and the emission of NO_x and SO_2 shall not exceed the limits of 12 kg/ton and 11kg/ton respectively (European Parliament, 2009a).

All the dangerous substances forbidden in raw material selection also apply in the production stage. Only flame retardants chemically bounded into fibers or on the fiber surface can be used in products, and there are a few more dangerous substances that should be excluded from production process. If any plasticizer substance is used in the production, then only phthalates that is not been assessed as dangerous can be used.

Additionally, DNOP (di-n-octyl phthalate), DINP (di-isononyl phthalate), DIDP (di-isodecyl phthalate) shall not present in products. No dyes that are carcinogenic, mutagenic or toxic to reproduction should be used, nor do potentially sensitizing dyes. Besides, dyes and pigments contain heavy metals must not be used, such as lead, cadmium, mercury or chromium (chromium total) or Cr (VI). For effluent treated off-site, the containment of COD shall not exceed 60 g/kg of greasy wool, while the limit for effluent treated on-site and discharged to surface water is 45 g/kg of greasy wool, expressed in annual terms. Waste water from wet-processing site should have the containment of COD less than 20 g/kg annually, and if being treated on-site and discharged to the surface water, the PH value should be between 6 and 9 with a temperature lower than 40 °C. Besides, at least 95% of detergents, fabric softeners and complexing agents should be eliminated during the effluent treatment procedures. If metal complex dyes are part of the dye recipe, the waste water shall contain less than 20% of these dyes, and the amount of Cu, Cr, and Ni should not exceed 75 mg/kg, 50 mg/kg, and 75 mg/kg respectively in the wastewater emission (European Parliament, 2009a).

The dangerous substance release at the in-use phase shall not exceed the criteria shown in Table 15.

Substance	Limit
Total organic compounds within the retention Range C6 – C16 (TVOC)	0,25 mg/m ³ air
Total organic compounds within the retention range > C16 – C22 (TSVOC)	0,03 mg/m ³ air
Total VOC without LCI (*)	0,05 mg/m ³ air
(*) LCI = Lowest Concentration of Interest.	

Table 15 Dangerous substance release requirements in in-use phase (European Parliament, 2009a)

Similar to the other two groups, the products should be fit for use evidenced by ISO, CEN, and other equivalent test. Use information about use method, maintenance, recycle or disposal method, and eco-label information should be provided on the packaging or in the manual (European Parliament, 2009a).

APPENDIX B: INTERVIEW NOTES

MOSA INTERVIEW NOTES

- 1. Does your company currently offer green floor covering products? What are they?**

All tile products of Mosa are green products with certification of Cradle to Cradle® Silver, including ceramic tiles for floor and wall covering.

- 2. What is the turnover of your company for green products comparing to that for conventional products?**

Nearly 100% of our products are certified as cradle to cradle which means they are green. Thus, the turnover of the whole company is also the turnover of the green products, and last year the number is 100 million euros.

- 3. To what extent do public and private sector organizations demand for green products?**

That depends a bit. When we first started this project in 2008 and also when we got our first certificate in the early 2010, we expected lots of demand from public sector, because at that time, Netherlands was developing the guidelines for sustainable procurement. However, I have to say, there are more demands from private sector than public sector. Although these guidelines are already developed, they are not thoroughly implemented. Speaking of purchasing green, the private sector is running ahead of public sector, I would say.

- 4. Why do you believe your products are green products? What are the environmental performance improvements of these green products over conventional products?**

When we focus on cradle to cradle, there are a lot of aspects we have to work on to achieve certification, which are raw materials, recycling, energy, water management, and social aspect.

Starting from the raw materials, the traditional ceramic tiles contain some toxic components (like lead, cadmium, and mercury) in the glazes and pigments which are only between 2-5% of the total weight of the end products, but they contribute a lot to the final appearance of the tiles, which makes them important for traditional

products. However, in our product design, we fixed them all, and there is no toxic component in our products today. As for recycling, we did some investigations on how to work in the optimum way. We managed to recycle almost all of our production wastes, and by the middle of this year, it will be 100%. The recycled wastes will be brought back to the process. We also use some secondary materials, like the byproducts from the stone industry. We are also doing quite a lot of effort to optimize the energy and water management. We are trying to switch to renewable energies, which is not easy for us to do now. As for water management, as you know, there is more than enough water in Holland, but it is seen as scarce resource in the world wide. Thus, we aim at zero discharge of waste water to the municipal sewers in 2020. We are going to evaporate water and let it go from the chimney, or reuse it in close loops. About social aspect, it is not easy for us. We are only producing from our two factories in Maastricht, and we do not buy from outside suppliers. Therefore, we know all the people working in our company, and we have to comply with the Dutch labor regulations, for example the equal treatment between men and women.

5. **What factors make your company decided to develop green products?** (to address enablers)

Well, mainly because our management at that time believed that in the long run, there will be no room in the market for non-sustainable building materials. We decided that it would be better for Mosa to be among the first ones and be pioneer than continuing in the old way and be left behind. We prefer being a front runner to being only complier to regulations. Of course, there are other reasons like building green images of our company, increase the competitiveness of our products, responding to the market demand requirements, and compliance with environmental regulations. As a company, you have to comply with lots of environmental regulations here, especially for Mosa, because we are located in the city center and in the middle of a residential neighborhood. Thus, we have to build rules to limit emission, such as fine dust, noise, CO₂ and so on.

6. **What kinds of risks did your company consider during the decision making process?** (to address barriers)

The main risk we were worried about when we first decided to produce green products is that customers perceiving our products to be expensive. People tend to think green products have higher price. Actually, we have not increased our prices

for the greener products. Besides, people may think the quality of green products would go down, which is not the case.

7. What do you know about Green Public Procurement policy?

Actually, we do not know much about the GPP policy because of the initial disappointment with the public procurement. We did not make GPP as our central focus anymore.

8. Does this policy have influence on your decision about developing green products? (Does it change your decision about developing green products?) What factor has been changed by it? (changes of enablers or barriers)

The GPP policy does not have obvious influence on our decision. We just continue our development plans, and we see LCA as an important method to evaluate the environmental performance of our products. The customer could be changed by the GPP policy, and it would also be an opportunity for us.

9. There is a list of enablers and barriers developed from existing literatures, please prioritize them according to your experience. (Please use 12345 to mark them. 1 stands for most important and 5 stands for least influential. If you have other enablers or barriers, please add them into the list.)

Enablers (drivers for you to go green):	Barriers:
● 5 Regulation compliance ● 3 Market requirements ● 4 Ecological responsibility (your company want to achieve ecological goal) ● 2 Competitiveness & image ● 1 Sustainable development (sustainable development is the trend that your company could get obsolete if not following)	● 1 Difficult to sell at competitive prices ● Not applicable Government subsidy may not last ● 4 Stringent public scrutiny to verify green products ● 2 development cost ● 3 Extra knowledge & expertise needed

10. The EU GPP criteria require 60-80% of building products used in public construction projects to be either eco-labeled or assessed by LCA method to provide clear information about the environmental performance. Besides, the comprehensive criteria require more than 80% of the building product materials to be recycled or reuse possible. 30-50% of building products used should contain at least 20% of recycled materials. If the products are wooden based, at lease 60-80% of the wood and wood-based materials shall be

responsibly sourced materials (Certification schemes that can certify this requirement such as FSC, PEFC, or any equivalent means of proof). To what degree do your products comply with these requirements?

All of our products are evaluated by LCA method, and we managed to achieve cradle to cradle design for all of them. Besides, all of our products are recycle or reuse possible, and in practice, our flooring products contain 21% of the recycled contents on average, some contain up to 45% of recycled materials.

11. What does your company plan to do in the future to improve the environmental performance of your products? (The key environmental performance indicator that needs to be improved)

The key indicator that needs to be improved is the energy. Tiles need quite high temperature during the production process. The current energy source is natural gas, but we would like to switch to renewable sources. Unfortunately, that is not available in right quantity and quality for now. We are hoping that we can make some progresses there.

DESSO INTERVIEW NOTES

1. Does your company currently offer green floor covering products? What are they?

The definition of green products varies, I cannot say that we are offering green products, but Desso started to embrace cradle to cradle design in 2007. What we did not want to do is having a few niche products being green, instead, we want to green the whole company and all of our products. We plan to achieve 100% cradle to cradle in 2020. For now, we have carpets that are cradle to cradle silver, while others are cradle to cradle bronze, depending on different product groups that we are talking about. Some products are more difficult to implement cradle to cradle than others. 90% of our carpet tiles are cradle to cradle certified.

2. What is the turnover of your company for green products comparing to that for conventional products?

Actually, I cannot say that we offer green products. Every product is supposed to be cradle to cradle, and they are advancing. The only number I can offer you is that 90% of our carpet tiles are certified cradle to cradle.

3. To what extent do public and private sector organizations demand for green products?

A lot of our customers are public authorities and big companies, and our largest market is the office market. Actually, they are more sensitive to sustainability than private sector, I mean private individual customers. We do a lot of business with public authorities, such as Provincie Noord-brabant, Rijkswatersraat, and Belastingdienst. Belastingdienst was the first public institution who tried out our new products, even though we said the products were not developed enough. In fact, we are well known for circulate economy, sustainability, and cradle to cradle design. The public sector does not really demand for green products, but we are doing it and we get a lot of public relations on it. After we started cradle to cradle, we have gained a lot of market share, so it is economically very successful. Besides, it also improves the image of our company. We used to an old fashion company and not very innovative, but now we are one of the front runner in this field.

4. Why do you believe your products are green products? What are the environmental performance improvements of these green products over conventional products?

We follow strictly to the cradle to cradle design philosophy. Most people think that cradle to cradle is only about recycling, but it is not actually. Before recycling, you have to take a few steps. First of all, you need to know every material in your products down to a very low limit, about 100 ppm. Because when you do recycling, these small things and chemicals make it difficult to do so. Also, there is a chance that they will be released, which is not good for human health. Our cradle to cradle philosophy asks us to get rid of substances which are not suitable for circulated economy. We go to our suppliers ask for lists of substances in raw materials, and we later send those lists to EPEA for evaluation. We select our raw materials according to the assessment report. We can say that our products contain no known toxic substances, and we have plans to finding out if there are other substances that potentially have negative impact on human health.

As for energy management, the cradle to cradle philosophy we are using is not about efficiency, so the energy & water saving is not our top priority. Because if you want to improve efficiency, then you will make incremental steps, reduce energy use by 2% for example, yet you are not changing the way you manufacture. In contrast, we make bigger steps, such as product design and production process change. We also save energy, since it is what government asks, about 2% reduction annually. In fact, the cradle to cradle philosophy asks us to use renewable energy in our production process, such as solar energy and wind energy. In this way, we reduce our carbon footprint for 50%.

For waste management and recycling part, we try to put all our waste streams from factories back to recycle. We also have "Take Back" program for our own products as a part of the recycling plan. Carpets are recycled using our innovative separation technique called Refinity®, which separates the yarn and other fibers from the backing. After an additional purification stage, the yarn (with the required purity) is returned to the yarn manufacturer for the production of new yarn. All non-recyclable fractions will be used as secondary fuel in the cement industry.

5. What factors make your company decided to develop green products? (to address enablers)

In the very beginning, 2007, our former CEO watched a documentary on TV about cradle to cradle philosophy, and he was very thrilled by the concept. After that he decided that Desso needs to embrace the cradle to cradle philosophy. Besides, we also had marketing and image consideration when making this decision. We believe that greener products are what market will ask in the future, and it is way to

improve the competitiveness of our products. Furthermore, from the marketing point of view, we believe green products are profitable.

We have support from partners, working groups, and government. We used to have government subsidy also. Government supports companies who are willing to explore in the sustainability field.

6. What kinds of risks did your company consider during the decision making process? (to address barriers)

As we did a lot of re-designs, there usually follows doubts about quality. Also, it takes time to develop new products, and there are many uncertainties about the future. Besides, the development cost is high, thus the price of the products will be increased accordingly. Although many customers say they will not mind, still, the market share is not big, yet we are determined enough to follow this path. We did need a lot of extra knowledge and expertise, but we had good in-house knowledge base and good cooperation with partners who can provide necessary technology support.

7. What do you know about Green Public Procurement policy?

I do not know much about the GPP policy actually. Usually our sales people will come to us, the sustainability people, if they need support in public tenders, yet apparently, they are not confronted with those issues.

8. Does this policy have influence on your decision about developing green products? (Does it change your decision about developing green products?) What factor has been changed by it? (changes of enablers or barriers)

There is no obviously influence of this policy on our decision. It could change the customer perception and stimulate the acceptance of greener products in public projects. Government should develop more stringent requirements, it can stimulate manufacturers to really innovate green. We have a working group which focuses on how to get cradle to cradle principle into the public procurement criteria. We are criticizing the government does not provide good, right criteria for us to work on, to differentiate us from other manufacturers.

9. There is a list of enablers and barriers developed from existing literatures, please prioritize them according to your experience. (Please use 12345 to mark them. 1 stands for most important and 5 stands for least influential. If you have other enablers or barriers, please add them into the list.)

Enablers (drivers for you to go green):	Barriers:
● 5 Regulation compliance ● 2 Market requirements ● 3 Ecological responsibility (your company want to achieve ecological goal) ● 1 Competitiveness & image ● 4 Sustainable development (sustainable development is the trend that your company could get obsolete if not following) ● Added by desso: partnership. Provide knowledge and expertise	● 2 Difficult to sell at competitive prices ● 5 Government subsidy may not last ● 1 Stringent public scrutiny to verify green products ● 3 development cost ● 4 Extra knowledge & expertise needed

- 10. The EU GPP criteria require 60-80% of building products used in public construction projects to be either eco-labeled or assessed by LCA method to provide clear information about the environmental performance. Besides, the comprehensive criteria require more than 80% of the building product materials to be recycled or reuse possible. 30-50% of building products used should contain at least 20% of recycled materials. If the products are wooden based, at lease 60-80% of the wood and wood-based materials shall be responsibly sourced materials (Certification schemes that can certify this requirement such as FSC, PEFC, or any equivalent means of proof). To what degree do your products comply with these requirements?**

Well, it is a good start to have criteria. It is always a little confusing for people to tell the difference between recyclability and recycle content. There is a difference in quality between recycle in one loop and recycle in indefinite loop. We are putting a lot of effort in making indefinite recycling loop which asks for better materials in the first place; otherwise it would still have negative influence with toxic substances being recycled again and again.

For now, we do not have all our products assessed by LCA method, if I have to give a estimation, I would say more than 50% of our products are evaluated by LCA. We are working on getting the rest of the products be covered, too. On average, 60% of our products are recycled or reuse possible and 30% of our products contain more than 20% of recycled materials. Again, because we have very advanced products and products below and criteria, these numbers are just average estimations.

11. What does your company plan to do in the future to improve the environmental performance of your products? (The key environmental performance indicator that needs to be improved)

We will just follow our roadmap, and we have many ambitions, such as renewable energies, bringing certified products to higher level, continuing detecting potential harmful substances in raw materials, etc. We may not apply for EU eco-label in the future since we have so many challenges at hands, and also because we have our own philosophy to continue green innovation.

INTERFACE INTERVIEW NOTES

1. Does your company currently offer green floor covering products? What are they?

We started to embrace sustainability 1994, and it is not just a project but more of a strategy or company mission to lead us to become what we want to be. Everything we do, no matter it is making a product, developing a process, or creating a new business model, should be align with this mission. By doing this, we are able to contribute more to the society than we take from. I would say 100% of our products are as sustainable as possible, but there is always room for improvement, just like an important saying we often use: "There has to be a better way." Besides, all services we provide are all built around sustainability.

As for certificates, we have decided to contribute to green buildings, such as BREEAM and LEED, instead of applying for various labels because they all have different demands. Actually, we have disclosed all information regarding the environmental performance of our products through a European system named Environmental Product Declaration. The report contains lists of materials used in our products and their possible impacts to the environmental at each stage of their life cycle. Meanwhile, we also get this information certified by a third party, so everyone can see, for example, the carbon footprint of our products. Although the EPD is only a declaration of the environmental performance of our products instead of comparative standards, customers can use it to make the comparison between products. Given all content and performance information, customers can make their own decision about what products to go for. For example, if you want to reduce carbon footprint, then you can choose products that have lower carbon footprint in the first place. Moreover, our products bear GUT label to prove that they are very healthy and green.

For now, we managed to delivery products with 85% lower carbon footprint on average than our products in 1996. Globally, 49% of our raw materials are recycled or bio-based, and we offer products made from 100% recycled nylon yarns. Besides, some products have very low VOC (volatile organic compound) emission, for example, Microsfera. We also have other products that are also sustainable, such as products made from 100% recycled nylon or contain recycled content in the backing. Actually, 70% of our backings contain recycled materials. So, there are different ways to work on sustainability. We are not only developing new modular products but also process in a sustainable way. For example, the European factory

in Scherpenzeel produces in a closed water loop system with no waste to landfill, and has 90% lower carbon footprint comparing to 1996.

2. What is the turnover of your company for green products comparing to that for conventional products?

Since all of our products are considered to be green, so the turnover of our green products is 100% which is a little bit less than 1 billion annually.

3. To what extent do public and private sector organizations demand for green products?

Our main business is business to business, and we supply products to construction projects of schools, hotels, and office buildings for municipalities and ministries. We receive requirements about supplying green products in public tenders certainly, though sometimes they do not ask explicitly. They usually value the total cost during the life cycle of the products, so suppliers who provide products with good quality as well as sustainability get more credits. Nevertheless, there are more factors which influence the tender awarding process, and price is always an important factor. In general, public authorities do ask for green products.

Comparing to the public sector, private sector has almost similar request frequencies. Private sector customers ask for sustainable products more explicitly. Thanks to the publicity of circular economy, people are working on circular procurement, thus they ask for circular products. Carpet tiles are one of the modern flooring products, and they are easy to be replaced by section if broken. We are working with government on a green deal of circular procurement. In this project, we are helping people to reuse their old carpet or choose products with high percentage of recycled content. Therefore, they can really lower their carbon footprint and build a healthier environment. Besides, we are sourcing on materials that are socially responsible, and we are working with the fisherman at Philippine who collect fishing nets, and we make those fishing nets into carpet tiles again. Also, we work with people from labor market to clean old carpets to give them a second life or third life even.

For both public and private sector, customers value recyclability most, basically because if they choose products with recycled content, then they will have a lower carbon footprint in the first place. Secondly, I think the social factor is more important than before as the sustainability publicity goes. The fact companies work with people from labor market is also appreciated.

4. Why do you believe your products are green products? What are the environmental performance improvements of these green products over conventional products?

If you look at our products back in the 1990's, thanks to the principle of ?, we started our project to phase out harmful materials and replace them with safer and healthier ones. Then, we focused on reducing the negative impacts of our products on environment by reutilization, using recycled content, and using bio-based content and so on.

Apart from the material improvement, we also made changes to our production process. One of our production facilities uses closed water loop and 100% of renewable energy (mainly bio-gas made from fish waste), and it generates no waste to the landfill. Besides, through all incremental and radical innovations, it finally achieved a 90% lower carbon footprint than in it was 1996. In worldwide, I believe we have achieved 40% of renewable energy using on average. Our plan is to achieve zero fossil energy using by the end of 2020.

We also value social influence of our products much, and it is a part of the sustainability. For that, we created a website named humanspaces.com. We believe that good products should have the attributes to make people happy with using them.

Therefore, we are not only making products have lower negative impacts through the value chain, but also we involve our clients and suppliers in the process. We consider the business model very important. We developed new business models to offer more services to our clients, such as help them creating inspiring environment, advising them about maintenance, teaching them to reuse old carpet tiles or clean them.

5. What factors make your company decide to develop green products? (to address enablers)

Back in the 1990's, clients who focus on green business asked us what we were doing for the environment. We answered that we were following legislation, and they thought it was not enough. Later, our founder, Ray Anderson, found it is important for us to follow this path, so he started the project group for sustainability. After reading a book which introduces the idea that ecology and economy can go together, Ray Anderson believed we should change into a more

suitable and sustainable system. All the ideas and concepts about circular economy, we embraced them back then.

Now, after a period of time implementing sustainability in our production practice, we identify more benefits for going green. For a starter, we are saving money, and we have a better organization. It is a great driver for innovation in processes and business models. Also, it engages people both within and outside of Interface to a higher level, and most importantly, it makes people be willing to work for Interface.

6. What kinds of risks did your company consider during the decision making process? (to address barriers)

Our stakeholders worried a lot when we decided to go green. They believed going green in this way, I mean with this concept, ambition and mission, we would go bankrupt in the end. They did not believe in good market response or our success.

As for the development cost, we invested a lot, but we are now actually saving money, and we say that sustainability actually finances itself. So, we do not consider it as an influential barrier. We consider the whole process an opportunity and challenge, and we are exciting to do this.

For the knowledge and expertise, we got a sustainable expert team to help us. At that time, there were not many companies which were working on sustainability, so we could not find many examples or experience from outside. So it is very different from nowadays that companies can get help through partnership as many companies are working on this. One of our suppliers back then even though we were crazy, but others and many of our clients (shareholders) lent us loan to do this project. Actually, they are very happy that we brought them on the sustainability project. Some of the small suppliers we got back then are now leading suppliers for 100% recycled materials.

We got some subsidies from the government, but as I said, our sustainability is funding itself, so even without subsidies, we still can manage to do it. As for the selection criteria for government subsidies, it really depends on the project you have.

7. What do you know about Green Public Procurement policy?

I do not know too much about this policy. Maybe because our products have met the standards, we have not confronted with any troubles with this policy.

8. **Does this policy have influence on your decision about developing green products?** (Does it change your decision about developing green products?) **What factor has been changed by it?** (changes of enablers or barriers)

I would not say that this policy have much influence on our decision. We started to go green before the implementation of those standards. I would suggest these standards to be more challenging than just keeping at the minimum level. I suggest the criteria to be more performance based and require lower carbon footprint. Instead of minimum performance criteria, the GPP criteria should drive the industry to innovate in sustainability field.

9. **There is a list of enablers and barriers developed from existing literatures, please prioritize them according to your experience.** (Please use 12345 to mark them. 1 stands for most important and 5 stands for least influential. If you have other enablers or barriers, please add them into the list.)

Enablers (drivers for you to go green):	Barriers:
● 5 Regulation compliance ● 3 Market requirements ● 2 Ecological responsibility (your company want to achieve ecological goal) ● 4 Competitiveness & image ● 1 Sustainable development (sustainable development is the trend that your company could get obsolete if not following)	● 4 Difficult to sell at competitive prices ● 5 Government subsidy may not last ● 3 Stringent public scrutiny to verify green products ● 2 development cost ● 1 Extra knowledge & expertise needed

10. **The EU GPP criteria require 60-80% of building products used in public construction projects to be either eco-labeled or assessed by LCA method to provide clear information about the environmental performance. Besides, the comprehensive criteria require more than 80% of the building product materials to be recycled or reuse possible. 30-50% of building products used should contain at least 20% of recycled materials. If the products are wooden based, at lease 60-80% of the wood and wood-based materials shall be responsibly sourced materials (Certification schemes that can certify this requirement such as FSC, PEFC, or any equivalent means of proof). To what degree do your products comply with these requirements?**

All of our products are assessed by LCA method, because all of them have EPD reports which are based on LCA method. 85% of our product materials are recycled

or reused possible. Globally, our products contain 50% of recycled materials. We also offer products made 100% from recycled nylon yarn, and our backing contains 70% of recycled content.

11. **What does your company plan to do in the future to improve the environmental performance of your products?** (The key environmental performance indicator that needs to be improved)

For the future, we will stick to our plan, and continue to improve the performance of our products through radical innovation. Also, we will continue to further improve all green attributes of our products.

About product prices:

We have various price ranges. We have certain quality standards and we do use good materials, so we cannot offer the lowest price in the market. I would say that most sustainable textile products are often products with less material, so they are usually cheaper than old products on average. So the products with least negative impact to the environment also have the lowest prices in our range. For example, the recycled nylon we are using is more expensive, yet by using special method to mix with other materials, clients do not have to pay more. Also, we invest in production machines to make more beautiful carpets which cater to clients' needs, yet we still manage to keep the price at old level. So, we do not believe that sustainability will cost more.