Green Supply Chains

Implications and challenges for Rhine-Scheldt Delta Seaports

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GREEN SUPPLY CHAINS

IMPLICATIONS AND CHALLENGES FOR RHINE-SCHELDT DELTA SEAPORTS

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DISCLAIMER

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FOREWORD

ING is proud to team up with University of Antwerp, VIL and Erasmus UPT to conduct a seventh extensive study on a maritime and logistical topic. The goal of these studies is to contribute to a better understanding, development and growth of our transport and logistics ecosystem. Sharing knowledge is a key element of our customer promise.

Climate change is one of the biggest challenges of our time. Scientists and governments alike agree that to mitigate the worst impacts, we must transition to a low-carbon and climate-resilient future, remaining well-below a 2-degree rise in global temperatures. Governments committed to this in what's known as the Paris Agreement. A global transition to meet this goal will require more than €30 trillion to be invested in clean energy and efficient infrastructure by 2035, according to the International Energy Agency. Bank lending makes up the most significant source of external capital. This means that banks have a major role to play in financing the transition to a low-carbon economy. What about ING? What are we doing to play our part?

As a financial institution, we can play a role by financing change, sharing knowledge and using our influence. Being sustainable is not just about reducing our own impact, it's in all the choices we make - as a lender, as an investor and through the services we offer our customers. That's why sustainability is inherent to our purpose of empowering people to stay a step ahead in life and in business. That is why the topic of this Port Study fits perfectly in ING's approach to climate action and knowledge sharing. The Rhine-Scheldt Delta Seaports face a difficult challenge: to drastically decrease environmental footprints against a background of growth in volumes and investments. Green shipping, inland logistics and synchromodality are just a few of the possible sustainable solutions this study analyses and evaluates.

But as a bank, ING has the most impact through our financing, via the money we loan to companies and customers. We have a loan book of about €600 billion across many sectors, which we have now begun steering towards meeting the Paris Agreement's two-degree goal. We call our strategy "the Terra approach". How does ING's Terra approach work? ING will focus on the sectors in our loan book that are responsible for most greenhouse gas emissions: energy (oil & gas, renewables and conventional power), automotive, shipping & aviation, steel, cement, residential mortgages and commercial real estate. We will use a specific approach per sector in order to make the most impact, partnering with leading external climate measurement experts where it makes sense.

We are convinced that the research and the conclusions of this study are relevant for all kind of maritime companies, port authorities and all the partners and stakeholders of this ecosystem. We want to thank Professor Theo Notteboom, Dr. Larissa van der Lugt, Niels van Saase, Kris Neyens and Steve Sel for their energy and knowhow. The members of the editorial board were a committed and powerful sounding board. Without them, the study would not be as thorough as the actual final result.

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EXECUTIVE SUMMARY

Green supply chain management (GSCM) can be defined as integrating environmental concerns into the inter-organizational practices of SCM. The fields of actions in GSCM include product design, process design and engineering, procurement and purchasing, production, energy use and mix and logistics (incl. distribution and transportation). GSCM implies a green logistics approach to connect the environmental concern with transportation, warehousing and distribution activities. The main **fields of actions** in green logistics are related to eco-friendly packaging, eco-friendly transport mode choice and synchromodality, load and route optimization and green distribution networks and distribution hubs. Co-operation between supply chain partners and the use of digital and integrated data solutions are key to support the above fields of actions.

GSCM has gained increased attention within industry as there is a growing need for integrating environmentally sound choices into SCM practices. Tighter regulatory requirements and strong demands for a cleaner and more sustainable environment exerted by communities at large are **pushing GSCM practices to the next level**. Actors involved in global supply chains are aware of the **sense of urgency** to move to greener supply chains. Since the early 2000s a slow **mental shift** is taking place from just being environment friendly to an integration of green initiatives as a way to achieve good business sense and higher profits. This mental shift seems to have accelerated in the past few years.

This report deals with the **role of seaports in the greening of supply chains**. The first chapter set the scene by analysing the **concept and practical implementation of GSCM**. Next to more theoretical considerations on the origins and components of GSCM, the chapter provides multiple **examples on GSCM practices** applied by a wide range of companies. Chapter 2 moves the focus to the **role and function of seaports in GSCM**. The empirical application is focused on the **ports of the Rhine-Scheldt Delta region**, the most important port region in Europe in cargo throughput terms. Chapter 2 concludes with a detailed overview of green actions and initiatives developed by market players and port authorities in the Rhine-Scheldt Delta ports. A **large-scale survey** conducted in the Belgian and Dutch logistics and port industry forms the backbone of chapter 3. The survey questions are deducted from the themes discussed in chapters 1 and 2 of the report.

The survey confirms that **greening has been put massively on the agenda by the firms** between 2010 and now. However, one can still see **a gap between words and actions** as from the responding companies roughly one in five is just or still must expand into effective action. The greening of supply chains does not have to be a burden but could constitute a **potential source of competitive advantage**. More than two-thirds of respondents see earning opportunities arising from newly to develop greening activities. It is furthermore hopeful to note that two thirds of the population does not consider greening to be a cost only. A clear majority (74%) estimates their company is **doing more than what has been imposed by their clients**. Quite a few indicate that greening is an integral part of internal company management and strategy. A major driver for doing more than asked for is environmental awareness and social responsibility, followed by reputation.

There are **diverse drivers and impediments** towards the greening of supply chains. Companies might initiate the implementation of environmental practices due to motivational drivers such as sales to customers, and legislative and stakeholder institutional pressures. There are clear signs that a focus on GSCM is needed to secure revenue growth, achieve cost reductions, develop brand value and mitigate risks. However, companies cannot blindly roll

out green initiatives as part of GSCM and **not all market players see GSCM as a business value driver**. Small operating margins and intense competition in the market can undermine the potential to move even faster towards the greening of supply chains. Also, **inconsistencies and discontinuity in government policies** can lead to uncertainty negatively affecting or delaying green investment decisions and the associated development of business cases. Logistics and supply chain managers have to balance efforts to reduce costs, improve service quality, increase flexibility and innovate while maintaining good environmental (ecological) performance. In other words, **green initiatives should not only best support the green supply chain, but also make business sense**. Otherwise, the competitive and financial position of the company might be negatively affected. The survey results show that the **positive contribution to reputation of the company** is a major driver and in line with this also the **ability to attract young employees** and the potential that greening offers for **developing new value drivers** within the company is highly valued. Striking is that companies seemingly are ambiguous on whether greening works positively on profits: many companies see the profit perspective as a barrier, but there are also companies that see this as a driver.

Companies acting in supply chains are influencing and are influenced by their supply chains partners in the greening of the chains. Almost half of the respondents say that they are **fully in control and also steer their partners**, mainly in the form of indicating that greening is a condition for contracting, but also by pushing specifications or by trying to collaborate. The other half of the set of respondents recognises that greening is a joint effort.

There is an important **role for (inter)national governments and organizations** in driving the developments in Green supply chains. Governments may or should act as catalysts for change. More than half of the respondents thinks that some form of intervention of the government is desirable, with only about 1 in 5 confirming they should not actively engage. **Taxes as a tool to enhance the greening of supply chains** is a contentious issue. Two thirds of the respondents consider **subsidies** beneficial to greening. Business wants government to be a soft enforcer; “tell us what to do and stimulate us… but do not punish us if we don’t engage quickly enough…”

Ports are hotbeds for initiatives aimed at a further greening of supply chains. Several fields of action for private and public actors involved in port-related activities exist to pursue GSCM objectives: green shipping; green port development and operations; green inland logistics; seaports and the circular economy; and, actions in the field of knowledge development and information sharing. The **long list of initiatives, actions and projects** for each of these domains illustrates that the port communities in the Rhine-Scheldt Delta are determined to reduce the environmental footprint of their activities and to make the transition to a more energy-efficient and circular economy. However, port communities also understand that the **challenges remain immense** and progress made is not at the same level in all domains of action. The port ecosystems are challenged to drastically **decrease their environmental footprints against a background of growth in volumes and investments**. This requires drastic and large-scale solutions such as Carbon Capture and Utilisation (CCU) and Carbon Capture and Storage (CCS), a further push towards greener shipping, a strong modal shift and adoption of synchromodality, etc. Ports are part of larger networks and chains thus requiring **co-ordination and co-operation between the actors** involved in these networks and chains, thereby facilitated by technology, new governance and business models and facilitation and regulation by governments.

The report also brings forward a set of **recommendations**:

1. The positive green attitude of supply chain actors involved in ports and their commitment towards a further green development of their activities should be fully recognized and embraced;

2. It is a joint responsibility of the port ecosystems to identify how to rightly tap upon the companies' underlying wish or nice feeling while 'doing good' in order to accelerate actions in the field of the greening of supply chains;

3. The environmental impact of seaports is typically significant given the large concentration of activities and the available connectivity over land. However, the clustering of activities in one location can also exert strong environmental advantages. It is imperative that 'ecologies of scale' advantages are fully acknowledged in environmental policy;

4. The port and logistics sector is already communicating and exchanging ideas on plans and real achievements in the area of green supply chains. Port ecosystems have to intensify their efforts in this area as it is expected this aspect is going to become even more important in the coming years.

5. The greening of supply chains demands a further mentality shift and joint commitment and dedication of all parties involved. More than ever, market actors will have to call out to other partners in the chains (including final customers) on how they can help companies to achieve green corporate and societal objectives.

6. One should acknowledge that progress remains difficult in some areas. While supply chain actors indicate that greening certainly is on their agenda's and sometimes already for quite long, real actions sometimes stay behind and especially those that imply new business processes and even more if this is in collaboration with other supply chain actors. Slow progress in the implementation of certain green initiatives in port-related supply chains does not point to unwillingness or ignorance of the relevant actors. It typically reflects the complexity and co-ordination needs linked to these initiatives and the corporate reality of the 'business case' approach.

7. Companies often act in a position of short-term survival. This asks for a continuous joint attention for the concern of individual companies in terms of uncertainty, for the question on how their business cases can be improved, or where compensation can be found for a thin business case or for the risk that other actors stop cooperating.

8. Concerning the energy transition, it is important for port ecosystems to explore and contribute to the development of a wide range of initiatives that support a transition to more renewable energy, and do not narrow their focus to only one renewable energy source.

9. CCU and CCS will be indispensable in view of meeting the CO2 reduction targets. The emerging cross-border and inter-port co-operation in this area is a positive step to bring its implementation to the next level.

10. Port ecosystems are expected to develop further into key locations for recycling activities and the re-use of materials in the context of the transition towards a circular economy. Ports should be given the possibility to fully adopt this role through an appropriate regulatory framework, knowledge development and infra- and superstructure.

11. Many actors in the port-related supply chains are focusing on the greening of maritime and land transport operations. Success typically depends on coordination and co-operation between the actors involved and the availability, use and sharing of data through appropriate (planning) platforms and systems. Risk and uncertainty are serious bottlenecks here, while trust between parties is an important enabler.

12. When considering of engaging in green initiatives, port authorities should evaluate whether they have a role to play (i.e. will their involvement likely lead to a superior outcome compared to no involvement?), what tools or instruments to use (e.g. pricing, knowledge development/sharing, investment, etc..) and whether they should act as facilitator or entrepreneur.

13. Port authorities should not be forced by policy makers at supranational or national level to act as the convenient tax collectors for the greening of supply chains. Any internalisation of environmental costs should target the polluter at the source and cannot lead to an obligation for port authorities to punish for externalities or to reward environmental performance. Obviously, the above point does not imply that port authorities should refrain from launching such schemes on a voluntary basis (individually or together with other ports).

TABLE OF CONTENTS

INTRODUCTION

The environmental impact of logistics systems is one of the main challenges to actors involved in global supply chains. In the past decades, green supply chain management (GSCM) has developed in view of integrating environmental concerns into the inter-organizational practices of supply chain management. In the past few years, tighter regulatory requirements and strong demands for a cleaner and more sustainable environment exerted by communities at large (e.g. Youth for Climate) are pushing GSCM practices to the next level. The sense of urgency rises with an escalating deterioration of the environment, e.g. diminishing raw material resources, proven climate change impacts and increasing levels of pollution. Adding the "green" component to supply chain management involves addressing the influence and relationships of supply chain management to the natural environment.

Seaports are nodes in global supply chains. They generate environmental impacts through their various functions linked to cargo handling, connectivity to maritime and land transport networks, industrial and semi-industrial activities, logistics and distribution activities and energy production and distribution. Port-related pollution not only damages the ecological balance of nature and the urban environment, but also causes adverse effect on global climate change, which further increases the risk associated with port operations. Seaports, as clusters of economic actors and activities, have adopted a real environmental role and function and in this way (should) contribute to the greening of supply chains in the context of GSCM. The emergence of the 'green port' concept is closely associated with the growing environmental awareness of seaport actors.

This report deals with the role of seaports in the greening of supply chains. The first chapter sets the scene by analysing the concept and practical implementation of GSCM. Next to more theoretical considerations on the origins and components of GSCM, the chapter provides multiple examples on GSCM practices applied by a wide range of companies. Chapter 2 moves the focus to the role and function of seaports in GSCM. Several fields of action to pursue GSCM objectives are identified for private and public actors involved in port-related activities. We make a distinction between actions in the areas of green shipping; green port development and operations; green inland logistics; seaports and the circular economy; and, actions in the field of knowledge development and information sharing. The empirical application is focused on the ports of the Rhine-Scheldt Delta region, the most important port region in Europe in cargo throughput terms. Chapter 2 concludes with a detailed overview of green actions and initiatives developed by market players and port authorities in the Rhine-Scheldt Delta ports.

A large-scale survey conducted in the Belgian and Dutch logistics and port industry forms the backbone of chapter 3. The survey questions were deducted from the themes discussed in chapters 1 and 2 of the report. The survey outcomes are analysed in detail with attention for possible linkages between the answers and differences in the answer patterns among respondent sub-groups.

The report concludes with a summary of the findings and a set of recommendations for the business communities in the Rhine-Scheldt Delta region in view of advancing the implementation of GSCM practices in seaports.

1 I A BROAD PERSPECTIVE ON GREEN SUPPLY CHAINS

1.1. Definition of green supply chains

Supply chain management (SCM) is the coordination and management of a complex network of activities involved in delivering a finished product to the end-user or customer. The process includes sourcing raw materials and parts, manufacturing and assembling products, storage, order entry and tracking, distribution through the various channels and finally delivery to the customer. Within supply chains, companies interact with external suppliers, internal departments, external distributors and customers. The successful management of a supply chain is influenced by customer expectations, globalization, information technology, government regulation, competition and environmental concerns.

Green supply chain management (GSCM) can be defined as integrating environmental concerns into the inter-organizational practices of SCM (Sarkis et al., 2011). Another similar definition is found in Srivastava (2007): 'integrating environmental thinking into supply-chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life'. We are aware that definitions slightly differ. For example, Ahi and Searcy (2013) found a total of 22 definitions for GSCM and 12 definitions for sustainable supply chain management. GSCM has gained increased attention within industry as there is a growing need for integrating environmentally sound choices into SCM practices. The growing importance of GSCM goes hand in hand with an escalating deterioration of the environment, e.g. diminishing raw material resources, overflowing waste sites and increasing levels of pollution. Adding the "green" component to supply chain management involves addressing the influence and relationships of supply chain management to the natural environment.

1.2. History and evolution of Green Supply Chain Management

The study and management of industrial pollution can be traced back to the start of the industrial revolution. The specialization of labour and companies which emerged during the industrial revolution led to the design and implementation of specific supplier and distribution channels. SCM evolved rapidly with the development of some of the initial best practices of modern supply chains, such as lean and just-in-time (JIT) manufacturing, in the 1920s by companies such as the Ford Motor Company. Early works on SCM (such as the study of Faurote, 1928) highlight that SCM during that period primarily focused on enhancing operational efficiency and minimizing waste. However, the avoidance and reduction of waste was driven by economic motivations, not for environmental reasons. At that time, industrial pollution was not a major topic of concern.

During the 1960s and 1970s, both economics and environmentalism had started to mature on the role of industry, its outputs, and implications on the environment. The work of Ayres and Kneese (1969) on the process from extraction to disposal in industrial processes is one of the earliest studies on the greening of the supply chain. The study talked about air and water pollution waste, the reuse of residuals and included early warnings of global climate change

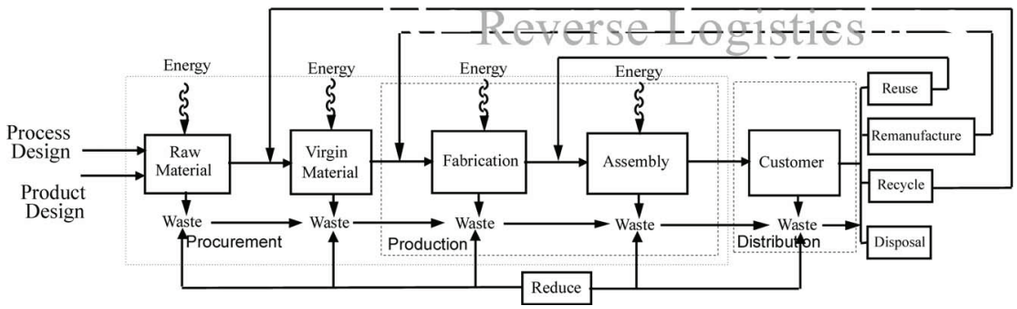
due to carbon and other greenhouse gas emissions. In the early 1970s, the focus shifted to the evaluation of process chains from raw materials to semi-finished or consumer products and the inventory of pollutants and waste during these processes. In the 1980s the concepts of 'industrial ecology' and 'life cycle assessment' were conceived. The growing regulations on environmental performance put an ever-increasing pressure on companies to move towards a greening of their supply chains.

In the 1980s, the pursuit of environmental excellence in product development, process design, operations, logistics, regulatory compliance and waste management was still spread over a large number of organizational units in companies. This started to change with the SCM revolution of the 1990s, when environmental management started to become more integrated in overall operations. For the first time, studies started to emerge that analysed environmental practices as a means to gain competitive advantage and economic benefits (see e.g. Frosch and Gallopoulos, 1989). The idea of using environmental strategies to gain competitive advantage was further developed by Porter and van der Linde (1995). Investments in greening can be resource saving, waste eliminating and productivity improving. Thus, the greening of supply chains does not have to be a burden but could constitute a potential source of competitive advantage (van Hoek, 1999). These ideas further ripened in the early 2000s with a slow mental shift from just being environment friendly to an integration of green initiatives as a way to achieve good business sense and higher profits. In other words, the industry started to show a growing awareness that GSCM could constitute a business value driver, not just a cost centre (Wilkerson, 2005).

1.3. Key features of Green Supply Chain Management

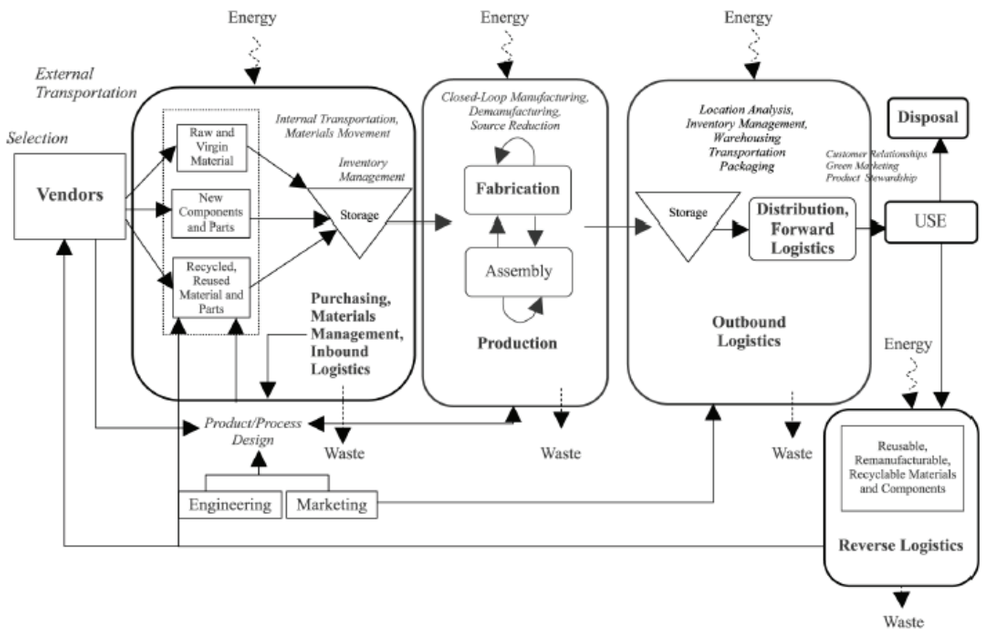
Figures 1 and 2 provide an overview of key aspects in green supply chains. The main idea is to strive for a reduction in environmental impacts by focusing on a series of R's throughout the supply chain: Reduce, Re-use, Recycle, Remanufacture, Reverse logistics, etc. GSCM is often linked to life-cycle assessment or analysis (LCA). LCA is as a process for assessing and evaluating the environmental, occupational health and resource-related consequences of a product or service through all phases of its life, i.e. extracting and processing raw materials, production, transportation and distribution, use, remanufacturing, recycling and final disposal. The scope of LCA involves tracking all material and energy flows of a product from the retrieval of its raw materials out of the environment to the disposal of the product back into the environment. The fields of actions in GSCM include product design, process design and engineering, procurement and purchasing, production, energy use and mix and logistics (incl. distribution and transportation). We discuss the main features in each of these fields in more detail in the sections below.

Figure 1: Functional model of an organizational supply chain with environmentally influential practices



Source: Sarkis (2002)

Figure 2: A further refinement of an organizational supply chain with environmentally influential practices



Source: Hervani et al. (2005)

1.3.1. Eco-design and green process engineering

Part of the environmental impact of any product, material or even service is determined in the design phase of the product or service, when materials and processes are selected. For example, effective reverse logistics practices largely depend on an eco-design focused on design for disassembly, design for recycling, and design for other reverse logistics practices.

Eco-design, also called design for environment (DfE) or environmentally conscious design (ECD), is helpful to improve companies' environmental performance and help organizations close the supply chain loop by addressing product functionality while simultaneously

minimizing life-cycle environmental impacts. One of the key aspects of eco-design is to facilitate reuse, recycling and recovery through smart design such as easy disassembly of used products. Next to the design of products for reuse, recycling and recovery of material, eco-design also involves other fields for action such as the design of products for reduced consumption of material or energy, or the design of products to avoid or reduce use of hazardous products and/or their manufacturing process. For example, a company might decide to replace a potentially hazardous material or process by one that appears less problematic, thereby taking into account potential impacts on the depletion of a potentially scarce resource or increased extraction of other environmentally problematic materials.

The roles of eco-design and environmental processes change with the stage in the product life cycle phase. When a new product is introduced, eco-design of the product is a key aspect. In the more mature and decline stages of the product life cycle, more focus will be on the improvement of processes and on having an efficient reverse logistics system in place.

Eco-design is an important GSCM practice that is aimed at combining product or service functionality with minimizing environmental impacts. Successful eco-design typically requires internal cooperation within the company and external cooperation with other partners throughout the supply chain.

1.3.2. Green procurement and purchasing

Enterprises have established global networks of suppliers that take advantage of country-industry specific characteristics. Key factors for green purchasing include providing design specification to suppliers that include environmental requirements for purchased items, cooperation with suppliers for environmental objectives, environmental audits for supplier's internal management, and suppliers' ISO 14001 certification. Companies can encourage their suppliers to develop environmental management systems in compliance with ISO 14001 [1], or even require their suppliers to be certified with ISO 14001. The procurement or purchasing decisions will impact the green supply chain through the purchase of materials that are either recyclable or reusable, or have already been recycled.

Many large customers, such as multinational enterprises, have exerted pressure on their suppliers for better environmental performance, which results in greater motivation for suppliers to cooperate with customers for environmental objectives. Also, the pressure of the final customer is a primary driver for enterprises to improve their environmental image and practices (see e.g. Christmann and Taylor, 2001).

Green procurement strategies are typically supported by national or supranational regulation. For example, the European Community Directives on Waste Electrical and Electronic Equipment (WEEE) and Registration, Evaluation and Authorization of Chemicals (REACH) have led many European and non-European suppliers to increase organizational efforts for product recovery.

[1] ISO 14001 is part of the ISO 14000 Series documentation. ISO 14001 Specifies minimum requirements for achieving ISO 14000 Certification. ISO 14004 Sets guidelines for developing an environmental management system (EMS). ISO 14010 Establishes the general principles of environmental auditing. ISO 14011 Establishes auditing procedures for the auditing of environmental management systems and ISO 14012 Establishes qualification criteria for environmental auditors (source: International Organization for Standardization)

1.3.3. Green production and remanufacturing

Green production complements eco-design, green purchasing and green logistics. Cooperation with suppliers and customers is indispensable to move towards cleaner and greener production processes.

Green production has often been associated with the concept of industrial ecology. Industrial ecology views the industrial world as a natural system, a part of the local ecosystems and the global biosphere (Lowe, 1990). Three levels can be distinguished in the industrial ecology (ecosystem) approach based on the amount of recycling or reuse of material that is within the system (Jelinski et al., 1996): a completely closed system with no material or energy leaving the system; a system characterised by some factor of energy and material reuse; and, a completely open system with little material or energy remaining within a system. Green supply chains play a critical and practical role to move from the lowest (third) level to the first level.

In practice, green production mainly focuses on (a) techniques for minimum energy and resource consumption in order to reduce the use of virgin materials; (b) a shift towards a more sustainable energy mix with less environmental and climate impacts; (c) techniques of product recovery; and (d) waste management.

Product recovery refers to the broad set of activities designed to reclaim value from a product at the end of its useful life in order to re-use products and materials. This can be achieved through recycling, remanufacturing, repair or refurbishment. Recycling is performed to retrieve the material content of used and non-functioning products and is often driven by regulatory and economic factors. Remanufacturing is recycling-integrated manufacturing (Hoshino et al., 1995). Remanufacturing systems often imply a thorough rethinking of traditional production planning and scheduling methods. Industries that apply remanufacturing typically include automobiles, electronics and tyres. The purpose of repair is to return used products to working order. The purpose of refurbishing is to bring used products up to a specified quality. Remanufacturing and the associated recycling activities typically involve disassembly to separate a product into its constituent parts, components, subassemblies or other groupings.

Cleaner production requires effective waste management for those products and materials that cannot be re-used. The supply chains of non-reusable waste involve waste collection, transportation, incineration, composting and or disposal. The general idea of cleaner production is to prevent pollution at the source rather than removing it after it has been created. Thus, cleaner production initiatives are also focused on preventing the creation of waste rather than managing it after it is generated.

1.3.4. Circular economy and reverse logistics

The transition to a circular economy, in which the value of products is maintained within the economy for the longest possible time whilst minimizing the generation of waste and using them as possible alternative raw materials as input for new production (feedstock concept), and the concept of Cradle to Cradle, a relatively new business model developed by Michael Braungart and William McDonough, in which products are designed for safe and recyclable use, are gaining ground, both in production processes, thus impacting consumption behaviour and patterns, and in supply chains.

The main driver for this shift consists of the short supply of raw materials and the subsequent soaring commodity prices. Transitioning towards a circular economy also protects companies from major and unexpected market fluctuations and geopolitical risks (Kuipers et al., 2015). Consumer preferences are also shifting away from the ownership concept towards models where they are willing to share or use products instead of owning them outright (MacArthur, 2014).

Therefore, this shift from a linear economy towards a circular economy should lead to the recuperation of used materials and resources at the end of the lifecycle of products, and this with a minimum of loss of quality. It requires the reverse supply chain to be completely closed (so-called closed loop supply chains).

Businesses and consumers are of course key in driving this process, and the European Commission for one, has adopted a "Circular Economy Package" laid down in an action plan "Closing the loop – An EU action plan for the Circular Economy", that next to a set of legislative proposals on waste to stimulate Europe's transition towards a circular economy, also includes a specific action plan aimed both at production (business) and consumption (consumers) and that need to be carried out before 2020 .

The impact of logistics herein is often underestimated. Even if it is clear that a strategy for product and process innovation with a closed loop of materials might be technically realistic, it will require logistics to support and achieve this. As long as the logistic chain cannot be closed in an efficient way, the circular economy model will not be "sustainable". The following criteria are crucial for the functioning of the circular economy model:

- Efficiency: the benefits of re-using materials replacing raw materials have to supersede the collection costs
- Effectiveness: collection needs to be organised in an effective way ensuring substantial volumes can be recuperated
- Ecological: the ecological impact of the collection of recyclables should be lower than the ecological gains attributed to recycling.

In other words, a true Cradle to Cradle concept comprises both production and logistic processes.

In practice, logistics often struggles with the collection of materials because of volume and cost constraints, as well as regulatory complexities. Reverse logistics operations and the supply chains they support are significantly more complex than traditional manufacturing supply chains. Thus, reverse logistics activities differ from those of traditional logistics. Collection is the first stage in the recovery process in which product types are selected and products are located, collected and transported to facilities for remanufacturing. Used products originate from multiple sources and are brought to the product recovery facility in a converging process where inspection and sorting of these used products takes place. Collection schemes can be classified according to whether materials are separated by the customers/users (i.e. separation at source) or centralized. The physical location of facilities and transportation links need to be chosen carefully as the transport network design has a large impact on the feasibility and total cost of reverse logistics.

1.3.5. Energy efficiency and changing the energy mix in supply chain management

Supply chains require energy to fuel production and logistics processes. The majority of the required energy for the coming decade will still be produced from fossil sources. The largest growth rate, however, will be seen for renewable energy sources. Changing towards a greener energy mix is a key field of action in GSCM.

Recent reports on 'The World Energy Outlook' of the International Energy Agency (IEA, 2016; 2017; 2018) summarizes the main issues affecting the longer-term global energy mix:

- The world's energy needs continue to grow. The IEA main scenario points to a 30% rise in global energy demand to 2040. Still, a higher energy efficiency and a growing use of cleaner energy sources worldwide should help to curb energy-related CO2 emissions.

- The share of electricity in global final energy consumption is approaching 20% and is set to rise further. Electricity is increasingly used in economies focused on lighter industrial sectors, services and digital technologies. In advanced economies, electricity demand growth is modest, but the investment requirement is still huge as the infrastructure needs to be upgraded.

- Efficiency gains from more stringent energy performance standards play an important role in the evolution of energy demand.

- Renewable energy is expected to see the fastest growth. Natural gas is expected to be the strongest grower among the fossil fuels, with consumption rising by 50% by 2040. Coal use saw strong growth in recent years, but for the future no further growth is expected. Growth in oil demand is expected to slow to 103 million barrels per day (mb/d) by 2040. By the mid-2030s developing countries in Asia are expected to consume more oil than the entire OECD.

- The objectives of the Paris Agreement on climate change, which entered into force in November 2016, can only be met when transformative change takes place in the energy sector. Countries are generally on track to achieve, and even exceed in some instances, many of the targets set in their Paris Agreement. While these efforts are sufficient to slow the projected rise in global energy-related CO2 emissions, they are insufficient to limit warming to less than 2 °C. Therefore, the EIA underlines the importance of the five-year review mechanism, built into the Paris Agreement, for countries to increase the ambition of their climate pledges. This should include actions in the field of (1) the acceleration of the deployment of renewables, nuclear power and carbon capture and storage; (2) greater electrification and efficiency across all end-uses; and (3) clean energy research and development effort by governments and companies.

- The main scenario in the EIA study shows that about 60% of all new power generation capacity to 2040 will come from renewables. The majority of renewables-based generation will be competitive without any subsidies. Therefore, EIA expects that by the 2030s global subsidies to renewables will start declining. However, cost reductions for renewables will be insufficient to secure an efficient decarbonisation of electricity supply. Structural changes to the design and operation of the power system are needed to ensure adequate incentives for investment and to integrate high shares of variable wind and solar power.

- The rise of solar power and wind power gives unprecedented importance to the flexible operation of power systems in order to secure enough energy at all times. The cost of battery storage declines fast, and batteries increasingly compete with gas-fired peaking plants to manage short-run fluctuations in supply and demand. However, conventional power plants remain the main source of system flexibility, supported by new interconnections, storage and demand-side response. The European Union's is aiming to create an "Energy Union" to deal with imbalances in demand and supply between different member states.

- Despite the above ambitions and expectations on the use of renewables, fossil fuels such as natural gas and oil will continue to form the backbone of the global energy system for many decades to come. By 2040 oil demand is expected to return to the levels of the late 1990s while the use of coal will move to levels last seen in the mid-1980s. Only gas will see an increase relative to today's consumption level. Based on an increase of oil price in the long-term, the trend for exploration of fossil energy sources will continue to offshore locations rather than onshore and to deeper waters and harsher environments. More complex energy sources such as tar sands or methane hydrates will also be exploited. Energy production on offshore wind farms will significantly increase and also other water-based energy production devices using wave and tidal current energy will have a larger market. These developments will lead to a large increase in renewable energy, particularly in Europe. It will also result in a significant increase in production and transport of cleaner fuels such as LNG, shale gas and hydrogen.

1.3.6. Green supply chains and Environmental Management Systems

An Environmental Management System (EMS) consists of "a collection of internal policies, assessments, plans and implementation actions affecting the entire organization and its relationships with the natural environment" (Coglianese and Nash, 2001). In practice, an EMS is a strategic management approach that defines how the company will address its impacts on the natural environment. An EMS typically includes the establishment of an environmental policy or plan; performing internal assessments of the organization's environmental impacts (including quantification of those impacts and how they have changed over time); creating goals to reduce environmental impacts, providing resources and training workers; checking implementation progress through systematic auditing to ensure that goals are being reached; correcting deviations from achieving goals and undergoing management review. An EMS can be regarded as a valuable element in improving environmental and business performance. Once an organization implements an EMS, it may elect to have it certified to the ISO 14001 standard. Organizations that develop an EMS typically show a higher regulatory compliance, which in turn can enhance their corporate image and increase profits (Stapleton et al., 2001).

There are different views on the relations between EMS and GSCM. One of the limitations of an EMS is that it mainly focuses on enhancing an organization's environmental performance, and not on extending this throughout the supply chain (Handfield et al., 2004). In other words, a company with an EMS may have little incentive to green their supply chains, since it can market itself as being environmentally focused (by having an EMS) without undertaking additional efforts. However, on the other side, by developing an EMS, a company develops skills and insights which can also be very useful when developing more comprehensive GSCM initiatives. Therefore, companies that adopt an EMS may actually have a stronger focus on implementing GSCM practices as well. Darnall et al. (2008) demonstrate that organizations

that adopt an EMS more frequently implement GSCM practices, regardless of how long the EMS has been in place. This suggests that EMS and GSCM may complement each other.

1.3.7. Green logistics, distribution and transportation

The implementation of GSCM has a large impact on how goods (should) move across supply chains. In that sense, GSCM implies a green logistics approach to connect the environmental concern with transportation, warehousing and distribution activities. Green logistics ties environmental and economic efficiency to logistics by trying to reduce the impact of the sector on the environment. Logistics service providers are challenged to be eco-conscious, fully comply with existing environmental regulation and prepare for upcoming regulation while performing their activities at the lowest cost possible. Logistics service providers have to focus on more supply networks in which clean forms of transport will meet all shippers' expectations as to cost and efficiency KPI's. Goods will have to be transported in an economically, environmentally and sustainable manner. To this extent, shippers will expect an orchestration function from service providers in which operational excellence is supported by the ability to obtain a greater convergence between physical and data processes. The main fields of actions in green logistics are related to:

- **Eco-friendly packaging**
  Packaging characteristics such as size, shape and materials have an impact on distribution due to their effect on the transport characteristics of the goods. Better packaging, along with rearranged loading patterns, can reduce materials usage, increase space utilization in the warehouse and in the transport modes, and reduce the amount of handling required. A good example of this is using strong and sturdy pallets, to ensure a long-term use. Systems that encourage and adopt returnable packaging require a strong customer supplier relationship as well as an effective reverse logistics channel. Efficiencies in packaging directly affect the environment. In many countries, take-back legislation on packaging has made the packaging operation and planning a critical environmental logistics consideration.

- **Eco-friendly transport mode choice and synchromodality**
  Environmental pressure from the customer base, society and legislation forces companies to systematically use greener alternatives for logistics. Advancing GSCM requires a massive re-engineering of supply chains in favour of a modal shift to environmental-friendly transport mode combinations and synchromodality. Modal shift and 'co-modality' policies have been implemented by supranational, national and regional governments aimed at stimulating the use of barges, rail and shortsea shipping. In the meantime, the terms modal shift and co-modality have made room for the notion of 'synchromodality'. The Platform Synchromodality defines this notion as "the optimally flexible and sustainable deployment of different modes of transport in a network under the direction of a logistics service provider, so that the customer (shipper or forwarder) is offered an integrated solution for his (inland) transport". A key characteristic of the concept is that not one single kind of party is leading in finding and implementing a synchromodal solution. Shipping lines, terminal operators, inland terminals, inland transport operators, 3PL companies, shippers and public authorities all have their role to play in the development of synchromodal solutions. Also, a synchromodal approach assumes that the shipper books a-modally thereby leaving the decision on the mode(s) of transport to be used to logistics service providers. This renders the whole transport system more flexible in terms of mode choice. Synchromodal transport especially has

potential on corridors and in regions where sufficient volumes are present; this allows for highly frequent transport by rail and barge.

- **Load and route optimization**
  One example of load optimization can be to send a truck only when it is fully loaded. Route optimization is about cutting transport costs, time or distance. By choosing the best route, is it possible to save fuel and, consequently, reduce the amount of emissions. Synchromodality makes it possible to consolidate consignments of cargo and find the optimal route, thus achieving additional efficiency benefits.

- **Green distribution networks and distribution hubs**
  The GSCM approach invites logistics service providers to include green considerations in the design and implementation of (European) distribution networks and the location choice and operational modalities of their distribution hubs and warehousing facilities. When it comes to overseas goods not all companies have the same distribution structure. Companies can opt for delivery without the use of a distribution centre, distributing through an EDC, distribution through a group of NDCs (National Distribution Centres) or RDCs (Regional Distribution Centres) or a tiered structure with one EDC and several supporting NDCs/RDCs. The choice is mainly influenced by the type of product and the frequency of delivery, but also green considerations increasingly surface when making such decisions. For example, distribution network configurations might evolve in case environmental costs of transport and distribution would fully be internalised in the transport and distribution cost (for example, through environmental taxes such as a CO_2 tax). The future distribution system configuration obviously has an impact on the cargo routing patterns and vice versa.

Co-operation between supply chain partners and the use of digital and integrated data solutions are key to support the above fields of actions. More horizontal collaboration between transport companies and logistics service providers is needed to deal with the need for shorter, more sustainable and cost-efficient supply chains. This will entail its own complexities, mainly where it concerns mutual trust concerning data-sharing protocols and protection of one's competitiveness. Logistics service providers will empower the supply chain with the support of ever more performant ICT systems. The data component will leverage performant and pro-active service providers to transform into companies that have a new outlook on the term of logistics services. Next to an increasing number of traditional activities being outsourced such as transport, warehousing and various types of value added services, the presence of collaboration platforms will capacitate certain service providers to develop new types of logistics services. The streamlining of supply chains through segmentation and standardization using advances in data analytics and visibility will lead to 'plug-and-play supply chain' (DHL, 2016) which can be described as finely-tuned, agile supply chains consists of core standardized, easily replicable solutions, augmented by standardized, process-proven bolts-on that are tailored to unique segments or market needs. These supply chains need to be supported by intelligent, data-driven decisions around customers and markets taking into account sustainability, profitability and service quality.

According to the European Technology Platform ALICE (Alliance for Logistics Innovation through Collaboration in Europe), the supply chain will evolve towards an open global logistic system founded on physical, digital and operational interconnectivity, through encapsulation, interfaces and protocol design, aiming to move, store, realize, supply and use physical objects throughout the world in a manner that is economically, environmentally and socially efficient and sustainable. It will require full standardisation of internationally recognised consignment codes in order to communicate throughout the physical realm of the chain. The various

transport systems and ICT platforms will have to integrate horizontally and vertically in order to become an open ICT infrastructure for the total logistics sector. In other words, the globally independently developed logistics networks will have to be connected enabling shippers an overall view. Maximal standardisation will be the open infrastructure's lubricant.

A last point relates to the circular economy. An important part of the success of the circular economy will hinge on the way smart logistics will enable the transparency needed to set up efficient and integrated fully circular supply chain networks. Next to the physical aspect of integrating supply chain flows to maximize circular economy opportunities, end-to-end integration of supply chain processes will be crucial. Thus, the circular economy will offer new opportunities for shipping and logistics service providers but will also challenge them to enter into closer collaboration with industry stakeholders.

1.3.8. The supporting role of service providers to achieve sustainability and green SCM

Service providers such as banks and insurance companies can and do take up a supporting role in order to enhance the transition to more sustainable and green supply chains.

The banking sector provides a good example. For example, ING Bank aims to double the so-called Climate Finance portfolio by 2022 compared to 2017. The banking sector finances wind farms, solar energy, and geothermal power production. ING Bank has developed 'Orange Circle', a circular economy programme, which has the ultimate ambition to help clients to transition to circular business models. It is based on the five pillars: knowledge (analyse the financial benefits of going circular), operations, deals (circular deals and relationships with circular clients), ecosystem (funding for circular business models) and innovation (work together with clients to develop circular propositions). Some circular deals include the merger of Shanks and Van Gansewinkel Groep to create Renewi, one of Europe's leading circular economy companies and the IPO of sustainable bio-plastics company Avantium.

Another key development in the banking sector is the 'Terra' approach launched in 2018. It is a holistic program of ING Bank co-created with the 2˚ Investing Initiative (a global think-tank for climate-related metrics in financial markets), to achieve a greener and more sustainable world. In a first phase, the approach is primarily focused on the sectors in the loan portfolio that are responsible for most greenhouse gas emissions: energy (oil & gas, renewables and conventional power), automotive, shipping & aviation, steel, cement, residential mortgages and commercial real estate. The overall lending portfolio of the banks is configured in such a way that it supports closing the gap between the current energy mix and the Paris Agreement climate targets. For example, the lending portfolio in the automotive industry is more directed towards R&D and production of electric cars. The approach recently entered a new stage when ING, BBVA, BNP Paribas, Société Générale and Standard Chartered signed the Katowice Commitment aimed at steering the banks' portfolios toward the well-below two degrees goal of the Paris Climate Agreement and to work together to further refine the metrics and tools needed to do this.

Other tools and instruments developed by the banking sector to promote sustainable and green supply chains include green loans, green bonds and the so-called 'sustainability loan initiative'. The latter initiative enables ING to support customers who are making progress in sustainability and to encourage corporate sustainability performance further. This can be done by linking the terms of a loan package provided to a client to the company's performance in terms of sustainability. The performance can for instance be based on the

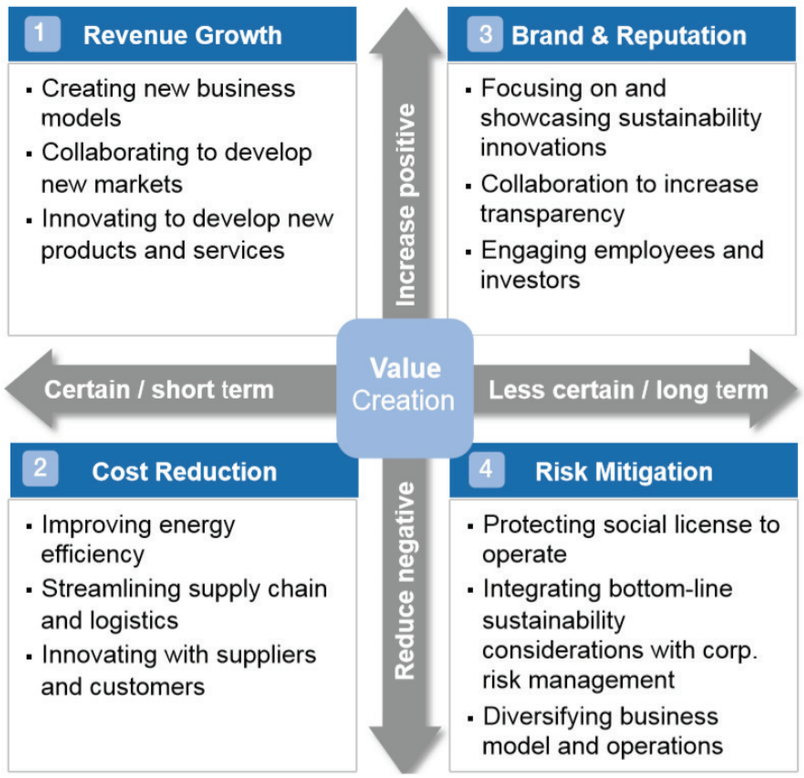
company's sustainability rating by Ecovadis or other rating agencies. The company bpost is one of the companies in ING's portfolio that has signed up for the initiative. ING acts as Joint Sustainability Coordinator for bpost's corporate revolving credit facility, supporting them in pursuing its CSR strategy. The pricing is linked to the Sustainalytics ESG rating of bpost: if the rating goes up (i.e. a better performance in terms of environmental, social and corporate governance or ESG), the margin goes down and vice versa.

1.4. Drivers of GSCM and companies' attitudes

There is a growing need for sustainability integration into supply chain management. Customers want companies to consider the environment when pursuing a more profitable supply chain (demand pull), while government regulation increasingly forces companies to become more environment friendly (regulatory push). Thus, companies might initiate the implementation of environmental practices due to motivational drivers such as sales to customers, and legislative and stakeholder institutional pressures. Diabat and Govindan (2011) identified the following drivers of green supply chain management: certification of suppliers' environmental management system; environmental collaboration with suppliers; collaboration between product designers and suppliers to reduce and eliminate product environmental impacts; government regulation and legislation; integrating quality environmental management into planning and operation process; reusing and recycling materials and packaging; environmental collaboration with customers; and reverse logistics. Thus, even though GSCM has significant environmental motivations, regulatory, competitive and economic pressures also play roles in its adoption across industries.

When focusing on the corporate context, there are clear signs that not opting for green supply chains can negatively affect companies' cost base and profitability, and that a focus on GSCM isneeded to secure revenue growth, achieve cost reductions, develop brand value and mitigate risks (Figure 3). World Economic Forum (2015) shows that companies like UPS, SABMiller, DHL, Unilever and Nestle are among 25 multinational companies that have increased their revenue by up to 20% while cutting supply chain costs as much as 16% thanks to a focus on sustainability. Profitability went up at almost the same rate a company's carbon footprint went down: carbon gas reduction was between 13-22%, while revenue was uplifted 5-20%. Furthermore, a focus on the environment has a positive impact on brand value: the WEF report argues that brand value increased an average of 15-30% when implementing GSCM practices. The mentioned report on "Beyond Supply Chains: Empowering Value Chains" outlines 31 best practices for businesses to follow. The basic idea is that companies work to achieve profitability through measures that benefit society and the environment at the same time.

Figure 3. A holistic view on value creation through GSCM



Source: WEF (2015) and Accenture

However, companies cannot blindly roll out green initiatives as part of GSCM. Logistics and supply chain managers have to balance efforts to reduce costs, improve service quality, increase flexibility and innovate while maintaining good environmental (ecological) performance. When deciding on green initiatives, companies take into account the above strategic performance requirements, which may not be environmentally based, such as cost, return on investment (ROI), service quality and flexibility. In other words, green initiatives should not only best support the green supply chain, but also result in a positive business case. Otherwise, the competitive and financial position of the company might be negatively affected.

Investment recovery is often cited as a critical aspect of GSCM. Investment recovery typically occurs at the back end of the supply chain cycle. Financial incentives or penalties given by public authorities (such as subsidies, tax breaks, etc. for green investments or penalties for non-compliance) or by private service providers (such as a commercial bank providing favourable loan conditions for green investments) are often very important in investment or divestment decisions and to achieve investment recovery.

As will be discussed in section 2 of this study, financial incentives and penalties are just one way for governments and public entities to support a further greening of supply chains. Whatever governments and public entities do in terms of environmental policy development, the business world is very sensitive to coherence and continuity in the developed policy, the legal (un)certainty of implemented policies, and the enforcement of policies through inspection and control. As many investment decisions have a medium to long-term payback time, any changes in government policy (for example, the abolishment of a subsidy scheme

for certain green investments) can have large ramifications on the soundness of the initial corporate decision related to a green initiative. Thus, government policies and regulation typically have a significant impact on green strategies, investments and GSCM initiatives pursued by companies, but should provide legal and investment certainty to the affected companies.

Even in less-regulated markets, some companies have engaged in green practices to reduce production costs, enhance brand image, meet changing customer expectations, protect aftermarkets, and pre-empt pending legislation or regulations. There is a growing awareness that GSCM can be an important business value driver (see earlier figure 3) and source for competitive advantage for companies. However, this does not imply that all companies are following the same approach when dealing with the GSCM challenges. In fact, companies' attitudes towards GSCM can range from reactive monitoring of the general environment management programs to more proactive practices implemented through the various Rs mentioned earlier (Reduce, Re-use, Recycle, Remanufacture, Reverse logistics, etc.). Kopicki et al. (1993) argued that companies can follow three different approaches in dealing with GSCM:

- *The reactive approach*: Minimal resources are committed to environmental management and the focus is very much on just meeting compliance in terms of environmental regulation;
- *The proactive approach:* Companies following this approach start to pre-empt new environmental laws by realizing a modest resource commitment to, for instance, initiate the recycling of products, reverse logistics and designing green products.
- *The value-seeking approach*: In this case, companies integrate environmental initiatives and activities such as green purchasing and green transport as strategic initiatives into their business strategy.

Companies have a series of alternatives/options available for improving the environmental performance of their supply chains. These alternatives may include technological, process, or organizational characteristics. For example, one such alternative might be an organizational goal to improve the total quality environmental management within and between organizations. ISO 14001 certification may also be a goal for the organization and its suppliers. This alternative is based on maintaining documentation and building an information network. Other alternatives may be the use of information systems and big data as part of a broader process of digital transformation. Information and communication technologies (ICT) are playing a key role in the co-ordination and integration of GSCM activities. Resource commitment to information technology can help to achieve superior environmental performance. Thus, digital transformation within and between companies may be primarily justified for other reasons, but can be evaluated also from a greening perspective.

Internal environmental management is central to improving enterprises' environmental performance. The support of senior managers is necessary and, often, a key driver for successful adoption and implementation of most innovations, technology, programs and activities in GSCM. For example, a study by Yeung et al. (2003) demonstrated that senior management's confidence is the most influential factor for the development of their quality management system. To ensure progress for environmental management and GSCM, top management, but also mid-level managers, must be fully committed.

Successful GSCM initiatives often involve several to many departments within and between companies, and this cooperation and communication is important to successful environmental practices. The inter-organizationally sharing of responsibility for various aspects of environmental performance is key to successful GSCM. In this vein, GSCM should

promote the sharing of environmental responsibility and lend itself to achieving a reduced environmental burden caused by industry. An example is Nestle: Nestle collaborates with rival PepsiCo, combining parts of their supply chain for fresh and chilled products in the Belgian market. The companies bundle warehousing, packaging and outbound distribution and synchronized deliveries to retailers to get full truck loads. As a result, transportation costs dropped 44%, carbon emissions were reduced by 55%, and retailer and customer satisfaction levels increased.

Not only individual companies can opt for co-operation on a bilateral or multilateral basis. Industry and branch organisations often play an important role in bringing companies together to take joint initiatives in GSCM. In other cases, private companies (sometimes with different backgrounds) and other organisations (such as public entities) form 'coalitions of the willing' to advance the design and implementation of GSCM solutions. These coalitions are associated with new models of governance to build trust among the parties involved and to achieve a fair distribution of costs/efforts and revenues/returns. Brewer and Speh (2001) present several concerns when developing GSCM initiatives and introducing performance measurement tools and systems across the greens supply chains:

- Overcoming mistrust: Trust in data sharing, acquisition and monitoring needs to be built;
- Lack of understanding: many managers are focused on internal systems, so moving to an inter-organisation scale often demands the development of a deeper understanding of what plays when co-operating with other parties in the chain;
- Lack of control: Managers and organizations are often focused on initiatives and measures they can fully control. Inter-organizational measures are difficult to manage and thus control;
- Different goals and objectives: the co-operation between organizations might lead to a confrontation between different goals and differing views on how to achieve these goals;
- Information systems: information systems often need to be adapted to include non-traditional information relating to (green) supply chain performance. Also, information exchanges between companies might be complicated by a lack of standards (in terms of units to use, structure, format, etc..) and harmonized protocols/procedures;
- Difficulty in linking GSCM to customer value: not all companies see the corporate and stakeholder value of co-operating with other companies in a GSCM context, or have difficulties in identifying and measuring possible value;
- Deciding where to begin: companies might face challenges when starting to develop supply chain-wide practices and related performance measurement. The U.S. Environmental Protection Agency (2000) provided four basic steps to implementing a green supply chain: (a) identify costs; (b) determine opportunities; (c) calculate benefits, and (d) decide, implement and monitor.

When engaging in GSCM initiatives, companies are challenged to measure the related performance. Existing literature provides a wide range of classifications, typologies and overviews of possible performance measures that can be used in a GSCM context, see examples in Tables 1 and 2. Table 1 give an example of a performance measure classification based on the Balanced Scorecard approach. Table 2 provide another approach to supply chain performance measures.

Table 1. Environmentally based performance measures by Balanced Scorecard categories

Financial	*Internal process*
Percentage of proactive vs reactive expenditures	Percentage of production and office materials recycled
$ Capital investments	# Certified suppliers
$ Operating expenditures	# Accidents and spills
Disposal costs	Internal audit scores
Recycling revenues	Energy consumption
Revenues from "green" products	Percentage of facilities certified
$ Fines and penalties	Percentage of product remanufactured
Cost avoidance from environmental actions	Energy use
	Greenhouse gas emissions
	Hazardous material output
Customer	*Learning and growth*
# Green products	Percentage of Employees trained
Product safety	# Community complaints
# Recalls	Percentage of renewable resource use
Customer returns	# Violations reported by employees
Unfavourable press coverage	# Employees with incentives related to environmental goals
Percentage of products reclaimed after use	# Functions with environmental responsibilities
Functional product eco-efficiency	Emergency response programs

Source: Hervani et al. (2005) based on Espstein and Wisner (2001)

Table 2. Example of a classification of GSCM performance measures

Performance Measure Classification	**Performance Measure (Measured over Product and Process Life Cycle)**
Resource Use	Total energy consumed Total material consumed
Product Recovery Remanufacturing Re-use Recycling	Time required for product recovery % recyclable/reusable materials (volume or weight) available at end of product life % product volume or weight recovered and re-used Purity of recyclable materials recovered % recycled materials (weight or volume) used as input to manufacturing % product disposed or incinerated Fraction of packaging or containers recycled Material Recovery rate (MRR) Core Return Rate (CRR) Ratio of virgin to recycled resources Ratio of materials recycled to materials potentially recyclable Materials Productivity: economic output per unit of material input
Product Characteristics	Useful product operating life Total mass of products produced
Waste Emissions and Exposure Hazard	Total toxic or hazardous materials used Total toxic or hazardous waste generated Solid waste emissions % product (weight or volume) disposed in landfills Concentrations of hazardous materials in products and by-products Estimated annual risk of adverse effects in humans and biota Waste ratio[2] : the ratio of wastes to all outputs.
Economic	Average life-cycle cost incurred by the manufacturer Purchase and operating cost incurred by the consumer Average total life-cycle cost savings associated with design improvements
Economic/Emissions	Ecoefficiency[3]: adding the most value with the least use of resources and the least pollution.

Source: Beamon (1999)

[2] Waste ratio = waste / (product + by-products + waste)

[3] Ecoefficiency = Value / (Resource Use + Pollution)

1.5. Main public policies to accelerate green supply chain practices

There is an important role for (inter)national governments and organizations in driving the developments in Green supply chains. Governments may or should act as catalysts for change. In the first place they are there to safeguard the public interests. They have the ability to set the pace for transformation by setting clear and ambitious policy goals, by establishing regulatory frameworks to implement their policies for reaching these goals, and by making available the resources needed for setting things in motion. But governments are not only responsible for the environment, they are also responsible for economic prosperity, the general welfare of the population, and overall socio-economic development. Their policy goals reflect this broad perspective on their responsibilities, incorporating a balance between environmental protection and economic growth.

The environmental policies of governments and other public entities can have a significant impact on GSCM. These policies typically define the emission and energy targets for economic activities and the mobility of people and freight. To reach these targets, a range of instruments and intervention mechanisms are available to public policy makers (see also figure 4). For instance, governments can change the behaviour of individuals and market actors by imposing restrictions and bans to eliminate or restrict choice. Through (environmental) pricing instruments, public policies can incentivize and penalize market actors active in supply chains. Moreover, non-regulatory and non-financial measures can be used to (gently) push towards greener solutions and transport modes.

Figure 4. Public interventions to enhance green behavior

	Regulation of the individual		Fiscal measures directed at the individual		Non-regulatory and non-fiscal measures with relation to the individual				
						Choice Architecture ("Nudges")			
Interventions category	Eliminate choice	Restrict choice	Guide and enable choice						
			Fiscal disincentives	Fiscal incentives	Non-fiscal incentives and disincentives	Persuasion	Provision of information	Changes to physical environment	Changes to the default policy	Use of social norms and salience
Examples of policy interventions	Prohibiting goods or services e.g. banning certain drugs	Restricting the options available to individuals e.g. outlawing smoking in public places	Fiscal policies to make behaviours more costly e.g. taxation on cigarettes or congestion charging in towns and cities	Fiscal policies to make behaviours financially beneficial e.g. tax breaks on the purchase of bicycles or paying individuals to recycle	Policies which reward or penalise certain behaviours e.g. time off work to volunteer	Persuading individuals using argument e.g. GPs persuading people to drink less, counselling services or marketing campaigns	Providing information in e.g. leaflets showing the carbon usage of household appliances **Regulation to require businesses to use front of pack nutritional labelling, or restaurants to provide calorific information on menus*	Altering the environment e.g. traffic calming measures or designing buildings with fewer lifts **Regulation to require businesses to remove confectionery from checkouts, or the restriction of advertising of unhealthy products*	Changing the default option e.g. requiring people to opt out of rather than opt in to organ donation or providing salad as the default side dish	Providing information about what others are doing e.g. information about an individual's energy usage compared to the rest of the street **Regulation to require energy companies to provide information about average usage*

*Note: * Demonstrates how regulation of businesses might be used to guide the choice of individuals, thus distinguishing it from regulation which restricts or eliminates the choice of individual.*

Source: Science and Technology Select Committee. Behaviour Change, House of Lords; HL paper no. 179; London, UK, July 2011.

Sustainability is at first a global issue, it is about our planet. Logically at all governmental levels of society we find policy goals related to sustainability: goals for sustainability in general and goals for sustainable supply chains specifically. This section gives an overview of those governmental goals, at the different governmental levels, which are relevant for the greening of supply chains. For this study we consider these goals as setting the context in which

greening of supply chains need to take place, is stimulated and is enabled to take place. The policy goals will be sorted on three levels of geographical scope. From broad to narrow the following three scopes will be applied: Supranational, EU and National, the latter referring to the Netherlands and Belgium/Flanders as the relevant units for this study. We also discuss some of the main public policy frameworks that have been designed to reduce environmental impacts of human activities, to achieve a more sustainable mobility of people and freight and to move to a greener and circular economy.

1.5.1. Supranational goals

At supranational level sustainability goals are developed within various global organisations/institutes, each consisting of a set of member-countries. These member countries then commit themselves to the jointly agreed-upon policy goals. This means that they develop their plans and policies in line with those goals. The most relevant organisations/institutes are mentioned below.

United Nations Sustainable Development Goals
The United Nations presented the agenda for Sustainable development in 2015: The Sustainable Development Goals (SDGs). The SDGs build on decades of work by countries and the UN, including the UN Department of Economic and Social Affairs. This agenda presents the goals that are crucial for reaching a sustainable development of our planet from an environmental perspective. In total, 17 main goals are set which should all be reached in 2030 (see figure 5). The United Nations defines sustainable development as: “the needs of the present without compromising the ability of future generations to meet their own needs”.

Figure 5. UN Sustainable Development Goals

Source: United Nations

In the 2030 Agenda for Sustainable Development, sustainable transport is mainstreamed across several SDGs and targets, especially those related to food security, health, energy, economic growth, infrastructure, and cities and human settlements. The transport sector will be playing a particularly important role in the achievement of the Paris Agreement, given the

fact close to a quarter of energy-related global greenhouse gas emissions come from transport and that these emissions are projected to grow substantially in the years to come.

The first main goal that matches with green supply chains is “responsible consumption and production”. This goal is mainly about promoting resource and energy efficiency and sustainable infrastructure. The most important sub-goals related to green supply chains are:

1 By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses;
2 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment;
3 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse;
4 Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle;
5 By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature;
6 Promote sustainable procurement practices to companies and organizations.

The second main goal is about promoting climate actions worldwide. The most important sub-goals are:

1 Integrate climate change measures into policies and strategies;
2 Implement the commitment of supporting developing countries with the 91 billion euros as stated in the Paris Agreement.

Paris Agreement

The Paris Agreement is an international agreement between 195 countries to reduce the GHG emission worldwide. On the 12th of December 2015 this agreement was presented at the climate conference in Paris and will hold for the period 2020-2050. The main points that are agreed upon are the following:

- The average temperature on earth may not increase more than 2 degrees Celsius compared to the pre-industrial area because researchers think this could distort the climate-systems on earth dramatically. The aim is therefore to not let the temperature further increase than 1,5 degrees.
- Every country should aim to implement measurements as fast as possible to reduce extra damage on the environment.
- All 195 countries need to report on their goals in relation to the scientific knowledge that is available and the state of the climate at that moment.
- Negative consequences of climate change should be tackled with urgent measurements. Though food production should not be in danger.
- The climate agreement is binding. All 195 countries are obligated to follow the agreement. Though, goals within countries and the level of money for the climate fund are not fixed.
- From 2020 onwards, every year 91 billion euros needs to be mobilized by the participating countries to support climate measurements in developing countries.

The Paris Agreement requires all Parties to put forward their best efforts through nationally determined contributions (NDCs) and to strengthen these efforts in the years ahead (as of 2015).

1.5.2. European goals

The EU and its national governments have set clear objectives in line with the Paris Agreement to guide European environment policy via 2020 and 2030 until 2050, with the support of dedicated research programmes, legislation and funding (European Commission, www.ec.europa.eu)

EU 2020

The 2020 package is a set of binding legislation to ensure the EU meets its climate and energy targets for the year 2020. The targets were set by EU leaders in 2007 and enacted in legislation in 2009. They are also headline targets of the Europe 2020 strategy for smart, sustainable and inclusive growth. The package sets three key targets for 2020:

- 20% cut in greenhouse gas emissions (from 1990 levels)
- 20% of EU energy from renewables
- 20% improvement in energy efficiency

For cutting the 20% in greenhouse gas emissions the EU emissions trading system is the EU's key tool. It focuses at the large-scale facilities in the power and industry sectors, as well as the aviation sector. These sectors, and as a consequence the ETS, cover around 45% of the EU's greenhouse gas emissions. In 2020, the target is for the emissions from these sectors to be 21% lower than in 2005.

For the sectors not in the ETS, such as housing, agriculture, transport and logistics (not aviation), national emission reduction targets have been formulated and EU countries have taken on binding annual targets until 2020 for cutting emissions in these sectors (compared to 2005), under the "Effort-sharing decision". The targets differ according to national wealth – from a 20% cut for the richest countries to a maximum 20% increase for the least wealthy). Progress is monitored by the Commission every year, with each country required to report its emissions.

EU member countries have also taken on binding national targets for raising the share of renewables in their energy consumption by 2020, under the Renewable Energy Directive. These targets also vary, to reflect countries' different starting points for renewables production and ability to further increase it – from 10% in Malta to 49% in Sweden. The overall effect will enable the EU as a whole to reach its 20% target for 2020 (more than double the 2010 level of 9.8%) and a 10% share of renewables in the transport sector.

EU 2030

The 2030 climate and energy framework presents three key targets for the year 2030:

- At least 40% cuts in greenhouse gas emissions (from 1990 levels)
- At least 27% share for renewable energy:
- At least 27% improvement in energy efficiency

To achieve the at least 40% target for cuts in greenhouse emissions, the EU emissions trading system (ETS) sectors would have to cut emissions by 43% (compared to 2005). To achieve this, the ETS is to be reformed and strengthened. Non-ETS sectors would need to cut emissions by 30% (compared to 2005) – this needs to be translated into individual binding targets for Member States.

Together with the targets set for renewables and improvement in energy efficiency, also for the cost side of the new energy systems goals are set, showing the balance that is sought between the environment and the economy:

- Costs do not differ substantially from the costs of renewing an ageing energy system, necessary in any case
- Total cost of the energy system in 2030 is projected to increase by an equivalent of 0.15% of the EU's GDP, if targets are met cost-effectively
- Overall there is a shift from operational costs (fuel) to capital costs (investments)

EU leaders adopted the framework in October 2014. It builds on the 2020 climate and energy package. It is also in line with the long-term perspective set out in the Roadmap for moving to a competitive low carbon economy in 2050, the Energy Roadmap 2050 and the Transport White Paper.

EU 2050
The vision for 2050 is at least 80-95% less Co2 compared to 1990, but leading to a climate neutral economy

1.5.3. Dutch policy goals

The Netherlands has its own climate agreement (Klimaatakkoord, December 2018), which has the aim of reaching the goals that are signed in the Paris agreement. Five “sector tables” have been formed in which representatives from each sector, together with governmental parties form concrete plans and actions for reaching the climate goals. The time horizons used in the agreements are 2019-2030 and 2030-2050. On the 21th of December 2018 the sector tables agreed upon their plans and presented the agreement to Minister Wiebes of Economic Affairs and Climate. In general, the process to come to clear, accepted and far reaching goals is a difficult one. At the final stage of binding agreements, actors hesitate to commit, quite often for economic reasons. In its plea towards all stakeholders involved the Dutch Minister (Wiebes) expresses the following starting points from his part:

- It is an issue of all acting together;
- The Netherlands is not aiming to do more than other countries, but at least to start earlier and make quicker progress;
- The measurements must be cost-effective: at least the most cost-effective measurements should be chosen.

In the remaining part of this chapter the focus will be on the goals and plans that are set by the sector table “mobility”, which is the most relevant for green supply chains.

Vision and Ambition of the Table Mobility for 2050
The members from the climate table mobility aim to achieve in 2050 flawless mobility for everything and everyone. Emissions should be eliminated and everybody, from young to old, rich and poor, should be able to reach every destination. Smart, sustainable and compact cities with an optimal flow of people and goods is the way it should be. Each area in the Netherlands should be attractive to live and mobility should be the flawless link between living, working and leisure time activities.

To reach the overall goal for the greenhouse gas emission of Co2 reduction with at least 95 percent compared in 2050, compared to 1990. For the mobility sector three goals are set:

- Clean: zero emission will be the norm and autonomous driving vehicles will make a breakthrough. Hydrogen fuels will become the standard option for freight traffic
- Smart: Chain management and zero emission-concepts are the standards
- Different: Multimodal hubs will have a central role in logistic chains

2030: Tasks and ambitions

The ambition is to reduce the Co2 emissions with 25 Mton in 2030. This means that 7,3 million Mton should be reduced until 2030, which is the stepping stone towards the emission reduction as stated for 2050. The climate table has set four main themes with ambitions to reach the goals until 2030. The relevant themes for this study are sustainable energy, stimulation of electrical transport and sustainability in logistics and Sea transport & air transport. An overview of those ambitions follows below.

Sustainable energy

- Use of renewable fuels
- Stimulation of hydrogen power
- Sustainable purchases of governments

Stimulation of electrical transport

100% zero – emission car sales in 2030

Sustainability in logistics

- ZE-zones freight transportation: The ambition is to set 30-40 Zero-Emission zones (ZE-Zones) before 2020. Those zones should be valid for freight transportation from 2025. This period of 5 years is set to give companies and local governments enough time to adapt to these zones. Reduction 1,0 Mton.
- ZE-zones construction traffic: The ambition is to set ZE-zones for construction traffic. This is linked to the green-deal and green-deal building-logistics which are initiatives from governments and companies in the building sector which aims to reduce Co2 from construction traffic. Reduction 0,4 Mton.
- Climate neutral infrastructure networks:
- Reduction of 30% in hinterland and continental transportation:
- Barge: 150 Zero-Emission barge vessels in 2030.

Shipping and Aviation

Agreements about shipping and aviation transportation are not part of the sector table Mobility. The sector Mobility argues that mainly international agreements are being made due to the cross-border characteristics of those transport modes. The separation of those modes has also been made in the Paris Agreement. Although those transport modes are not included in the Dutch Climate Agreement, there are international and national ambitions to reach a reduction in CO2 within those sectors. Those ambitions will follow below.

International ambitions in shipping (as stated by IMO)

- 2050: 50% reduction of CO2 for international sea transportation compared to 2008 and the ambition to become climate-neutral in the years that follow after 2050
- 2030: 40% reduction on average for international shipping

International ambitions in aviation (as stated by ICAO)

The IACO is only responsible for CO2 reduction ambitions in international aviation, whereas separate countries are responsible for CO2 reduction in inland aviation.

Besides those international organizations also initiatives on a national level are undertaken. The shipping sector is working on the “Green Deal Shipping, Barge and ports” on an action plan to reduce the Co2 emission with 40% in 2030, which is equal to the goal of the IMO. Also, the aviation table wants to actively support the in the reduction of emissions for inland aviation.

1.5.4. Flemish policy goals

In order to achieve the Paris agreement objective, the Flemish government wants to reduce greenhouse gas emissions drastically over the next 30 years. This requires a trend break. To do so, a proposal ("voorontwerp") for a climate policy for the period 2021-2030 was presented in June 2018 (Vlaamse Overheid, 2018). In line with the objective imposed by the EU for Belgium, the plan lays down the objective of reducing greenhouse gas emissions in Flanders by 2030 by 35% compared to 2005. In the plan, the required effort is mapped per sector, and, where necessary, the greenhouse gas target is converted into sub-objectives. In addition, the plan also includes the main measures necessary to achieve this objective and to prepare Flanders towards a low-carbon future. This plan also reflects the level of ambition of the so-called "Climate Resolution", which was approved by a large majority in the Flemish parliament in November 2016. The strategy outlined in the resolution and the recommendations made are largely elaborated in the plan.

The plan forms a strategic framework for policy-makers over the next ten years. Given the rapidly changing technological and economic conditions, certain measures can be implemented differently in practice, but the broad lines of policy are fixed. It is important to note that the plan focuses on sectors not covered by the European system of Tradable Emission Rights (EU ETS). Transport is one of these non-ETS sectors, next to the built environment, agriculture, waste and a small part of the industry.
The European Effort Sharing Regulation (ESR) regulates that the European Member States reduce their greenhouse gas emissions in the non-ETS sectors in the period 2021-2030 to a linearly decreasing path. This linear trajectory is determined, for Belgium, as follows:

- The starting point of the path is laid in May 2019 on the average non-ETS emissions in the years 2016, 2017 and 2018.
- The end point of the route is 2030 and is recorded at the level of non-ETS emissions in the year 2005, minus the reduction target set for Belgium in the ESR, namely 35%.

The final emission ceilings for the years 2021-2030 are determined by the European Commission only in 2020, on the basis of non-ETS emissions in the base years (2005, 2016, 2017 and 2018) in the emission inventory which is to be provided by the Member States in that year. The path for Flanders included in the Flemish climate policy plan assumes that the route for each region is built up in the same way as the routes of the Member States.

Specific targets and policy instruments for the transport sector
The greenhouse gas emission target for road transport is a decrease of at least 27% by 2030 compared to 2005. The plan also targets a decrease in the number of kilometres by road to max. 51.6 billion vehicle-km in 2030. This means a decrease of 12% compared to 2015 for passenger cars and vans and a limitation of the increase to a maximum of 14% for trucks.
There are also targets related to a spatial planning that supports climate-friendly mobility and sustainable accessibility. In 2030, more than half of the population should live in well-accessible locations. More than 60% of the employment sites should be easily accessible. Important societal functions should be accessible to all in a smooth and secure way with sustainable (collective) means of transport or a combination of them. Relevant for the greening of supply chains is that the climate policy plan states that logistical flows should be organised in a sustainable way (i.e. focus on a good balance between economy, smooth accessibility, viability and road safety).

The Flemish government wants to promote the further development of a multimodal transport system. In commuting, the proportion of sustainable modes should increase to at least 40% (i.e. car use max. 60%). In the highly urbanized transport regions of Antwerp, Ghent and the “Vlaamse Rand”, the proportion of sustainable modes should be at least 50%. In freight transport, a shift of 6.3 billion tonne-kilometres from the road to alternative modes of transport (via waterway or rail) should be realised by 2030. The share of rail and inland waterways in the modal distribution should increase to 30%. In the various seaports, the use of sustainable modes should be strongly used. The combined share of these modes (rail, inland waterways and estuary shipping) should increase by 5 to 10% by 2030 compared to the total (compared to 2013).

To promote sustainable travel and transport behaviour, the Flemish government is considering the implementation of a budget-neutral smart kilometre charging system for all light vehicles, eliminating the fixed vehicle taxes. Such a kilometre charge is hoped to reduce vehicle kilometres, reduce congestion on roads, apply the "user pays" principle and internalise external costs. The environmental performance of the vehicles would be taken into account when fixing the charge. At the same time, good (mobility) alternatives will be further developed. When a smart kilometre charge for light vehicles is introduced, the Flemish government also intends to evaluate the existing kilometre charges for trucks and examine how it can be differentiated based on the time and place.

The climate policy plan also focused on the transition to low carbon and zero-emission vehicles. It is the objective that, from 2030, all newly sold passenger cars are low carbon, of which at least half are emission free. In the case of newly purchased heavy goods vehicles, the proportion of low-carbon vehicles in 2030 should be at least 5%. In 2030, at least 30% of newly purchased light trucks/vans should be low-carbon vehicles. In the use of combustion engine technology, the government targets the maximum utilisation of recycled carbon fuels (recycled carbon fuel) and biofuels.

A wide range of policy instruments and tools are proposed to reach the above targets. In summary they relate to the following domains:

- Demand-driven investments in accessibility and connectivity, also to support the modal shift;
- Spatial planning aimed at climate-friendly mobility and sustainable accessibility;
- Steering mobility by developing an integrated multimodal and synchromodal mobility system, by changing mobility behavior through incentive and penalty pricing and new approaches to (road) pricing mechanisms taking into account time, place and environmental vehicle profile (such as the introduction of a smart kilometre charge) and by monitoring climate and air quality objectives in the evaluation of traffic-generating functions and large infrastructure projects;
- See to it that emissions decrease in practice, for example, by helping to implement more realistic test cycles for new vehicles; by developing traffic management systems (such as a network of electronic sings with variable maximum speed indication, trajectory control, smart traffic lights, etc.)
- Greening of the vehicle fleet: One of the policy instruments is the European Clean Power for Transport Directive (CPT Directive). Flanders endorses the objectives of the European CPT Directive, with an ever-increasing share of vehicles with alternative drives being the target. The Flemish ambitions in this area have been outlined to 2020 in the Flemish ‘CPT Action Plan’. The ambitions up to 2030 will be worked out in a new CPT vision. Flanders’ policy is focused on low-carbon and zero-emission vehicles by giving financial incentives to support a transition to a green fleet, by stimulating the use of electric and zero-emission vehicles, by supporting the development of

charging and fuel stations; and by actively participating in the specification of new European emission norms.

The Flemish government is aware that a transition to zero emission is less evident for trucks. In the coming years, the government looks forward to more new trucks based on advanced renewable fuels (bio and synthetic), with fuel cells, supported by innovations in the area of batteries and charging infrastructure. In the transitional period to low carbon freight transport, CNG and LNG are alternative fuels for trucks. A "Roadmap for the reduction of climate and air emissions from freight transport" was launched in early 2018. The results and recommendations that result from this will be reviewed and, if appropriate, stimulated and/or implemented. The Flemish government is already providing funds for the greening of trucks. There is still a lot of potential as this aid is not yet fully used and budget is available. The government argues that the further provision of resources for the greening of trucks continues to make sense in the coming years, but this is best coupled with the drafting of a greening plan by fleet owners.

As mentioned earlier, the Flemish government sees the development of an integrated multimodal and synchromodal mobility system as an important factor to reach a greener mobility. The further development of a hierarchical network of multimodal nodes (such as seaports and inland ports) where users can switch between different modes is key to reach a multimodal integrated transport system. This also requires a good exchange of information. A stronger linking of different networks implies seamless data exchange between different modes and offering customised freight mobility solutions. Technological developments in logistics simplify the flow of information and facilitate the cooperation between the chain players. The Flemish government is convinced that this facilitates genuine synchromodality with a more prominent role for inland waterway transport and rail transport in the transportation of goods. Both the emissions resulting from maritime transport and inland waterway transport can be remediated mainly through the use of cleaner fuels and engines and the use of shore power solutions.

1.6. GSCM by shippers and logistics service providers: some examples and best practices

The greening of supply chains is not only something for the future, it is already happening today. Shippers, logistic service providers (LSP) and other service providers undertake actions to develop a greener supply chain. In this part the focus is on the current sustainability initiatives and investments that are set up by logistics service providers, shippers, other companies and non-governmental organizations (NGOs). Port Authorities and direct port-related companies will be excluded in this part because those actors will be the focus in part 2 of the study. It is important to note that the initiatives that are discussed in this chapter are purely illustrative for what is going on in the broader supply chains. Some good initiatives within supply chains might therefore be ignored while good actions are undertaken, but this is inevitable.

Each green initiative will be sorted under one of the categories of section 1.3. However, no examples are given for two categories of the seven categories, i.e. eco-design and green process engineering and green production and remanufacturing. These two categories are very much focused on the production stages of products and less on the external logistics processes and goods flows. However, it is obvious that shippers also develop green initiatives in these areas. For example, packaging design is part of eco-design and can have a large impact on reverse logistics and the overall reduction of transport. A good example is Ikea which is constantly (re)designing product packaging to make them more eco-friendly (for example by using cardboard instead of plastics) and to reduce the volume and weight of the product (impact on transport costs) without increasing damage risks. Next to the categories of section 1.3 we also added some other examples which cover initiatives of NGOs.

A specific template structure is used to analyze each initiative which is as following: company description, company categorization (Shipper, LSP or Other), initiative explanation and status. A critical assessment will follow at the end of this paragraph about the true impact of those initiatives on making supply chains greener.

1.6.1. Green procurement and purchasing

Green procurement and purchasing is about considering the level of greening that suppliers apply in their company processes, while considering which supplier to choose for the delivery of products and services. See 1.3.2 for more information. Examples are provided below.

Coca Cola European Partners

Company description	Coca Cola European Partners is a global beverage producing company. In 2017 23.5 thousand employees worked at the company. Over the same year Coca Cola realized a revenue of 11.1 billion Euro.
Company categorization	Shipper
Initiative	Sourcing locally: 65% of purchases are from the Netherlands, 99.7% of the purchases are from Europe. Buying more locally leads to lower transportation costs and lower Co2 emissions.
Status	Ongoing https://www.cocacolanederland.nl/content/dam/journey/nl/nl/private/file-assets/NL-CSR-Report-Downloadable-Version-2015-2016.pdf

Deutsche Post DHL Group

Company description	DHL and Deutsche post group form the biggest post & logistic service provider in the world. Worldwide more than half a million people are employed. In the Benelux 6.000 Parcel workers are active.
Company categorization	LSP
Initiative	New acquisitions: any new acquisition of assets should be more carbon efficient than the asset that will be replaced. This is a group-wide policy.
Status	Ongoing https://www.dpdhl.com/en/responsibility/environment-and-solutions/gogreen-program.html

BICEPS Network

Company description	The BICEPS Network is a network of shippers joining forces to accelerate the transition in the global shipping sector towards more sustainability.
Company categorization	Shippers
Initiative	The BICEPS Rating System is an instrument that will be used by shippers in their global procurement processes of ocean freight container carriers. The rating system qualifies the carriers on their performance on five relevant themes for sustainable and effective shipping operations. Members are: AB InBev, Akzo Nobel, DSM, Elkem, Farm Frites, Friesland Campina, HUNTSMAN, IOI Loders Croklaan, LambWeston and Vion.
Status	Launched and ongoing https://bicepsnetwork.org/about/

1.6.2. Circular economy and reverse logistics

In a circular economy the value of products is maintained within the economy for the longest possible time whilst minimizing the generation of waste and using them as possible alternative raw materials as input for new products. Reverse logistics play an important part in bringing back those products to recycling facilities. See 1.3.4 for more information. Examples are provided below.

Avantida

Company description	Avantida is a cloud-based, online platform offering services that aim to transform traditional container logistics processes.
Company categorization	Other
Initiative	Avantida created a platform for the re-use of containers in 2011. Transport companies can request to reuse the empty container and bring it straight to their export customer to get loaded instead of bringing it back to the port or assigned depot. Avantida took over the ownership of the MICCS system from MSC Belgium NV in 2012.
Status of initiative	Implemented and on-going

Timberland

Company description	Timberland is a shoe company that delivers shoes worldwide
Company categorization	Shipper
Initiative	Timberland has partnered with a tire manufacturer named Omni United. Footwear is one of the biggest rubber consumers so both partners decided to bundle their forces. Rubber tires that are at the end of their lifetime are now used in the production process of outsoles in Timberland shoes.
Status of initiative	Implemented and on-going https://www.timberlandtires.com/our-story/

Contraload

Company description	Asset pooling company
Company categorization	Other
Initiative	Contraload aims 100% circularity by 2022. This means sourcing food-approved raw materials from recycled plastics and pushing virgin material out. It also means working with customers to improve tracking and tracing and to get to a zero loss of pallets and bins. Re-use assets, when broken re-pair, if unrepairable than re-grind and re-use the raw material. If possible upcycle other plastics.
Status of initiative	on-going

1.6.3. Changing the energy mix in supply chain management

Changing the energy mix is about using cleaner fuels to transport goods and services along the supply chain. This is needed to accomplish the CO2 reduction goals that are stated in the Paris agreement and other policy goals. See 1.3.5 for more information. Examples are provided below.

DB Schenker

Company description	DB Schenker is a worldwide logistic service that supports industry and trade with transportation over land, air and sea. In 2018 it reported a revenue of 21.5 billion dollars and the company employs 95,000 people worldwide.
Company categorization	LSP
Initiative	Bio-Fuel: increasing the proportion of bio-fuels in 2017 to 36%
Status	Ongoing https://www.dbschenker.com/resource/blob/530418/872f7d56a0260234dfc0200646064ba3/sustainability-report-2017-data.pdf

AB InBev

Company description	AB InBev is a beer producing company which sells beer worldwide. In 2017 it had a revenue of 56.4 billion euros and the company employed almost 183.000 people.
Company categorization	Shipper
Initiative	Pre-order of 40 Tesla Trucks: in 2017 Ab InBev set a pre-order of 40 Tesla trucks. Important to note is that AB InBev uses subcontractors for its truck transport and that it is still uncertain which party will be the owner of the trucks. This pre-order is part of the ambitions to reduce 30% total Co2 emissions in the 2025.
Status	Trucks are pre-ordered

Heineken

Company description	Heineken is a beer producing company which sells beer worldwide. In 2017 it had a revenue of 21.9 billion euros and the company employed 76,000 people.
Company categorization	Shipper
Initiative	Green corridor: Heineken aims to make the brewery in Zoeterwoude (The Netherlands) climate neutral. They are planning to do this by investigate in electrical propulsion systems, let the Alpherium terminal run on sustainable energy and making bridges and locks carbon neutral.
Status	Until now this is an ambition. https://www.theheinekencompany.com/sustainability/case-studies/green-corridor

Ninatrans

Company description	Ninatrans is a transport company specialized in time-critical transport.
Company categorization	Logistics Services Provider
Initiative	While Ninatrans recently invested in LNG (Liquid Natural Gas) trucks, it also believes in another technology for the future for long-distance transport, in particular trucks powered by hydrogen. In the beginning of 2018, Ninatrans placed a pre-order for trucks with the American brand Nikola. Nikola is developing a model specifically for the European market, the Nikola TRE. This model, of which Ninatrans has ordered 10, will be officially presented in the United States in the spring of 2019. The Nikola TRE has a range of 500 to 1200 km, depending on the options.
Status	Trucks are pre-ordered.

Kaneka Belgium

Company description	Kaneka Belgium NV is a subsidiary of Kaneka Corporation, a leading technology-driven chemical company, with headquarters in Japan. Business activities span a broad spectrum of markets, from chemicals, functional plastics, food products, life science, synthetic fibers to electrical and electronic materials.
Company categorization	Shipper
Initiative	Kaneka set itself a five-year goal of realizing a CO2 reduction of 14 kg CO2 / 1000 kg sold products, or 22.1% reduction in its logistic processes. The company will significantly reduce road transport to the port(s) by maximizing inland shipping and rail transport. In line with its 'green procurement' strategy, Kaneka Belgium is aiming to optimize cross-company partnerships in multimodal freight transport. Moreover, Kaneka has recently opened a new, onsite distribution center, resulting in a decreased number of shuttle transports to external warehouses.
Status	On-going

1.6.4. Green supply chains and Environmental Management Systems

An Environmental Management System (EMS) consists of "a collection of internal policies, assessments, plans and implementation actions affecting the entire organization and its relationships with the natural environment" (Coglianese and Nash, 2001). In practice, an EMS is a strategic management approach that defines how the company will address its impacts on the natural environment. See 1.3.6 for more information. Examples are provided below.

Deutsche Post DHL Group

Company description	DHL and Deutsche post group form the biggest post & logistic service provider in the world. Worldwide more than half a million people are employed. In the Benelux 6,000 Parcel workers are active. The revenue of DHL was 60.4 billion euros in 2017.
Company categorization	LSP
Initiative	DHL provides its customers with the Carbon Calculator, which gives customers insight in the carbon footprint of their logistic activities via DHL.
Status	Launched and ongoing. https://www.logistics.dhl/content/dam/dhl/global/core/documents/pdf/gogreen/dhl-gogreen-carbon-calculator-062016.pdf

Unilever

Company description	Unilever is an international company specialized in fast moving consumer goods which has over 400 brands in their portfolio. In 2017 Unilever had 169,000 employees and the company made had a total revenue of 53.7 billion euros.
Company categorization	Shipper
Initiative	Unilever is an example of a company which has an Environmental Management System (EMS) in place. This system is part of the sustainable living program of Unilever which states how Unilever plans to decouple the growth of the environmental footprint, while increasing a positive social impact. The EMS is based on ISO 14001 and consists of a circle with 5 elements, which repeats itself. The elements are: environmental policy, planning, implementation and operation, checking and management review.
Status	Launched https://www.unilever.com/sustainable-living/

1.6.5. Green logistics, distribution and transportation

The implementation of GSCM has a large impact on how goods (should) move across supply chains. In that sense, GSCM implies a green logistics approach to connect the environmental concern with transportation, warehousing and distribution activities. Green logistics ties environmental and economic efficiency to logistics by trying to reduce the impact of the sector on the environment. See 1.3.7 for more information. Examples are provided below.

UPS

Company description	UPS is a worldwide logistic service provider which provides transportation via air and road. Worldwide more than 0.4 million people are employed, of which 49,000 are working in Europe. UPS realized a revenue of 70.28 billion dollars in the year 2018.
Company categorization	LSP
Initiative	City logistics: use bikes with removable small containers to transport goods within Seattle. This reduces the amount of trucks and thereby lowers congestion and Co2 emissions within the city.
Status	Pilot started in October 2018. http://www.citylogistics.info/business/ups-introducing-cargo-bikes-in-seattle/

Special Fruit

Company description	Special Fruit is a company that imports superior fruits to supermarket chains, food service and other large consumers in Europe. The number of employees was 165 in 2017 and the realized revenue was 155 million euros.
Company categorization	Shipper
Initiative	Lean & Green objective: > 20% CO2 reduction (2012-2017) Most important measures: Investment in ripening chambers for mangoes and avocados in order to enable a modal shift from air (ready-to-eat) to sea (unripe). The growing of raspberries and blackberries closer to the consumer market, e.g. in Spain instead of Latin America (transport avoidance).
Status of initiative	Realized and ongoing

BAM

Company description	BAM is a construction company which has ten operating companies in five different European countries. It has a total of 19,500 employees and realized a revenue of 6.6 billion euros in 2017.
Company categorization	Other
Initiative	Hyperloop facility: BAM started a partnership with a start-up in Delft, Hardt Global Mobility, to realize the first European test facility for hyperloops. They aim to develop this futuristic transport further.
Status of initiative	Pilot started in 2017 and still ongoing. https://www.duurzaambedrijfsleven.nl/stad-van-de-toekomst/22885/bam-maakt-vaart-met-eerste-testfaciliteit-van-hyperloop

Covestro

Company description	Covestro is a world-leading manufacturer of high-tech polymer materials for key industries. In 2017 Covestro employed 16,200 people and realized a revenue of 14.1 billion euros.
Company categorization	Shipper
Initiative	Covestro used three main measures to reduce the Co2 reduction per transported ton with more than 20%: - Modal Shift from inland navigation to pipeline for specific products - Container payload optimization by using alternative types of packaging - Compressed air for pneumatic transport of granulates
Status of initiative	Reduction is realized and ongoing. https://www.covestro.com/en/company/profile/annual-report

Dell

Company description	Dell is an American computer technology company. In 2017 Dell employed 138.000 employees and it realized a revenue of 78,7 billion U.S. dollars.
Company categorization	Shipper
Initiative	Dell aims to reduce its impact on the environment by minimizing their carbon footprint. “Green packaging and shipping” is one way to achieve this. Below, some examples of this ambition will follow. *3 c`s:* (1) Cube Engineers are continuously busy with reducing the amount of empty space within packages which results in making smaller boxes which increases the number of packages per pallet. (2) Content: Dell makes its packaging material from other materials than plastic. In 2009 it introduced Bamboo-based packaging materials and in 2011 mushroom packaging was introduced. Also Ocean-bound plastics are nowadays raw materials for packaging. (3) Curb: 95% of packaging material is recyclable and the parts services team reuses boxes on average 7 times before they are recycled. *Better Logistics:* Retail partner expansion is parts of “better logistics”. An example is the optimization of processing orders. In the U.S. some orders are handled through DC`s while others are handled directly. In Europe Dell expanded their fulfilment centre network for retail orders on the mainland and changed the way they deliver accessories.
Status	Realized and ongoing. https://www.dell.com/learn/us/en/uscorp1/corp-comm/mushroom-packaging

Ikea

Company description	Ikea is a worldwide operating retailer that mainly sells furniture and other house-related articles. The company is well-known for its innovative products which consumers can construct their selves. In 2018 Ikea realized a revenue of 38,8 billion euros and it employed 208,000 people worldwide.
Company categorization	Shipper
Initiative	100% zero emissions for last-mile delivery: Ikea switches from fossil to electrical-powered vehicles or other zero-emission solutions in the following 5 cities: Amsterdam, Los Angeles, New York, Paris and Shanghai. This should already be implemented in 2020 and it will result in 25% of last-mile deliveries to be green. The aim is to have 100% of home deliveries done by electrical vehicles in 2025.
Status	To be implemented https://www.ikea.com/us/en/about_ikea/newsitem/091318-IKEA-group-zero-emissions-targets-home-delivery-2020

CHEP Benelux

Company description	**CHEP** (Commonwealth Handling Equipment Pool) is an international company dealing in pallet and container pooling services, serving customers in a range of industrial and retail supply chains. CHEP is owned by Brambles Limited.
Company categorization	Other
Initiative	VIL and CHEP Benelux, provider of supply chain solutions, have put together a pilot project with Coca-Cola European Partners (Chaudfontaine), AB InBev (Jupiler) and retailer Delhaize regarding mutual transportation of fully loaded goods and empties between the three distribution centers. During a full roundtrip of 296 km, the truck drove maximum 10 km empty. That directly affects the environment and the traffic: a reduction of CO2 emission between 10 and 15% *and 15% cost reduction*
Status of initiative	Realized and ongoing

1.6.6. Examples of non-governmental organizations

Not only companies are active in the greening of supply chains. NGOs play an important role as well. These are organizations that are independent of governmental support with the aim of reaching societal goals. They are important because they bring parties together and come up with innovative ideas. Below follows an overview of initiatives that are proposed by those NGO`s, both from Belgium and the Netherlands.

SmartPort

Organization description	SmartPort is a collaboration between the Port of Rotterdam, Deltalinqs, Municipality of Rotterdam, TNO, Deltares, Erasmus University and the Technical University in Delft. By inspiring, initiating and forming alliances SmartPort stimulates and finances scientific research for companies within the Rotterdam port area.
Initiatives	- Truck platooning: let trucks drive in convoys to reduce Co2, improve traffic flows, reduce truck driver-costs and increase traffic safety (2020: 300-500 trucks a day, which is 10% of total truck amount). - Synchro gaming: put chain parties together and let them play a real-life game about synchromodality. In this way chain parties experience the consequences of their decision without feeling the direct financial consequences. Synchrogaming leads to new insights that can be applied in reality and it improves collaboration between parties. - Sailing through slib: new way to determine the depth of a canal by looking at slib strength instead of slib density. This means that the effective depth for vessels can be deeper at some waterways which can improve the loading rate and reduce dredging costs and emissions (10-20% reduction in dredging)
Status	1. Under investigation 2. Realized 3. Under investigation http://smart-port.nl/voor-partners/#rm1

Topsector Logistiek:

Organization description	Topsector Logistiek is on out of nine Topsectors in which the Netherlands excels. It is a collaboration between people from business, science and the government that aims to strengthen the international competitive position of the Netherlands by following an action program with concrete ambitions.
Initiatives	Ishare project: eliminate barriers within the data sharing process between chain parties, where the biggest barriers are data integration and data safety. Within the Ishare project organizations share data with each other with the same identification, authentication and authorization, so they don`t have to make new agreements every time data needs to be shared.
Status	Launched and ongoing https://topsectorlogistiek.nl/Projecten/ishare-project/

VIL

Organization description	VIL aims to enhance the competitiveness of Flemish companies in the logistics sector by implementing sustainable and innovative concepts and technologies. Enabling Flanders to retain and strengthen its position as a top region for logistics in Europe.
Initiatives	- LSI: VIL is creating a Logistics Sustainability Index (LSI). This index will give scores to the sustainability of logistics activities within a company. In this way companies can compare their sustainability progress with other companies which should support them in becoming greener. - Lean & Green: VIL supports and guides companies in Flanders in improving the energy-efficiency of logistic activities with 20% in a period of maximum 5 years. Besides Belgium also the following countries are connected to Lean & Green: The Netherlands, Germany, Italy, Luxembourg, Spain, Czech-Republic and Slovakia.
Status	Both initiatives are launched and ongoing https://vil.be/lean-green/

Connekt

Organization description	Connekt is an independent network which consists of people working in the private sector public sector, which is responsible for the non-research part of the Topsector Logistiek. This covers program-management, communication and finance & administration.
Initiatives	- LEARN: The Logistics Emissions Accounting and Reduction Network project (LEARN) empowers business to reduce their carbon footprint across their global logistics supply chains. - Lean&Green: Connekt is the inventor of the Lean&Green initiative that is described in the VIL table.
Status	Under development

1.6.7. Critical assessment of the initiatives

The previous sections show that several cases or examples of companies that undertake greening measures in their supply chains can be found. Many companies are actively writing up and communicating what their greening ambitions are and how they plan to achieve those ambitions. This may lead to the conclusion that companies do adopt the sustainability policy goals as set by the various governments and that they start complying.

At the same time, we know that sustainable business today for a company means acting on three major points to change its business: ecological, social and economic. Companies are in principle still very much driven by revenue and profits, in line with the actual market paradigm in our western countries at least. Changing the business model into a more sustainable one requires a paradigm shift which can be painful and, at first sight, unprofitable. That brings us the notion that in a context where awareness under consumers and stakeholders about greening is increasing and where companies feel the need to show commitment towards a greener production and supply chain, but where also companies are striving for competitive advantage and making profits based upon positive business cases, we may question to what extend companies really engage in sufficient greening of supply chains or that it is to a large extend “greenwashing” what they do.

For instance, companies might announce loudly about a transition towards the use of cleaner fuels. At the same time, it could be that those fuels are only used in a very limited percentage of the total transport moves. The same holds for environmental management systems (EMS) that are implemented by companies to assess the impact of logistic activities on the environment. Assessing the impact on the environment is not the same as lowering the environmental impact, so checking whether EMS are not used as window-dressing is crucial.

It is thus important to assess the initiatives taken by companies on their impact, viability and reality. That is not an easy job as it requires an in-depth assessment of what the companies are really doing, with what performances and potential side-effects.

For the cases as presented in this section 1.6, we are not able to assess each case on its reality of activity and impact, as this requires insight information that we lack. However, based on literature, but also based on what we see in practice we can state that the successful introduction and implementation of greening actions is severely limited in cases where:

- The business case for a company is not clearly positive
- The measure or action requires the collaboration of – maybe competing – companies whereby it remains unclear where benefits and costs land.

In section 1.4 we already mentioned the drivers of GSCM, but also pointed to potential obstacles and barriers to further advances in GSCM. For the further assessment of the status of the greening of port related supply chains we will certainly also look into its reality and impact and we will take the two critical points into consideration.

1.7. Summary of findings

Green supply chain management (GSCM) can be defined as integrating environmental concerns into the inter-organizational practices of SCM. GSCM has gained increased attention within the industry as there is a growing need for integrating environmentally sound choices into SCM practices. Investments in greening can be resource saving, waste eliminating and productivity improving. Thus, the greening of supply chains does not have to be a burden but could constitute a potential source of competitive advantage. Since the early 2000s a slow mental shift is taking place from just being environment friendly to an integration of green initiatives as a way to achieve good business sense and higher profits. In other words, the industry started to show a growing awareness that GSCM could constitute a business value driver, not just a cost centre.

The main idea behind GSCM is to strive for a reduction in environmental impacts by focusing on a series of R's throughout the supply chain: Reduce, Re-use, Recycle, Remanufacture, Reverse logistics, etc. The fields of actions in GSCM include product design, process design and engineering, procurement and purchasing, production, energy use and mix and logistics (incl. distribution and transportation).

GSCM implies a green logistics approach to connect the environmental concern with transportation, warehousing and distribution activities. Goods will have to be transported in an economically, environmentally and sustainable manner. The main fields of actions in green logistics are related to eco-friendly packaging, eco-friendly transport mode choice and synchromodality, load and route optimization and green distribution networks and

distribution hubs. Co-operation between supply chain partners and the use of digital and integrated data solutions are key to support the above fields of actions. An important part of the success of the circular economy will hinge on the way smart logistics will enable the transparency needed to set up efficient and integrated fully circular supply chain networks. Thus, the circular economy will offer new opportunities for shipping and logistics service providers but will also challenge them to enter into closer collaboration with industry stakeholders.

The greening of supply chains is not only something for the future, it is already happening today. Shippers, logistic service providers (LSP) and other service providers undertake actions to develop a greener supply chain, as was illustrated by the many examples in this part of the report. A range of actions and initiatives are taken in the field of green procurement and purchasing; circular economy and reverse logistics; green supply chains and Environmental Management Systems; and green logistics, distribution and transportation.

Companies might initiate the implementation of environmental practices due to motivational drivers such as sales to customers, and legislative and stakeholder institutional pressures. There are clear signs that not opting for green supply chains can negatively affect companies' cost base and profitability, and that a focus on GSCM is needed to secure revenue growth, achieve cost reductions, develop brand value and mitigate risks. However, companies cannot blindly roll out green initiatives as part of GSCM. Logistics and supply chain managers have to balance efforts to reduce costs, improve service quality, increase flexibility and innovate while maintaining good environmental (ecological) performance. In other words, green initiatives should not only best support the green supply chain, but also make business sense. Otherwise, the competitive and financial position of the company might be negatively affected. Successful GSCM initiatives often involve several to many departments within and between companies. Industry and branch organisations often play an important role in bringing companies together to take joint initiatives in GSCM.

There is an important role for (inter)national governments and organizations in driving the developments in Green supply chains. Governments may or should act as catalysts for change. The environmental policies of governments and other public entities can have a significant impact on GSCM. These policies typically define the emission and energy targets (global, Europe, national) for economic activities. To reach these targets, a range of instruments and intervention mechanisms are available to public policy makers. For example, financial incentives and penalties of governments and public entities can affect the further greening of supply chains.

2 I GREEN SUPPLY CHAIN MANAGEMENT IN A SEAPORT CONTEXT

2.1. Introduction

A seaport is a logistic and industrial node accommodating seagoing vessels and characterised by a functional and spatial clustering of cargo transport, storage and transformation processes linked to global supply chains (Notteboom, 2016). Seaport functions are thus diverse in scope and nature and evolve over time. Port roles and functions can be identified through political, geographical (urban and spatial), economic and social perspectives.

From a macro-analytical and public policy perspective ports are viewed as economic catalysts for the regions they serve where the aggregation of services and activities generates benefits and socio-economic wealth. Ports create direct and indirect value-added and employment as reported in the annual studies of the National Bank of Belgium for Belgian ports and the Port Monitor for Dutch seaports. Often, port macro-economic impacts focus a lot on national or regional competitiveness, thereby ignoring port impacts on the wider economic space and on international trade and logistics. Ports are often approached as clusters (De Langen, 2002) and maritime industrial development areas (MIDAs). Consequently, they receive a lot of attention as part of national or supranational maritime cluster policy and industrial policy. Other issues of interest to the public policy maker at a macro-level include urban planning and expansion, safety, security and environmental sustainability.

From an environmental perspective, port planning and management should ensure sustainable development. Environmental sustainability of port projects and operations has become as important as economic and financial viability. Ports, as clusters of economic actors and activities, have adopted a real environmental role and function and in this way (should) contribute to the greening of supply chains in the context of GSCM.

Ports, as nodes in extensive global transport networks, and intersections of large bundles of supply chains covering a multitude of commodities and cargo types, create environmental impacts through their various functions. Terminal activities are one source of the environmental impact of seaports which can be summarized by several categories, namely, 1) port construction related pollution[4], 2) air emissions of ships at berth and terminal handling equipment (such as cranes and yard equipment), 3) noise associated with cargo handling operations, and 4) the environmental effects and potential congestion associated with landside operations of barges, rail and trucks. Environmental impacts occur at all stages of a terminal's life cycle., i.e. port planning, terminal construction, terminal operation, terminal expansion or terminal closure/termination. Regarding landside operations connecting inland transport, environmental impacts caused by intermodal connections and congestion lead to adverse effects such as air pollution. Depending on modal choices and the associated cost and transit time requirements from shippers, such environmental effects vary.

Other port functions also generate environmental impacts, such as industrial and semi-industrial activities in ports and warehousing and distribution activities. While particularly

[4] UNESCAP (1992) identified nine groups of environmental facets in port development and construction including water quality, coastal hydrology, bottom contamination, marine and coastal ecology, air quality, noise and vibration, waste management, visual intrusion and socio-cultural impacts (e.g. relocation of villages).

industrial activities in ports are often associated with negative effects in terms of emissions and noise pollution, port clusters can exert strong environmental advantages. For example, 'ecologies of scale' are achieved in the (petro-)chemical industry by which companies utilize each others' waste material or by-products such as heat. It would be far more difficult to achieve this when the plants concerned would be spatially scattered. It is imperative that these 'ecologies of scale' advantages are fully acknowledged in environmental policy.

Port-related pollution not only damages the ecological balance of nature and urban environment, but also cause adverse effect on global climate change, which further increases the risk associated with port operations. The development of a low-carbon economy is a fundamental way to solve environmental problems.

The greening of ports is attracting a growing attention in academic circles. Doerr (2011) provided an overview of policies and strategies for sustainable ports across the world. Acciaro et al. (2014) defined a set of quantitative objectives to evaluate the success of innovations with respect to environmental sustainability at seaports. In business practice, the growing green reflex is mirrored in the many green initiatives of individual ports and the coordinated actions of the wider port community as exemplified in Europe by the EcoPorts foundation (embedded in the European Sea Ports Organisation - ESPO). Puig et al. (2015) provided a good overview of current environmental issues in seaports and the overall performance of European ports in terms of environmental management. Their study is partly based on the ESPO/EcoPorts Port Environmental Reviews which show that the prioritisation of environmental effects of port activities and development changed over time.

The emergence of the 'green port' concept is closely associated with the growing environmental awareness of seaport actors. The concept of green port (or low-carbon port) was officially proposed in the United Nations Climate Change conference in 2009. On the basis of an organic combination of port development, utilization of resources and environmental protection, the green port concept refers to a development characterized by healthy ecological environment, reasonable utilization of resources, low energy consumption and low pollution. Pavlic et al. (2014) define green port as 'a product of the long-term strategy for the sustainable and climate friendly development of port's infrastructure'. The green port concept or sustainable and climate friendly development of the port's infrastructure in a broader sense means responsible behaviour of all stakeholders involved in port management and operations.

2.2. Main fields of action for GSCM in seaports

We can identify several fields of action for private and public actors involved in port-related activities to pursue GSCM objectives. We make a distinction between actions in the areas of green shipping; green port development and operations; green inland logistics; seaports and the circular economy; and, actions in the field of knowledge development and information sharing. In the following sections, we list some concrete actions for each of these domains.

2.2.1. Green shipping

Vessels are a major source of air pollution, mainly because of the quantities and types of fuel being used. The main emissions include sulphur oxides (SO_x), CO_2, particulate matter (PM) and NO_x. The main type of bunker oil for ships is heavy fuel oil, derived as a residue from crude oil distillation.

The International Maritime Organization (IMO) has developed regulations on energy efficiency to support the demand for ever greener and cleaner shipping. One of the aims is to reduce SO_x emissions, which also reduces particulate matter. SO_x is harmful to human health, causing respiratory symptoms and lung disease. In the atmosphere, SO_x can lead to acid rain, which can harm crops, forests and aquatic species, and contributes to the acidification of the oceans. Limiting SO_x emissions from ships will thus improve air quality and protects the environment. IMO regulations to reduce SO_x emissions from ships first came into force in 2005, under Annex VI of the International Convention for the Prevention of Pollution from Ships (MARPOL). Since then, the limits on sulphur oxides have been progressively tightened. From 1 January 2020, the limit for sulphur in fuel oil used on board ships operating outside designated emission control areas will be reduced to 0.50% m/m (mass by mass). There is an even stricter limit of 0.10% m/m already in effect in emission control areas (ECAS) which have been established by IMO. This 0.10% m/m limit applies in the four established ECAS: the Baltic Sea area; the North Sea area; the North American area (covering designated coastal areas off the United States and Canada); and the United States Caribbean Sea area (around Puerto Rico and the United States Virgin Islands). Domestic emission control areas also exist in other parts of the world such as in parts of mainland China and Hong Kong SAR.

Some actors in the shipping industry have echoed concerns that the 2020 deadline is not feasible given the large investments needed to adapt the fleets to the regulation. However, most shipping lines have already taken or are taking action by implementing a range of measures, including the switch to other low-sulphur fuels (e.g. LNG, low-sulphur Marine Diesel Oil or biofuels), by retrofitting vessels with so-called scrubbers designed to remove sulphur oxides from the ship's engine and boiler exhaust gases, by reducing vessel speed (slow steaming and support slow steaming practices), by designing fuel-efficient and low-emissions vessels, etc.

Ships do not only emit harmful substances when sailing. Ships are also a major contribution to emissions in ports, even when they are idling or berthed. An OECD study argues that shipping emissions in ports account for 18 million tons of CO_2 emissions, 0.4 million tons of NO_x, 0.2 million of SO_x and 0.03 million tons of PM10 in 2011. Around 85% of emissions come from containerships and tankers (Merk, 2014). Approximately 230 million people are directly exposed to the emissions in the top 100 world ports in terms of shipping emissions. The study also revealed that European ports have much less emissions of SO_x (5%) and PM (7%) than their share of port calls (22%), which can be explained by the EU regulation to use low sulphur fuels at berth.

Next to supranational regulation from IMO, also seaports and their actors have a role to play to reduce ship emissions in ports. Various ports have developed infrastructure, regulation and incentives that mitigate shipping emissions in ports. The main fields of actions are related to the following.

Reduce ship emissions in ports by decreasing waiting times and the turnaround time of vessels in port

This can be done by for instance synchronizing and integrating the nautical chain (which includes pilotage, towage, lock operations, etc.) through optimized vessel traffic management systems. Also, terminal operators can play a major role by optimizing terminal activities and ensuring that enough quay/yard capacity and dock workers are available to limit the vessel turnaround time at the terminal;

Green port dues and voluntary green shipping schemes

Ports can implement voluntary programs to incentivize ship operators to green their ships. Green ship operators in return receive a benefit, such as a discount in port dues. An example is the Environmental Ship Index (ESI). The ESI builds on an initiative by the International Association of Ports and Harbours (IAPH) in which the port authorities of Rotterdam, Amsterdam, Antwerp, Le Havre, Hamburg and Bremen participate. Shipping companies can register their ships for this index on a website. On the basis of the data entered, such as fuel consumption and emissions, each ship has a given score from 0 to 100 (from highly-polluting to emission-free). The ports themselves decide what advantages to offer participating ships, but it mostly involves a rebate in port dues. While ports or other public authorities could in principle also decide to implement strict regulation on emission criteria for ships entering the port (i.e. dirty ships are not granted access), such access restrictions have only been implemented in a few ports around the world.

Cold Ironing, Shore Power Supply or Alternate Marine Power (AMP)

Cold ironing for seagoing vessels and barges implies that a ship at berth uses shore power for the auxiliary engines instead of bunker fuel. This helps in reducing the emissions from the ships by a great margin, although the reduction in pollution occurs only when the ship is stationary at berth. Power cables are plugged into an electricity supply board at the terminal on one end and to the ship's power supply board on the other. The power is used for lights, refrigerators, air-conditioners and other equipment on a ship. The power coming from the shore can be from a separate power generation unit or from the power plant supplying power to the port city or town. Due to strict local and state environmental regulations for idling ships, early adopters of cold ironing practices are found along the west coast of North America (i.e. Vancouver Seattle, Vancouver, Los Angeles, San Diego, San Francisco and Oakland). Cold ironing for commercial vessels was launched in Los Angeles in 2004 when China Shipping's container ships were plugged into a dedicated port barge floating close to the berth. At present, cold ironing is most widespread in the cruise shipping market and ferry business as the pressure on cruise and ferry terminals to reduce emissions is high, particularly when they are located close to (historical) city centres. In North Europe, Scandinavian countries, Germany, Belgium and the Netherlands have already developed cold ironing solutions. Since 2010, vessels berthing for more than 2 hours have had to switch to a 0.1% sulphur fuel or use alternative technologies, such as shore side electricity. The EU approved Directive 2014/94/EU on the deployment of alternative fuel infrastructure in 2014. This directive obliges Member States to implement alternative infrastructure networks such as shoreside power technology by December 2025. The EU's TEN-T program has indicated that shore power is an area where funding was available to help with up to 50% of the costs of research and 20% of the costs of implementation. Cold ironing technologies are also being implemented in several Asian ports. China has included cold ironing in its 12th five-year plan and links it to the existing domestic emission control areas.

Despite its potential contribution to promoting green shipping, the cold ironing solution faces some major challenges. First, there are challenges related to the investment cost (terminal and ship), the division of these costs between different stakeholders (shipping line, terminal

operator and port authority) and the break-even cost compared to bunker fuel. Second, there are still some issues with the standardisation of on-shore power systems in terms of on-board and terminal equipment and voltages. Third, shipping lines are not always eager to invest in the retrofitting of ships as long as cold ironing possibilities are limited to only a few ports of call ('chicken and egg' problem). Even certain ships are not compatible and suitable for the process of on-shore power. Most of new build ships are pre-equipped. Fourth, the large-scale application of cold ironing in a port might require extensive capacity upgrading of the local or regional power grid. For example, a large container ship typically requires approximately 1,600 kilowatts (kW) of power while at berth, but the power requirements can differ substantially (cruise ships need a lot more power), depending on the size of the vessel and the number of refrigerated containers on board. Finally, the environmental advantages of cold ironing depend on how clean the shore-based electricity production process is. If shifting the power production from ship to shore increases the load on fossil-fuel power plants and increases the air emissions, then the overall impact on emissions might be marginal.

Support the transition to LNG as a ship fuel

Most experts indicate that Liquefied Natural Gas (LNG) serves as an attractive fuel for ships to meet the stringent environmental regulations enacted by IMO, particularly in terms of sulphur and NO_x emissions. However, some critics argue that LNG is not the ship fuel of the future as the savings in CO_2 compared to fuel oil are quite limited and that there are unresolved questions about the impact of methane slip (unburned natural gas) on the total global warming effects. The systematic literature review in Wang and Notteboom (2014) presented perspectives of and challenges for the adoption of LNG as a ship fuel. Several crucial barriers, such as the lack of bunkering infrastructure and operational standards, slowed down its development. However, rising environmental concerns gave a strong incentive to the public sector to provide policy support in removing any remaining obstacles.

The widespread application of LNG as a ship fuel is supported by the competitive environment: global LNG supply chains are already in place. Still, the use of LNG as a ship fuel is expected to first gain momentum in niche markets, like small ferry routes and regular liner traffic. LNG carriers are pioneers in the use of LNG as a ship fuel as typically burn a portion their own boil-off gas. In late 2017, container shipping line CMA CGM announced to equip nine 22,000 TEU newbuilds with all the equipment necessary to run on natural gas (Marex, 22 November 2017). The use of LNG is expected to reduce carbon emissions of these ships by 25% compared to using fuel oil and to bring these vessels into compliance with the 2020 global fuel sulphur content regulations of IMO. However, competitor MSC announced in September 2018 it plans to retrofit a significant part of its fleet with scrubbers to meet the IMO sulphur cap. This illustrates that shipping lines are making different choices (i.e. scrubbers, low-sulfur fuel/LSFO or LNG). Experts expect most carriers will switch to low-sulfur fuels in order. Container shipping lines have already implemented new types of fuel surcharges to partly or fully cover the cost associated with the shift to LNG or LSFO or scrubber technology.

In the longer run, the adoption of LNG as a ship fuel on a global scale rests on three main factors: (1) the price differences between LNG, low sulphur fuel (LSFO) and scrubber technology; (2) the dynamics in the global emission regulations; (3) the availability of LNG bunkering facilities in a global context. In the past five years, investments in LNG bunkering infrastructure in ports have really taken off. Quite a few public port authorities are playing a proactive role in facilitating the use of LNG as a marine fuel, often in close partnership with industrial actors. Port authorities are also using various types of financial instruments to promote the market development of LNG facilities, for instance, (a) by building joint ventures or PPPs with private actors to invest in bunkering facilities; (b) by providing funding or

applying for subsidies from the EU or local government to support investment; (c) by developing a differential port tariff favouring ships powered by clean fuels, like LNG), or by providing funding for ship conversion (e.g., in port of Stockholm); and (d) if applicable, by establishing pilot projects, for example, owning LNG-powered port vessels, to kick-start LNG market development and solve the chicken-and-egg problem (Wang and Notteboom, 2015).

2.2.2. Green port development and operations

Green port development is about actions in ports that make the port and its environment greener and more sustainable. Within port areas a lot of GHG are emitted into the atmosphere, mainly due to industrial and transportation activities. This paragraph describes multiple instruments and concepts of green port development and operations that lead to greener ports. These are concession policy, ecologies of scale, developments of green zones and buffers in the port area, development of windmill and solar parks, CO2 capture and fume return systems, production of bio-fuels and bio-based chemicals, low emission yard equipment, reduce idling of transport modes and create green warehousing and distribution activities.

Concession policy

Ports can use concession policy as a governance instrument in the greening of ports. A concession is a grant by a government or port authority to a (private) operator for providing specific port services, such as terminal operations or nautical services. It is a powerful governance tool for port managers because of two reasons. Through concession policy, port authorities can retain some control on the organization and structure of the supply side of the port. Concession policy can be used to encourage port service providers to optimize the use of scarce land. Besides that, it can also be applied to steer port service providers towards greener activities (Notteboom, 2006). Port authorities have a variety of instruments that they can use to apply green targets in terminal concession agreements. Instruments that directly limit environmental impact are for example modal split targets, cap on total Co2 emission of terminals and maximum noise levels. Instruments that only indirectly limit environmental impact are pollution charges, information reporting and subsidies/discounts (Notteboom & Lam, 2018).

Ecologies of scale

The stimulation of ecologies of scale is a way to reduce the impact of port industrial activities. Ecologies of scale are achieved when companies use each other's waste material or by-products as input for production processes. For example, the utilization of heat from the (petro-)chemical industry. The easiest way to accomplish those collaborations is by forming clusters of companies which are related to each other with respect to input/output of production processes (De Langen, 2002). Taking into account these ecologies of scale in port policy is crucial in order to reduce the impact of port/industrial processes on the environment. Two examples of measures that ports can take to promote ecologies of scale are environmental zoning and co-siting/location.

Development of green zones and buffers in port area

Port areas create a variety of environmental impacts related to the activities that take place. The impact is mainly related to shipping activity, activity on the port land and impact from hinterland transportation. The main impacts on the environment are on air emissions, water quality, soil, waste, biodiversity and noise. This can have a strongly negative impact on the health of port-city inhabitants (OECD, 2010). One measure to limit those negative impacts is

to create buffer zones. These areas are meant to compensate the negative impact of ports. Buffer zones are for example areas with nature that form a shield between heavy port industry and residential areas (Daamen & Vries, 2013). Another example is the development of mixed development areas such maritime training institutes in Rotterdam. Another option is the co-existence of port and urban functions. In these areas, measures are undertaken to protect citizens against negative impacts, e.g. with dust covers and sound covers. In the US ports compensate citizens for the negative impact that they face from the port processes (OECD, 2010).

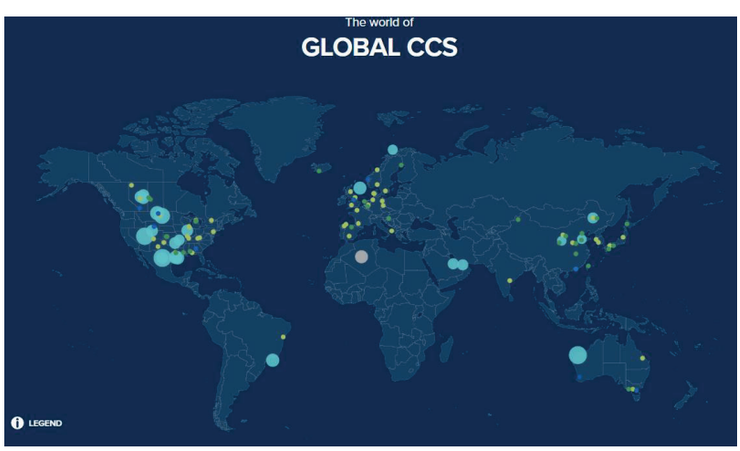
Development of windmills and solar parks/roofs in ports

Energy efficiency within ports and terminals is receiving more attention over the last years because of the growing awareness of climate change. Ports are areas with a high concentration of processes that demand much energy. Examples of these processes are crane operations in terminals, reefer-cooling in warehouses and heating activities in factories. Thus, it is interesting to see if ports are actively investing in sustainable energy sources to reduce the environmental impact of port operations. Ports are often suitable places to apply sustainable energy sources due to the presence of wind (e.g. Rotterdam & Kitakysushu) waves (e.g. Port Kembla in Australia) and differences in tides. Besides, ports generally have big flat spaces on the roofs of warehouses where solar panels can be installed. Acciaro, Ghiary en Cusano (2014) state the importance of Port Energy Management (PEM) in Ports. The uptake of new technologies such as onshore power supply, LNG bunkering and developments in renewable energy installations calls for a PEM that clarifies how and where port authorities can reduce the energy efficiency within ports.

CO2 capture and fume return system

Carbon Capture and Storage (CCS) is broadly seen as an instrument that could help achieving climate change targets, by emitting a lower net-amount of Co2 into the atmosphere. The process of CCS consists of three steps which are capturing, transportation and storage (Bui et al., 2018). According to Page (2018), CEO of the Global CCS institute, the year 2018 will be an important tipping point in the application of CCS in the battle against climate change. In 2018, for the first year in a long time, governments have been making steps towards the application of CCS. Worldwide in 2018 there were 43 large-scale CCS facilities of which 18 commercially operational, 5 under construction and 20 in various stages of development.

Figure 6. Mapping of CCS operations in 2018



Source: Global CCS Institute

Ports are important players in creating CCS projects. Through the clustering of industrial processes, emissions in ports are not only from logistic ports processes but also for a large part from factories. For example, in the Port of Rotterdam 20% of the total emissions in the Netherlands` are produced. In 2.3 a description of a CCS project from the Port of Rotterdam will be described.

Production of bio-fuels and bio-based chemicals

A biofuel is a hydrocarbon that is made by, or coming from, a living organism that humans use to power something. A biofuel is any hydrocarbon fuel that is produced from something living, or once living, in a shorter period of time (maximum a number of months). This is in contrast with regular fossil fuel which are created over millions of years. Biofuels are renewable because they can be grown year after year. Though, this does not mean that bio fuels are good for the environment after burning them. At the same time the world population is growing and the demand for fuels is still increasing. So, biofuels might be a necessary addition to the total energy mix. Ports that have good access to biomass and a good transportation network could be smart places to locate production facilities for biofuels. Lloyds (2018) concluded that the most cost-effective way for shipping companies to accomplish the 2050 climate goals is to switch to bio-fuels. If shipping companies are taking the path towards biofuels it might be an additional opportunity to create these production facilities within sea-ports.

Low-emission or zero-emission quay and yard equipment on terminals

Terminal operators are under pressure to invest in zero-emission and low-emission equipment to operate yards and quays. Traditionally most terminal equipment is powered by diesel generators which causes greenhouse gas emissions and a reduction in the air quality. The median amount of diesel that was needed to handle a single dry container in Latin-America and the Caribbean equalled 8 litre in 2015. Wilmsmeier and Spengler (2016) investigated the terminal energy consumption via an activity-based cost approach. This methodology is applied because of two reasons. First, it enables to see what operation area consumes what amount of energy. Second, it makes it possible to establish a set of detailed indicators.

The energy activities are divided in several clusters which are:

1. Vertical operations (quay cranes)
2. Horizontal operations (reach-stacker (RS) cranes & rubber-tyred gantry (RTG) cranes
3. Lighting
4. Buildings
5. Cooling (reefers)

Table 3. possible energy sources per terminal activity

	Diesel	Petrol	Natural gas	Electricity
Ship-to-shore cranes	•			•
Mobile cranes	•			•
Rail-mounted gantry cranes	•			•
Rubber-tyred gantry cranes	•			•
Reach stackers	•			•
Straddle carriers	•			•
Tractor-trailer units and lorries	•		•	•
Generators	•		•	
Buildings				•
Lighting				•
Reefer containers				•
Other port vehicles	•	•	•	•

Source: Spengler (2015)

As can be seen in Table 3 all processes that are operated by diesel engines can be operated by electrical power as well. Schmidt et al. (2015) investigated the economic viability of battery-electric AGV's. They concluded that electric mobility is beneficial in container terminals because the charging and maintenance costs are significantly lower compared to diesel-powered equipment. It even compensates for the higher required investment costs.

Reduce idling of ships and inland transport modes and waiting times at terminals

Idle time in terms of shipping means unproductive time where the ship is waiting until it can be handled or continue its operations. International Shipping News (2018) specifies three forms of idling time: before entering the port, time where the ship waits at the berth to start with (un)loading operations and the time between handling the last container and leaving. Average idling time for these forms in 2017 where respectively 1.85, 1.55 and 1.52 hours, which sums up to almost 5 hours. Those hours lead to a lower utilization of ships and an unnecessary amount of GHG emissions. A measure to reduce idling time is the improvement in information sharing. Ports can introduce platforms where chain parties share real-time information about their operations. In this way parties can adjust their behavior towards each other. E.g. terminal operators inform captains of ships that the terminal is congested and captains can adjust their speed towards the port. An example of such a system is Portbase, which is developed by the port of Rotterdam. More about these initiatives will follow in section 2.3.

Idling not only takes place on the seaside but also on the inland side of the terminal. A good example of this can be found in barge containers operators. Barge operators sail from inland terminals towards deepsea terminals to deliver export containers or to pick import containers for the hinterland. Though, those barges are dependent of the reliability of large deepsea container-vessels which become more and more unreliable in terms of sailing scheme punctuality. Barges sail towards deepsea terminals and sometimes have to wait several days until they are served by the deepsea terminals, which causes a lot of idling time and congestion within ports. Also, deepsea terminals always serve the big deepsea vessels first before serving barges because they have contracts with those shipping lines and not with barge operators. A measure to reduce this congestion is the use of fixed-windows. If barge operators arrive with a minimum call size towards the terminal within the fixed-window time frame, the deepsea terminal guarantees that they will be served within that time.

Also at the truck/land side idling takes place. Truck gate congestion causes relatively high amounts of particulate matter and nitrogen oxides. Those gasses are the two most harmful for the air quality according to Brodrick et al (2002). Some measures to reduce congestion are road/toll pricing and vessel dependent time windows (Chen et al., 2013). More advanced solutions are truck appointment management solutions (TAS). Terminal operators announce the opening hours and a quota for each time slot through a web-based information system. Truck operators can choose which hour they prefer. Huyn and Walton (2008) designed a methodology that determines the maximum number of trucks that a terminal can handle per time period. In this system, the terminal operator announces opening hours and entry quota in each hour through a proprietary web-based information system, where truckers can choose an entry hour as they prefer. In this way the number of trucks will be spread more efficiently over the available capacity.

Green warehousing and distribution activities in ports

Warehousing activities are responsible for a significant amount of CO2 emissions. In 2009, the World Economic Forum estimated that 5.5% of global GHG emissions was the result of logistic activities, which include transport, warehousing and terminals. 0.55% from these activities

can be assigned to logistic facilities, which equals 10% of total logistic activities. Therefore, making this process greener has a significant impact on the greening of supply chains (World Economic forum, 2009). The following factors are important in realizing green warehousing. First, and most important, is the factor location. Most energy is consumed by transport modes that are reaching the warehouse, not the energy in the warehouses itself. Modelling tools can help in finding the most energy efficient location. Second, lightning is important. Lightning can have a stake up to 30% of total the total energy consumed. Making warehouses more light by using natural light is an effective way to reduce the energy consumption. Besides, artificial light should be automatically turned off when no activity takes places in certain areas of the warehouse. Third, taking into account recycling when building the warehouse is effective. For example, using recycled materials such as plastics and steels. Also, converting old warehouses into new ones is a good way of recycling. Fourth, “smart buildings” that contain energy-measuring device can support the greening process of warehouses. In this way data analysis can be performed on each process and improvements can be identified.

2.2.3. Green inland logistics: modal shift, synchromodality and the role of inland terminals

Inland logistics comprises the transportation of goods from the hinterland to the port or from the port to the hinterland. These cargo movements generally take place with the modes barge, rail and truck. The way in which the inland transport and logistics system is used for the cargo flows through the port has a strong impact on the sustainable performance of the port-related supply chains. The commonality of those transport modes is that they all consume energy. Though, the amount of energy that is consumed differs between the modes. Thus, the impact on the environment in terms of GHG emissions, in the form Co2, CH4, NOx and PM, differs as well. This paragraph focusses on ways to reduce the environmental impact of inland transportation. The following main areas where greening takes place are: organization of the use of multimodal transport systems, optimization of the use of each modality and the energy mix of each modality.

The organization of the use of the multimodal transport system

This paragraph will state two measures to organize the use of a multimodal transport system. Two facets of the multimodal transport network that can reduce the environmental impact are the application of a modal shift and synchromodal transport.

Modal shift simply means a change in transportation mode. Over the last years, port authorities put much on shifting goods from the road towards railways, inland waterways and short sea shipping. The aim is to reduce GHG emissions per ton-kilometer and to reduce the congestion on the road (Meers and Macharis, 2015). There are multiple instruments that policy makers can apply to move the industry towards a favorable modal shift. First, taxation can be applied such as fuel taxes, vehicle duty and road-user charges. Second, financial incentives can be provided such as supporting in capital investments or subsidizing greener freight modes. Third, regulation can be applied on vehicle design and operations. Fourth, liberalization of freight markets could lead to a beneficial effect on the environment. Fifth, invest in infrastructure to make certain transport modes more attractive. Lastly, policy makers can identify best-practices in the market and spread this information among relevant stakeholder that can influence transport policies (Green logistics, 2010).

Port authorities can play a role in the shift towards more sustainable transport modes. The first way to do this is by using their concession policies. Port authorities can require terminal operators to realize a certain modal split. Not realizing this modal split will lead to sanctions. A second way is to invest in infrastructure, both physical and digital, in order to make

transport modes such as barge more efficient and transparent. In this way, shippers are encouraged to shift towards alternative transport modes.

Another way to make hinterland transportation more efficient is by applying synchromodal transportation. The underlying principle of synchromodal transportation is multimodal transportation. This means that goods are shipped from origin to destination by using multiple transport modes. For example, a container is first transported by a deepsea container ship and after that the container is loaded on a truck or train to reach its final destination. To optimize the use of multimodal transportation the concept of synchromodality is developed. Behdani et al. (2016) and Tavasszy et al. (2015) explain their vision on synchromodality as following: a horizontal integration of freight transportation planning, which allows for parallel usage of different transportation modes from origin to destination. The main difference between multimodal and synchromodal transportation is the role of the shipper in the process. In multimodal transportation the shipper determines which mode will be used for the transport. Whereas, with synchromodal transportation the mandate for this decision is given to the logistic service provider. The service provider will arrange the transportation with the mode that is most optimal at that moment, by taking into account the requirements of the customer with respect with delivery time (Topsector Logistiek, 2019). This integral system can add significant value to the supply chain because it results in higher loading rates and better utilization of transport infrastructure such as roads, railways and waterways. Though, synchromodal transport is not easily realized because multiple modalities have fundamental juridical statuses, bookings procedures and transport performances.

Pfoser et al. (2016) describe the most important requirements for synchromodal transportation to work. These are the following. First, close cooperation of all stakeholders within the transport chain is necessary to use the available resources in a flexible way. Second, technical ICT infrastructure is necessary to share chain information and optimize logistic flows. Third, a proper physical infrastructure is crucial in synchromodality. Think hereby of hinterland connections and physical hubs. Also, it should be competitive with other transportation measures in terms of costs and service quality. Lastly, the favourable legal conditions should be in place. Parties that are suitable for offering these synchromodal services are not only freight forwarders. Every party that has an overview of the transport chain can develop these services. Think hereby of shipping lines, deepsea-terminals and consortia of shippers and expeditors.

Optimization of the use of each modality

This paragraph focusses on the optimal use of each modality. The application of new technologies and cleaner engines are important to reduce the environmental impact of transportation. Though, the optimization of the current fleet can also bring a significant positive impact on the environmental performance. Three measures will be discussed. First, a reduction in the amount of empty kilometres. Second, the improvement of utilization rates of trucks, trains and barges. Third, an increase in scale of the transport modes.

The first measure is to reduce the amount of empty kilometres. These are kilometres that are driven or sailed without carrying load. These empty runs have high economic cost because they lead to a wastage of fuel, time and labor. Also, it leads to more congestion on roads and waterways. Besides, it has a direct negative impact on the environment. The share of empty-kilometres is usually higher with inbound transport than in outbound transport (Demir et al., 2014). According to ‘Paris Process on Mobility and Climate’ (PPMC), a quarter of the truck kilometres in the UK are empty kilometres. The cause of empty kilometres is generally related to a lack of information. If a trucking company does not have information about a new load that is close the depot where he dropped his previous load, he will go back to the home-depot

without carrying any load. Measures to prevent this are joint planning and smart planning. An effective way to reduce empty kilometres is joint planning. When a truck company makes its own optimal planning, generally a significant amount of repositioning movements and thereby empty kilometres are required. Cooperative Truckload Delivery (CTLD) is a form of cooperation where trucking companies make a joint planning about the use of their resources (depots, trucks, drivers, equipment etc.). By making a joint planning, companies can benefit from the synergy in networks of depots and delivery requirements and thereby decreasing the amount of empty kilometres. One obstacle in joint-planning collaboration is the fact that these trucking companies are generally direct competitors from each other. For the functioning of these collaborations gains must be equally shared among the involved parties. Also, it should be determined upfront how gains in the network will be shared (Hezarhkani et al., 2016). Another obstacle is the reluctance of companies to share information with each other, because they fear to lose their competitive advantage. Another way to reduce empty kilometres is using smart planning. Route planning should consist of as much parameters as possible to enable the most efficient route and the right estimation of the estimated time of arrival (ETA). Knowing the ETA is important when a company wants to determine which load it can pick up next. In this way it can effectively plan a return or “in-between” truckload and thereby reduce the number of empty kilometres. An important facet of smart planning is the use of real-time traffic information.

The second measure is the improvement of utilization rates on trucks, barges and trains through smart planning and bundling.

Smart planning

Bundling is referred to the joint use of a modality. Bundling can be applied within a company but also between competitors. Bundling of load gives opportunities to individual parties that they generally do not have when they arrange transport on their own. By bundling load, the utilization of the transport mode can be increased, as well as the scale of the transport mode. Besides, due to the availability of more load, the sailing frequency can be increased which improves the flexibility. An example of bundling can be found in barge container transportation. Small-scale inland terminals are bundling their load, both within and between terminals. This enables them to sail with bigger call sizes and bigger vessels towards the deepsea terminals. This leads to less vessels sailing towards the ports, which improves the efficiency in the deepsea terminals as well. An example of these container bundling practices will be given in 2.3.

The third measure is an increase in scale of the vehicles. This can be accomplished in multiple ways. An innovation in truck transportation that is currently under development is truck platooning. This is a way of truck transport where multiple trucks are electronically connected to each other like a train with wagons. The first truck in the row contains a truck-driver and the rest of the trucks are following without the involvement of a driver. Truck platooning has multiple advantages compared to traditional truck transportation. First, by letting trucks drive close towards each other more space on the road is available which leads to a better utilization of the infrastructure. Second, this leads to Co2 reduction because of a better aerodynamic flow. This could lead to a reduction in Co2 emission up to 10%. Third, it could lead to safer and cheaper transport, which is beneficial for the whole industry. Another way to reduce the environmental impact is by increasing the scale of a single vehicle. For example, the application of longer trucks, barge combinations and longer trains.

Energy mix by use of modalities

Ports can promote the greening of trucks, rail and barges. The emission standards for transport modes are usually developed at the supranational or national level, but the use of cleaner engines can also be supported by public and private actors in ports.

One way to achieve this is to impose minimum emissions standards on vehicles entering the port area (i.e. a kind of low emission zone). One of the pioneering programs in this field is the Clean Truck Program, part of the San Pedro Bay Ports Clean Air Action Plan. In 2008, the Port of Los Angeles banned pre-1989 trucks followed by a progressive ban on all trucks that did not meet 2007 emission standards by 2012. Since 2018, only trucks of model year 2014 or newer are allowed to sign up in the so-called Port Drayage Truck Registry (PDTR). These trucks need to comply with the California Air Resources Board's Drayage Truck Regulation (Port of Los Angeles website). The program has reduced air pollution from trucks by more than 90 percent.

Another way is to stimulate the shift to non-fossil fuels. For example, in early 2019, it was announced that a hydrogen fuel production company will supply zero emission hydrogen for a fleet of fuel cell electric trucks to be operated at the ports of Los Angeles and San Diego. The annual greenhouse gas emission reductions that are associated with the project are expected to be 77 metric tons per zero emission truck per year. The fleet of trucks receives funding through grants from the California Air Resources Board (CARB) grant and California Climate Investments.

Promoting the role of inland terminals and port-hinterland concepts in GSCM

In the past decades, the dynamics in logistics networks have created the right conditions for a large-scale development of inland ports and inland logistic platforms throughout Europe. The range of functions presented by inland logistics centres is wide ranging from simple cargo consolidation to advanced logistics services. Many inland locations with multimodal access have become broader logistics zones. Not only have they assumed a significant number of traditional cargo handling functions and services, but they also attracted many related services like distribution centres, shipping agents, trucking companies, forwarders, container-repair facilities and packing firms. The concept of logistics zones in the hinterland is now well-advanced in Europe: e.g. 'platformes logistiques' in France, the Güterverkehrszentren (GVZ) in Germany, Interporti in Italy, Freight Villages in the UK and the Zonas de Actividades Logisticas (ZAL) in Spain. Logistics zones are usually created within the framework of regional development policies as joint initiatives by firms, intermodal operators, national, regional and or local authorities, and or the Chambers of Commerce and Industry. The interaction between seaports and inland locations leads to the development of a large logistics pool consisting of several logistics zones.

Many market players and port authorities have come to understand that landside operations are key to a successful integration along the supply chain and to move to a greener port-hinterland connectivity. A number of shipping lines extend their scope beyond terminal operations to include inland transport and logistics. Inland terminals and rail and barge services are combined to push import containers from the ocean terminal to an inland location, from where final delivery to the receiver will be initiated at a later stage. This "push" strategy is initiated by the shipping line, yet prioritized based on the required delivery date. Export containers are pushed from an inland location to the ocean terminal, initiated by the shipping line, yet prioritized based on available inland transport capacity and the estimated time of arrival (ETA) of the mother vessel.

Some terminal operators in Europe are also increasing their influence throughout supply chains by engaging into inland transport. They seem to do so mainly by incorporating inland terminals as 'extended gates' to seaport terminals (see example of Extended Gate concept of ECT in Rotterdam in section 2.3) and by introducing an integrated terminal operator haulage concept for their customers. The advantages of the extended gate system are substantial: customers can have their containers available in close proximity to their customer base, while the deepsea terminal operator faces less pressure on the deep-sea terminals due to shorter dwell times and can guarantee a better planning and utilization of the rail and barge shuttles. The success of both extended gates and terminal operator haulage largely depends on the transparency of the goods and information flows.

A close coordination with shipping lines, forwarders and shippers is needed to maximize the possibilities for the development of integrated bundling concepts to the hinterland which can also reduce the environmental footprint of port-hinterland connections.

New or renewed transport modes in a seaport context

Freight transportation by trucks and vans leads to much congestion in nowadays` supply chains which reduces the efficiency and environmental performance. An alternative or addition to the current freight transport modes could be underground freight transport (UFT). This transport mode can have two variants. The first variant uses pipeline transport in the form of a capsule for goods with a diameter of less than one meter. The second variant needs individual trains or other vehicles to move forward. UFT could be applied in four ways of freight transport (Visser et al., 2018):

1. Urban area transportation
2. Inside or between industrial/port complexes
3. Long distance transport
4. Hinterland/cross country transportation

One variant of a possible underground transportation system is the Hyperloop concept. A Hyperloop is a tube-based transportation system, which includes freight capsules that move through a vacuum tube. The big advantage compared to conventional trains is that there is almost no friction in the tube due to the absence of air. The hyperloop could be applied for both passenger and freight transportation. Currently, hyperloop technology is not yet applied on a large scale within supply chains, but the potentials are big. An example of a port who is actively seeking the possibilities is the port of Hamburg.

Green inland-focused port dues

Port authorities can influence the greening of hinterland transportation activities by applying port dues as a tool (Berqvist and Egels-Zanden, 2012). Port dues are the tariffs that (logistic) companies pay to use the port. Green port dues are meant to internalize the external costs of hinterland logistics into the transportation system. A possible variable set that determines the port dues is the following: transport mode, distance to the port, technical performance and distance towards the closest intermodal hinterland terminal. Although this policy sounds good on paper, it is something that seaports find hard to implement. For a seaport, green port dues are equal to a raise in prices. Thereby they run the risk of losing business volume. At the same time, shippers and LSP`s might be opposed to green port dues which makes ports even more reluctant to implement it. The benefit for seaports would be a strong signal to the market that it cares about the environment. Though, it is questionable whether this benefit outweighs the risk of losing freight volume and business.

Advanced and integrated traffic management systems for rail, barge and truck.

Traditionally, every (transport) company coordinated its own freight movements. This leads to low utilization of infrastructure, suboptimal loading rates and peak moment during the day. In the ideal world, all modalities have an integrated traffic management system, which centrally coordinates the planning of all freight flows. The most important success factor for the functioning of these systems is having the right information available to the right party at the right moment. Supply chain parties are often reluctant in directly sharing information with their customers. Independent organizations / platforms that collect and process these data are therefore crucial. An illustrative example in the barge sector within Rotterdam is the platform Nextlogic, which will be further elaborated in chapter 2.3.

Pricing mechanisms and other instruments to spread traffic in time and space

Ports, and especially terminal operators, face problems with truck congestion during peak hours. It would be in the interest of multiple stakeholders to spread this traffic more smoothly over the day. Terminal operators will experience a better utilization of their terminal, trucking companies face less waiting hours and the public faces less congestion on the road which reduces greenhouse gas emissions and results in time savings. Terminal operators have three main tools to influence the arrival time of truck drivers (Zhang et al., 2019).

1. Truck appointment: reduce truck-waiting time by setting an arrival quota (upper bound) for each time window.
2. Time window control: In this method, two windows are assigned to each vessel for container pickups and deliveries.
3. Truck congestion pricing: charging a traffic mitigation fee during peak hours.

A variant of time window control is applying extended opening hours on terminals. This leaves more room for trucks to reschedule their trips to the ports from peak hours to off-peak periods. However, the shift to night-driving is not easily implemented by trucking companies. They are dependent on the opening hours of their clients, which have their own belongings and regulations. Clients will not shift their procedures without seeing clear benefits.

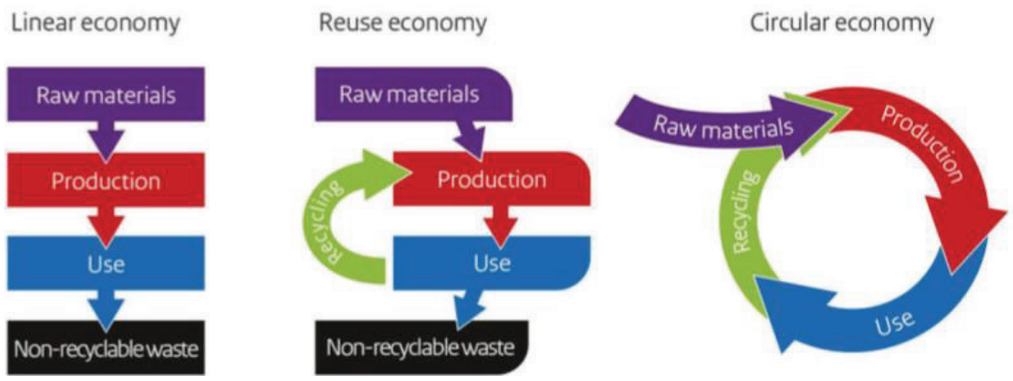
Development of pipeline network (intra-port, inter-port and port-hinterland)

Pipeline networks can be used for transportation of liquids over both short and long distances. These networks can contribute to the CO2 reduction goals in two ways. First, it reduces the amount of CO2 that is emitted in the air because pipeline transportation is cleaner than other transport modes such as truck, rail and barge. Second, it is essential in the development of a circular economy. Pipelines will be necessary in transporting CO2 to places where it can be stored or where it will be used in other production processes.

2.2.4. Seaports and the circular economy

This field of action includes measures that facilitate the transition to a circular economy. The traditional economy is built upon a linear model. This means that a product is built from raw materials, consumed and used by society, and then ends up as an end-of-lifetime (EOL) product. This EOL product is generally destroyed (Stegeman, 2015). A more sustainable way is to re-use EOL products in order to reduce the amount of new commodities that are needed for each product. The most sustainable form is the circular economy. Here, it is attempted to close the entire loop. Thus, raw materials enter the production process and every component of the product can be recycled and used in the production process of a new product. Figure 7 describes the three above mentioned ways of production processes in a schematic way.

Figure 7. Three forms of production processes, build up from non-sustainable to sustainable



Source: Ballini (2017)

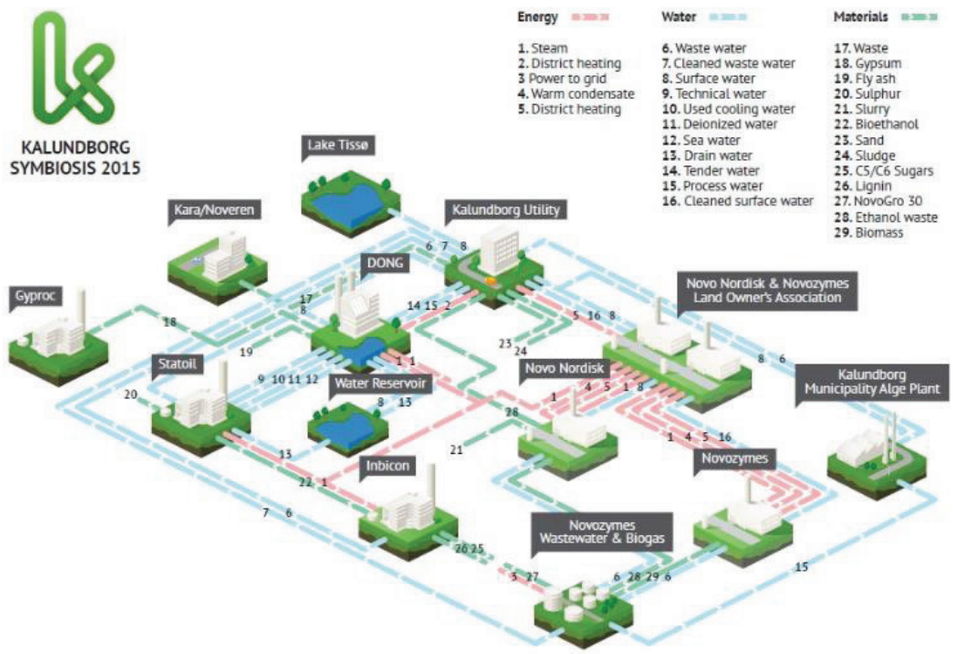
Preston (2012) describes the circular economy as following: “restructuring the industrial systems to support ecosystems through the adoption of methods to maximize the efficient use of resources by recycling and minimizing emissions and waste”. Van Dooren and Braam (2015) distinguish four focus areas of ports to create a circular economy: (1) minimizing the use of inputs and eliminate waste and pollution, (2) maximize the created value at each stage, (3) manage flows of bio-based resources and recovery of flows on non-renewables into a closed loop, (4) establish mutually beneficial relationships between companies within each circular chain. In this paragraph the following concepts of the circular economy in ports will be discussed: Industrial Ecology, seaports as hubs for recycle-flows and use of renewable energy sources.

Industrial Ecology

Industrial ecology attempts to optimize waste management by making interactions between stakeholders within the same geographical area stronger. A well-known way to achieve this is by using Industrial symbiosis. This means that traditionally separated industries are forming collective approaches by exchanging materials, water and by-products and thereby reducing the amount waste that is been produced. This functions best when industries with synergies are located in close proximity from each other (Chertow, 2000). One of the most well-known industrial symbiosis locations can be found in the Danish city of Kalundborg. Here, a partnership between nine public and private companies have been formed. It started in 1961, when Statoil needed water for its refinery near to Kalundborg. Statoil created a pipeline between the refinery and a nearby lake called Tissø. Over the years more companies linked to the port area in Kalundborg which led to a partnership of eight private and public partners

and in total 50 symbiotic exchanges in three categories: energy, water and materials. Figure 8 below shows schematically this symbiosis.

Figure 8. schematic view of the Kalundborg Symbiosis process



Besides intercompany relations it is also possible to form symbiotic relations between cities and industry. A lot of heat is produced within industrial complexes and letting this heat flow into the air is a waste of energy. Therefore, ports are undertaking initiatives to connect the heating systems of houses to the rest heat of industrial complexes in order to use this heat to warm houses.

The question is how ports can foster the development of these industrial symbiosis. In the Kalundborg case no multi stakeholder processes have taken place to set up the collaboration. The initiatives have been set up based on private sector goals such as cost reduction, revenue enhancement, business expansion, and securing long-term access to water and energy. After starting the collaboration processes, coordinative actions started to arise by managers to help creating more exchanges and move collaborations forward (Chertow, 2007).

Seaports as hubs for recycle flows

Worldwide large amounts of recyclable goods are transferred. A good example of these international trade in recycling flows is the export of plastics towards China. Since the 1990`s China started to import large amounts of plastics from over the world to process it into the production of goods. It is estimated that China imported 45% of total plastic imports worldwide. Though, China faced big environmental problems with processing these enormous amounts of plastic and put a ban on 24 kinds of plastic in 2018. This has led to reduction in imports of solid waste – which included paper, metal and plastics – of 54 percent in the first quarter of 2018 (CNBC, 2018). International trade in recycling flows is growing and ports are well-suited to serve as a hub in these international flows due to the already existing seaport infrastructure and international connectivity (Kuipers, 2015). Within these hubs recycling flows are delivered, transformed into new products and re-exported around the

world (VIL, 2015). Though, it is also possible that ports solely serve as re-export hubs to send for example recycling flows towards the hinterland. In 2.3 several real-life examples of recycling hubs will be stated. An example of a big European recycling hub is HAROPA, a port which is located close to Paris. The logistics trade in recycle products is big in this area with more than 1,500 companies and 25,000 employees. Activities that take place are the collection of hazardous waste, processing and disposal of non-hazardous waste and the collection and sorting of waste (HAROPA, 2017).

Use of renewable energy sources

De Langen and Sornn-Friese (2019) also refer to the use of renewable energy sources as part of the circular economy. According to them, ports are well-suited for the generation of renewable energy. Currently, most energy is still generated from coal and gas-fired power plants but at the same time most new investments are in renewable energy. Though, the social and political pressure is growing and countries like the Netherlands and the UK are even planning to phase out the coal plants in ports. Alternatives for these plants are for example hydro- and offshore power installations. Ports can be good locations for these installations for multiple reasons. This is because ports are located close by large geographical space (sea). Also, ports offer space for storage and transportation of components. Lastly, those installations are in need of maintenance activities which are available within ports (De Langen and Sornn Friese, 2019).

2.2.5. Knowledge development, information sharing and exchange of best practices

This field of actions includes measures that facilitate knowledge development, information sharing and exchange of best practices in the field of GSCM in seaports. A non-exhaustive list of some areas for initiatives is presented below.

Development of interactive environmental and energy information and management systems.

For example, a proper analysis of the energy consumption and emissions brings additional information in ordinary business cycle from which stakeholders can obtain more reliable and accurate information about company's general performance and efficiency, also from the operational and cost perspectives. Energy and environmental management systems enrich business processes with new knowledge about energy consumption and emissions and lead to a better understanding of activities and processes, allowing stakeholders to better plan their strategies. A vital element of the energy and environmental management systems is benchmarking or comparing efficiency of different processes or activities. On the implementation level, the greatest challenge is how to empower workers to achieve enduring performance improvements.

Co-operation in the framework of port-related associations

Port authorities and port-related firms exchange knowledge and best practices on green ports and green supply chains and jointly aim for innovation in these fields through a broad range of associations, ad hoc co-operation arrangements and partnerships of all sorts. For example, port authorities are working together on green issues through EcoPorts, World Port Sustainability Program (WPSP) of the International Association of Ports and Harbors (IAPH) and the World Ports Climate Initiative (see section 2.3).

Environmental strategies of ports combined with or integrated in broader corporate social responsibility (CSR) strategies and stakeholder relations management.

Corporate social reporting (CSR) is concerned with learning about the effect an organisation has on society, about determining what corporate social responsibilities the organisation has within society, and allows the organisation to be accountable for these responsibilities. A lot of port authorities, port companies and branch organisations have developed extensively sustainability and CSR programs to improve the social and environmental performance of the port cluster and to improve communication and exchanges on these topics with a broad range of stakeholders (environmental groups, community groups, the press, government, port users, etc.). CSR practices in ports have gained increasing interest in business and academic circles. For example, Grewal and Darlow (2007) studied the business paradigm for CSR within the context of Australian seaports by focusing on the drivers for CSR (societal demands, government demands for transparency in social responsibility), key management concerns and issues regarding CSR (financial, cost, risk, etc.) and the key benefits expected to accrue from CSR (trust and reputation, important cost savings and the importance of CSR to sustainable success). Vanelslander (2016) examined how CSR emerges among company goals in seaports, and the extent to which innovation initiatives respond to the goals raised. The study also applied a scoring of how port innovation initiatives respond to the raised goals. CSR related issues of ports are often included in sustainability reports.

Sustainability reporting at company, port authority or port industry level

The practice of sustainability reporting, beyond mere environmental reporting, started in the late 1990s. More recently, the port industry is adopting this sort of reporting to conceptualize sustainability and as an essential basis for the license to operate (Maigret, 2014). Mainly larger port authorities have started producing sustainability reports or integrated reporting on a voluntary basis in the past decade (e.g. Antwerp, Hamburg, Rotterdam), while others have been obliged to adopt the practice due to enforced legislation by governments when it comes to example-setting by state-owned enterprises (e.g. Swedish ports) (Geerts and Dooms, 2017). Ports increasingly follow global guidelines and standards for sustainability reporting (such as the Global Reporting Initiative - GRI). In 2016, the first Sustainability Report at the level of the European Port Industry was presented in the context of the EC PORTOPIA project (PORTOPIA, 2016). The report is set-up along six dimensions (Market Trends and Structure indicators - Socio-Economic indicators - Environmental and Occupational Health, Safety and Security indicators - Logistics Chain and Operational Performance indicators - Governance indicators - User Perceptions on Port Quality indicators) and uses datasets present within the European Seaports Organisation (ESPO) and the ECOPORTS project. Geerts and Dooms (2017) demonstrated that many unsolved conceptual issues and differences in approach among ports remain when it comes to sustainability reporting: (1) the scope and the boundaries of the reporting i.e. organizational, functional or geographical boundaries; (2) the perspectives of performance and the calculation/definition of indicators, and; (3) the integration of stakeholder perspectives.

Develop the local knowledge base on GSCM in ports

Innovation is high on the agenda of many ports. This includes also innovation in the area of sustainability and green supply chains. To drive innovation in the port cluster, port authorities, port industry and branch associations/organisation, private companies and government agencies develop a broad range of local initiatives, such as:

- The setting up of incubators and smart-labs for start-ups and scale-ups (e.g. Prodock in the Amsterdam port area, the Boston Waterfront Innovation District, Barcelona Co-

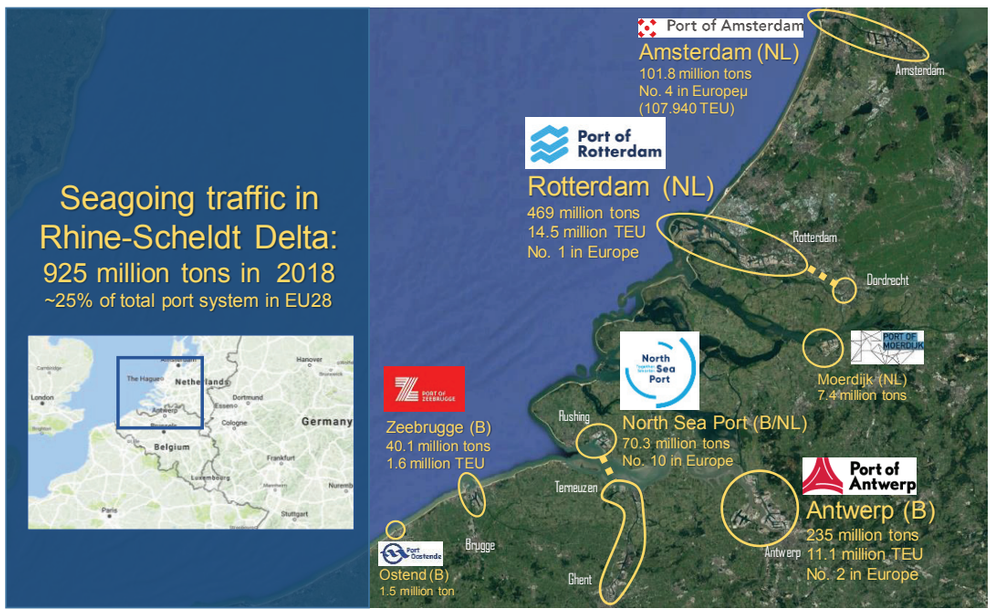
Innovation Center). Many of these incubators are based on the co-creation and co-innovation principles and the exchange of knowledge among companies;

- The organisation of Hackathon events (Boston Seaport Hackathon, Maritime Hackathon Hamburg, World Port Hackathon Rotterdam, etc.) A hackathon is a design sprint-like event in which computer programmers and others involved in software development, and others, often including domain experts, collaborate intensively on software projects. The goal of a hackathon is to create usable software or hardware with the goal of creating a functioning product by the end of the event. Many of these solutions in the port sphere are having a focus on more sustainable and green supply chains and port operations;
- Co-operation (agreements) with universities and research institutions;
- Creating a good business environment for R&D focused firms, research centres, consultancy firms and start-ups.

2.3. GSCM in seaports: approaches in the Rhine-Scheldt Delta

This part gives a more detailed discussion of the above fields of actions, substantiated by concrete examples of port authorities, private companies and associations in the Rhine-Scheldt Delta ports. The Rhine-Scheldt Delta features established large ports, such as Rotterdam and Antwerp, as well as a whole series of medium-sized to smaller ports each with specific characteristics in terms of hinterland markets served, commodities handled and location qualities. The Rhine-Scheldt Delta port system handled about 925 million tons in 2018 or a quarter of the total port throughput in the EU28. Four of the ten largest ports in Europe (in throughput terms) are located in the Delta. The unique blend of different port types and sizes combined with a vast economic hinterland, shapes port dynamics in the region. While Figure 9 features all seaports in the Delta region, we will mainly focus on the ports of Rotterdam, Antwerp, North Sea Port (Flushing, Terneuzen and Ghent) and Zeebrugge.

Figure 9. Total maritime traffic (seagoing) in the Rhine-Scheldt Delta



Source: own compilation based on port authority statistics

The discussion of initiatives in the Rhine-Scheldt Delta follows the structure of measures, tools and instruments as presented in section 2.2. We use tables to summarize the initiatives. Each table identifies the type of action, the (leading) actor or initiator involved, a short description of the initiative and the current status. Before turning to the examples, we briefly present the actors potentially involved in the greening of ports and the dynamics in GSCM.

2.3.1. The actors involved

First, there are the **port authorities or managing bodies of the port**. In many countries around the world, governments and public port authorities have retreated from port operations in the belief that enterprise-based port services and operations would allow for greater flexibility, more competition, higher efficiency in the market and a better response to port users' demands. Many ports have adopted some sort of landlord port authority model. Under this model, the landlord port authority typically is a separate entity under public law established by a specific legislation with the capacity to conclude contracts, enforce standards and to make rules and regulations applicable within the port area. Port operations (especially cargo-handling) are carried out by private companies. Today, the landlord port is the dominant port model in larger and medium sized ports in Europe (Verhoeven, 2010). In the Rhine-Scheldt Delta, all port authorities are corporatized landlord port authorities resulting from gradual corporatization processes. In practice, this implies port authorities have a public limited company status and have financial and managerial autonomy to develop and implement port strategies. In this vein, the word 'port authority' is often seen as outdated. Managing body of a port, port managing company or port development company are alternative terms being coined to refer to active landlord ports which enjoy great autonomy.

The port authorities in the Rhine-Scheldt Delta, just like many other ports around the world, are pursuing a greening of port management to safeguard their license to operate, to comply with and anticipate to environmental regulation and to increase their economic and environmental competitiveness. For example, port authorities show increasing concerns about the impacts of noise pollution and air emissions on the sustainable functioning of the port. These types of pollution clearly affect the health of people working or living around ports (Puig et al., 2015). As such, limiting air and noise pollution is not only an environmental goal of port authorities. It has also become a clear mission in the context of corporate social responsibility (CSR) and stakeholders relations management in port areas (Dooms et al., 2013; Parola and Maugeri, 2013). The Delta ports have recognized quite early the necessity to carefully consider environmental issues in their strategic planning and behaviour, and to communicate actively with the entire range of stakeholders. They have taken measures to show their environmental concerns and their reliability in taking care, and have started to implement the concept of sustainability. Given the potential environmental impacts of ports, port authorities are challenged to avoid and or reduce effects through a range of green management instruments. We define a green management instrument as a tool used by port authorities to implement their environmental policies. Lam and Notteboom (2014) classified such instruments in four distinctive groups: 1) penalty and incentive pricing, 2) monitoring and measuring, 3) market access control, and 4) environmental standard regulation.

A second group of actors are the **port and terminal operating companies.** Port operations are usually oriented towards the two traditional components of ships and cargo. Services to ships include those performed at the sea or waterways side (dredging, pilotage, mooring/unmooring, etc.) and at the ship/shore interface (berthing, repair and maintenance, supply and bunkering, etc.). Services to cargo can be divided into those performed at the

ship/shore interface (stowing, loading, discharging, etc.) and those entirely performed in land-side areas such as consolidation, storage and distribution performed by logistics companies. Key are the concepts of efficiency/performance and sustainability at the operational level (i.e. a company or terminal). Port and terminal operating companies can and do take action to reduce the environmental footprint of their operations and to contribute to GSCM.

A third group of actors consists of **supply chain and transport organizers** such as forwarders, shipping agencies and logistics service providers. They can have a large impact on GSCM and the greening of ports through the actions and decisions they take in terms of transport mode choice, cargo bundling and information exchange.

A fourth group of actors includes the **companies involved in industrial and semi-industrial activities** in the port area. Ports in the Rhine-Scheldt Delta are home to a large diversity of industrial activities. Steel plants can be found in North Sea Port (ArcelorMittal) and Amsterdam (Tata Steel). Automotive plants are found in the vicinity of the North Sea Port area (Volvo Cars and Trucks). Energy plants and energy-related industries are found in almost every port in the Delta, with major LNG facilities in Zeebrugge (both pipeline and LNG carriers) and Rotterdam, a nuclear power plant in the port of Antwerp, coal-powered and biomass-powered plants, windfarms, etc. Probably the largest industrial activity in the Delta is related to petrochemical and chemical companies. The (petro-)chemical and industrial complexes in the Delta ports attach great value to sustainability. 'Ecologies of scale' play an essential role here, combined with further increases in energy-efficiency and plans for carbon storage. Industrial co-location or co-siting and the intra- and inter-port pipeline system in the Delta are two key factors supporting the creation of 'ecologies of scale' in the Rhine-Scheldt Delta. A further improvement of the pipeline system in the Delta and a continued support to co-location and co-siting solutions are important for the entire Delta, but also play at the level of individual ports. Individual industrial companies in ports can further enhance 'ecologies of scale' through asset sharing and product exchanges among chemical plants. The industrial companies in ports also implement strategies to cope with a partial transit from fossil energy to sustainable energy. The shift away from fossil fuels to non-fossil fuels is considered as a major challenge and opportunity. They also take action in the area of the circular economy and the use of CO2 as a raw material.

A fifth groups of actors includes **associations, government agencies and NGOs**. A large number of government agencies (national, regional, provincial or city level), ministries and public entities are involved in the Delta ports and the greening of these ports. Furthermore, port community associations (e.g. Deltalinqs in Rotterdam, Alfaport, etc.), branch organisations (e.g. Fedichem, Koninklijke Belgische Redersvereniging, etc.), environmental groups (e.g. Natuurpunt) and community groups of all kinds also contribute to the stakeholder debate on the greening of ports and port-related supply chains.

Finally, service providers (such as banks, insurance companies, classification and certification societies, rating agencies, IT companies and start-ups, etc.), research institutes, universities and innovation centres of all sorts contribute to the search for novel ways to support GSCM practices in the port context.

2.3.2. Examples of initiatives in the area of 'green shipping'

Action	Reduce ship emissions in ports by decreasing waiting times and the turnaround time of vessels in port
Party	Port Authority
Initiative	The Port of Rotterdam implemented an application called Pronto. This system provides a real-time overview of the available berthing places and handling capacity. If there is no berthing space in the port, ships can adjust their speed and thereby do not have to wait in the port anymore. This saves fuel, both at sea and within the port. The application will function optimally when all relevant parties within the chain share their real-time information.
Status	Implemented but under development

Action	Green port dues and voluntary green shipping schemes
Party	Port Authority
Initiative	**ESI: The Environmental Ship Index (ESI)** The ESI was designed by the ports of Le Havre, Bremen, Hamburg, Antwerp, Amsterdam and Rotterdam and adopted by the World Port Climate Initiative. It identifies seagoing ships that perform better in reducing air emissions than required by the current emission standards of the International Maritime Organization (IMO). The ESI evaluates the amount of nitrogen oxide (NOx) and sulphur oxide (SOx) that is emitted by a ship. The ESI is used as an indicator for environmental performance by port authorities. Port authorities provide a discount on port dues to those shipping companies that sail with cleaner ships according to the ESI. Most ports in the Delta are part of the ESI scheme. North Sea Port Flanders gives price reductions for vessels that use LNG as a fuel and for ships with ESI or Green Award certificates. Some ports, like the port authority of Zeebrugge, are taking action to start introducing price reductions for vessels that use LNG as a fuel in the future.
Status	Implemented

Action	Support the transition to LNG as a ship fuel
Party	Port Authorities and market parties
Initiative	**LNG Hub**: Port authorities are serving the market with LNG fuel. The port of Zeebrugge and the port of Rotterdam import and export LNG on a large scale, for usage in Europe. **LNG bunkering**: Besides trading activities, many of the ports in the Delta have facilities to use LNG in the port itself. Examples are ship to ship and truck to ship bunkering facilities. French utility and LNG player Engie operates an LNG bunkering station for barges in the port of Antwerp. Truck-to-ship bunkering has been available at the Belgian port since 2012. The first seagoing vessel bunkered at the Port of Antwerp on September 2015. Fluxys Bunkering SPRL as concessionaire markets

	capacity for LNG bunkering at Quay 526 in Antwerp. In early 2019, Fluxys and Titan LNG formed a partnership for the construction of FlexFueler 002, a bunkering pontoon for LNG as a ship fuel. The pontoon is expected to start operations in mid-2020. In Rotterdam the LNG import terminal, the GATE terminal initiated by De Nederlandse Gasunie en Vopak, was opened in 2011. It is a terminal with a capacity of 12 billion m3 for import and re-export. An adjacent LNG break bulk terminal is operational from mid-2016. Related to these terminals there are large investments in LNG infrastructure in the Port of Rotterdam. The bunkering of LNG is permitted, facilitated and encouraged. ENGIE Zeebrugge, a ship owned and operated by Mahon Shipping SA and LNG Link Investment AS, is the world's first LNG bunkering vessel for refuelling LNG-powered vessels at sea. The ship is home-ported at Zeebrugge. The vessel supplies LNG to LNG-fuelled vessels operating principally in the North Sea and the Baltic Sea. The ship receives LNG from Fluxys LNG terminal in Zeebrugge. Fluxys signed an agreement with ENGIE, Mitsubishi and NYK Line to acquire 25% stake in the vessel in October 2015. Furthermore, Fluxys LNG SA as owner and operator markets all capacity in the Zeebrugge terminal for liquefied natural gas (LNG) in Belgium. LNG bunkering in North Sea Port is happening since 2016 with the first truck to ship bunkering in Flushing. In October 2018, an LNG bunkering operation from trucks to a sea-going vessel was successfully completed in North Sea Port Flanders. The bunkering service was provided by Titan LNG, a supplier of LNG for ships and industrial applications in north-western Europe. The aim is for bunkering with LNG to become more routine in North Sea Port in the future. North Sea Port recently launched a feasibility study (market potential and possible locations) for development of LNG-bunkering infrastructure within the port area.
Status	Implemented or ongoing

Action	**Cold Ironing, Shore Power Supply or Alternate Marine Power (AMP)**
Party	Port Authority
Initiative	North Sea Port provides shore-side power for inland waterway vessels. Recently, two additional shore-based power units for inland waterway vessels were installed at the Sifferdok's inlet dock in Ghent, on top of the existing facilities in Terneuzen. A further two shore-based power units will be installed in Terneuzen in March 2019. By mid-2019, North Sea Port will have a total of 23 shore-based power units offering a total of 80 connection points. The feasibility of providing shore-side power in Vlissingen in the future is currently being investigated. The development of shore power facilities as a service for private quays is also currently being investigated in North Sea Port. In the port of Zeebrugge, paper producer Stora Enso and the naval base already provide their vessels with shore power. The Antwerp Port Authority has installed onshore power connection points on Quay 75, the barge holding dock, so that barges can draw electricity while they

	are at berth. The Port Authority fleet of service vessels has been using onshore power since the beginning of 2018. The port authority also aims to create the necessary conditions to supply onshore power for seagoing ships in the port. In March 2018 an agreement was signed between the Port Authority and five technical partners (Techelec, Schneider Electric, ABB, Actemium and Siemens) to share expertise to enable onshore power for seagoing vessels in the port area to be realized in the short term. The Port of Rotterdam installed cold ironing systems where inland shippers can connect their vessel to. This shore-side electricity for ships effectively reduces Co2 emissions and noise from vessel in the port.
Status	Partly implemented https://en.northseaport.com/north-sea-port-takes-further-steps-towards-realising-shore-side-power-for-inland-waterway-shipping https://www.portofzeebrugge.be/en/port/sustainability/shore-power-supply https://www.portofantwerp.com/en/onshorepower https://www.portofantwerp.com/en/news/port-antwerp-pushes-ahead-onshore-power-ships https://www.greenport.com/news101/europe/cold-ironing-for-inland-vessels-part-of-the-clean-air-plan-of-port-of-rotterdam

Action	**Promote the use of non-fossil fuels in shipping**
Party	Port Authority
Initiative	**Marine Energy Transition Forum**: Petrospot and the Port of Antwerp worked together on a one-day forum held at The Port House in late March 2019. The inaugural forum aimed at providing a platform for experts from the shipping, port, bunker, financial and technology sectors to explain how collaboration between stakeholders in the marine energy supply chain will be key in helping the shipping industry to move beyond its dependence on fossil fuel-based energy. Barge Terminal operator CCT applies 100% biofuel on a barge vessel named “for-ever”. This results in a reduction in Co2 emission of 90%. Port of Rotterdam and Port of Antwerp provided subsidies for experiments with this project.
Status	Ongoing

Action	**Promote the use of non-fossil fuels in shipping**
Party	Maritime group CMB
Initiative	Hydroville is the first certified passenger shuttle that uses hydrogen to power a diesel engine. Hydrogen has the advantage that no CO2, particulate matter or sulphur oxides are released when burning it. The shuttle is mainly used as a platform to test hydrogen-technology for commercial sea going vessels. In a first phase the Hydroville transports staff of the CMB group from Kruibeke to the south of Antwerp during the rush hour to avoid traffic jams.
Status	Implemented http://www.hydroville.be/

Action	**Promote the use of non-fossil fuels in shipping**
Party	Private companies and Rotterdam Port Authority
Initiative	The port authority of Rotterdam is taking part in a test of a new sustainable marine bio-fuel oil. The bio-fuel oil was developed by GoodFuels and is

	completely derived from forest residues and waste oil products. It is expected to deliver a CO2 reduction of 80-90% versus fossil equivalents, and virtually eliminates sulphur oxide (SOx) emissions - without any requirement for engine modifications. The test is overseen by project partners IKEA Transport & Logistics Services, CMA CGM and the Port of Rotterdam in the context of the GoodShipping Program. The testing started with the bunkering of the marine bio-fuel oil on a CMA CGM container vessel at the Port of Rotterdam on 19 March 2019.
Status	Ongoing

2.3.3. Examples of initiatives in the area of 'green port development and operations'

Action	Concession policy
Party	Port Authority
Initiative	The Port of Rotterdam makes agreements with logistic companies in the port, such as terminal operators, about modal split restrictions. Modal split is the ratio between the different modalities rail, barge and truck. The aim of this is to realize a shift freight from truck transport towards rail and barge, which leads to a better access to the port, less congestion and a lower impact on the environment due to a reduction in total Co2 emissions. The aim is to have a modal-split in 2035 which consists of: barge 45%, truck 35% and rail 20%. However, between 2007 and 2015 the share of truck only reduced from 49.8 to 46.4% so it seems challenging to achieve this.
Status	Implemented

Action	Production of bio-fuels and bio-based chemicals
Party	Industrial company
Initiative	Neste is the biggest refinery of renewable fuels in Europe. The refinery is located at the Maasvlakte in the Port of Rotterdam and it produces the following renewable fuels: diesel, jet fuel and propane. In 2016 Neste built a new installation that produces Bio-LPG. This renewable fuel emits significantly less Co2 and can be applied in every vehicle that is LPG-powered. SHV Energy is the buyer of this fuel and it is selling the fuel on the North-Western European market. Hereby those parties contribute to the transition towards a circular economy. North Sea Port is home to the Bio Base Europe Pilot plant which is a scale-up and testing facility for bio-based chemicals.
Status	Implemented

Action	Ecologies of scale
Party	Port Authority and industrial companies
Initiative	The Port of Antwerp is one of the leading European oil and chemical cluster in Europe. The port is home to both base chemicals and fine chemicals production and offers more than 7 million m^3 of third-party liquid storage solutions, 2 top 10 refineries, 4 steam crackers and no fewer than 30 companies operating in the oil and chemical sector. The cluster offers great integration possibilities in terms of the supply of feedstock, raw materials and intermediates, the opportunities for integration of products and energy, and the extensive pipeline connectivity, tank storage and product handling.

	Ecologies of scale are realized by, for example, minimizing inter-firm transport distances of products (via pipeline or over land), the use of waste or residual products of one company by other companies. Companies can further realize ecologies of scale via co-siting and co-location. The same co-siting and co-location dynamics are visible in the industrial complexes of other Scheldt-Rhine Delta ports, particularly in Rotterdam. In early 2019, the Port of Antwerp launched an initiative to bring different players together to produce sustainable methanol. The pilot project aims for 4,000 to 8,000 tonnes of sustainable methanol per year. Methanol is an important raw material with multiple uses in the chemical industry, and also has many applications outside of it. The idea is to produce methanol from waste CO2 and sustainably generated hydrogen. The waste CO2 will be collected by Carbon Capture and Utilisation (CCU) in which at least some of the CO2 emissions are recovered. This CO2 is then combined with hydrogen generated on a sustainable basis using green energy in a new electrolysis plant. Also other ports are home to initiatives to generate ecologies of scale. For example, several projects have been realized in North Sea Port, such as heat exchange between Volvo and Stora Enso or the delivery of heat and CO2 by Yara to greenhouses (WarmCO project). The port is actively seeking to realize further ecologies of scale by focusing on the chemical cluster Dockland and the biobased cluster Kluizendok. Another important initiative is the plan of Dow Benelux, Yara and Gasunie to exchange hydrogen for industrial use via a gas transport pipeline that is no longer in use. The collaboration is part of the Industrial Cooperation for sustainable growth within the Smart Delta Resources platform, which is facilitated by the Zeeland development company Impuls. It is the first step towards the realization of the hydrogen pipeline between Dow in Terneuzen and Yara in Sluiskil. The hydrogen released by Dow crackers is used as a raw material for high-quality Yara products. This will result in an initial decrease in energy consumption of 0.15 PJ per year. In addition, it will produce a CO2 saving of 10,000 tons.
Status	Ongoing

Action	**Development of green zones and buffers in port area**
Party	Port Authority, government and environmental organizations
Initiative	There are many protected nature reserves in the port of Antwerp with a unique range of plant and animal life. Some of these areas are open to the public. Some of these reserves, such as Kuifeend, Grote Kreek and Verlegde Schijns, can be visited through guided excursions organised by environmental organisation Natuurpunt. Overall, there is instense co-operation with Natuurpunt for the maintenance and management of many of the nature reserves in the port. In addition, there are several hundred hectares of ecological infrastructure where nature is allowed to flourish alongside human activities.

	Rotterdam's Green Gateway project is intended to revitalise the port embankments and to provide birds and fish with an environment to rest and forage. Also North Sea Port is active in this area. Buffer zones focused on nature and recreation have been realized in the 16 linkage areas in the port. North Sea Port Flanders is investing in the strategic project Moervaartvallei to compensate for nature values lost elsewhere in the port. The Groene Knoop and Koegorspolder are similar nature projects realized by North Sea Port Netherlands. The temporarily non-used land areas near the Kluizendock are managed through an agreement with Natuurpunt and the agricultural industry.
Status	Implemented https://www.portofantwerp.com/en/nature-areas

Action	**Development of windmills and solar parks/roofs in ports**
Party	Port Authority, energy companies and terminal operators
Initiative	The Rotterdam port authority is investing in wind power energy. The current capacity of wind power is 200MW which is 10% of the total produced wind energy in the Netherlands. In 2020 it plans to have 300MW capacity within the port. The port of Zeebrugge is home to a series of wind turbines on the Eastern breakwater. The overall capacity of the park that is exploited by Aspiravi, is 8.5 MW, which equals power for 5,000 families. There are also another 18 wind turbines with an overall capacity of 33.3 MW in the inner port area, exploited by Elicio, Electrabel and Aspiravi. The Transportzone Zeebrugge has another 2 Electrabel wind turbines. Through its subsidiary company Portfineco (a joint venture between MBZ and the intermunicipal company Finiwo) the port authority is also participating in the 'Libeccio' wind turbine park of Eneco Wind on the terminals of Wallenius Wilhelmsen and Toyota in the inner port. These 4 wind turbines are mainly supplying electricity for port related activities. Portfineco wants to set up more wind turbines on the car terminals in the inner port in the future. Zeebrugge is also an important onshore landing point for electricity from offshore wind parks off the Belgian coast, through the projects "Stevin" and "Nemo" of transmission network administrator Elia. Also in Zeebrugge, the ICO terminal in the inner port has solar panels in place and is in the process of installing led lighting. They also are erecting up to 11 windmills, turning the terminal into a "Green" terminal. The Antwerp Port Authority and the Left Bank Development Corporation collaborate with a private partner to build a large-scale wind farm on the left bank of the Scheldt. The project is managed by 'Wind aan de Stroom'. In phase 1 (2014-2015), 16 turbines of 3.0 MW to 3.2 MW each have been installed. In phase 2 (2017), four more turbines of 3 MW each have been installed. In 2018, another turbine was added. On the right bank, already a significant number of turbines have been installed. Another large onshore energy project started in 2016 with the construction by VLEEMO NV of 19 3 MW wind turbines on the

	right bank in the port of Antwerp. The turbines have a tip height of nearly 200m and a rotor diameter of 115m. VLEEMO NV is a collaboration between the Flemish companies Aspiravi NV (50%) and Polders Investeringsfonds (50%). Katoen Natie partnered with EDF Luminus, the largest windmill constructor in Belgium, to build six high-tech wind turbines with a height of 185 meters each in Loghidden City, Katoen Natie's logistics park on the left bank of the port of Antwerp. The turbines were inaugurated in December 2017. The turbines have a combined installed capacity of 19 MW, and generate about 52 GWh per year. This comes down to the yearly electricity consumption of 13.000 households. Katoen Natie has also invested heavily in solar panel roofs. In the past years, the North Sea Port area (Flushing in particular) has developed into a major logistics hub for the offshore wind turbine industry in the North Sea. When it comes to wind energy generation in the port area, about 50 wind turbines have received permits. Solar energy generation is already taking place at solar parks in Scaldia and Zonneberg, while solar park Mosselbanken is a new realisation. The Sunshine project is aimed at the production of green hydrogen from wind and solar power. North Sea Port has a totalled installed wind turbine capacity of about 280 MW, equally divided between the Flemish and Dutch parts of the port area. Also, the port of Ostend has become a major logistics hub for the offshore wind turbine industry. Since 2008 Energy Port of Ostend has been closely involved with the development and operation of wind farms in the North Sea. The investment company REBO NV was founded for this purpose. The REBO-terminal specializes in serving offshore wind activities.
Status	Implemented or ongoing

Action	**Development of windmills and solar parks/roofs in ports**
Party	Warehouse operators
Initiative	Sunpowered freezer-warehouse: Frigocare, is a freezer-warehouse in the Waalhaven, located in the Rotterdam port area. This company invested in a sunpower roof with a surface of 7.500 square meters in 2016. It produces an annual amount of 750.000 kWh, which is enough for 1/3 of the total energy need of the warehouse. In 2014, Kloosterboer (also freezer-warehouse located in the North Sea Port area) invested in solar panels with a total capacity of 450.000 kWh annually.
Status	Implemented

Action	**Green container terminal operations**
Party	Container terminal operators
Initiative	**APM Terminals in Rotterdam** is a container terminal that produces zero GHG emissions. The power requirements of the complete terminal are produced by wind-generated energy. All equipment at the terminal is powered by electrical power, which makes that the terminal produces no GHG emissions. Also, operations are quieter due to the removal of diesel engines.

	DP World, operator of Antwerp Gateway in Antwerp, is investing in hybrid straddle carriers. In November 2018, 15 new hybrid straddle carriers (HSC) from Kalmar were delivered with another 19 coming in 2019. The hybrid straddle carriers consume 40% less fuel and emit a lot less CO2 than conventional machines. The lower fuel consumption is possible because the energy that is released when braking or lowering containers is stored in special batteries on board. Innovative technology ensures an optimal balance between the diesel engine and the battery power. Innovative technologies such as a biogas plant, wind energy, automatic stacking cranes and hybrid straddle carriers ensure that DP World Antwerp remains one of the greenest terminals in the port. In 2014, **PSA Antwerp** invested significantly in making its car and machine fleet greener by purchasing 11 electric quay cars and 2 hybrid straddle carriers at MSC PSA European Terminal (MPET) and at Europa Terminal. These hybrid machines' regenerative energy systems convert electrical braking and spreader energy into electric power. This new system can deliver a 40% decrease in CO2 emission. In addition, PSA Antwerp is making great effort in minimizing its environmental impact by recovering energy from quay cranes and implementing energy-efficient illumination and automated lighting control to its terminals.
Status	Implemented

Action	**CO2 capture and fume return system**
Party	Port Authority
Initiative	**CCS Porthos**: The Rotterdam Port authority started the initiative Porthos, which is a collaboration between the Port Authority, Gas Union and Energie beheer Nederland. The project aims to store Co2 from the industry in empty gas field in the North-Sea. The goal is to store 50 Mton Co2 in 2030. Currently the initiative takers ask companies in the Rijnmond Region for their expression of interest in delivering Co2 for this project. In May 2019, it was announced that the Port of Rotterdam, Port of Antwerp and North Sea Port have applied to the European Commission for a project to collect, transport and store 10Mton of CO2 in the North Sea. Port of Antwerp and North Sea Port will also connect to the Porthos initiative. Phase one of the **CO2TransPorts project** is focused on the development of CO2 transport and storage infrastructure at the Port of Rotterdam. This involves the development of an onshore pipeline through the Port of Rotterdam, a compressor station, and an offshore pipeline to access the P18 gas fields for CO2 storage. The project requires CO2 pipeline infrastructure to be established between the ports. In phase two, a cross border CO2 pipeline will link the ports of Antwerp and Rotterdam. A CO2 network in the Port of Rotterdam is due to be established by 2026. A CO2 pipeline collection network will then be developed in Antwerp and North Sea Port. As part of phase three, the realisation of which is expected from 2030, the CO2TransPorts consortium has identified that under certain, reliable economic and regulatory conditions, the total CO2 transport demand from the three regions may exceed the maximum design

	capacity of phases one and two of 10 Mt/year. Furthermore, demand for CO2 transport may arise from third-party countries needing access to offshore storage sites. To prepare the necessary capacity (pipelines and storage), this will start with a pre-feasibility study. The results will be input for decisions on pipeline dimensioning and storage capacity within phases one and two. The discussion on Carbon Capture, Utilisation & Storage (CCUS) in Flemish ports started in 2011 in consultation with the Flemish Institute for Technical Research (VITO), the Belgian Geological Service and the Environment, Nature and Energy department of the Flemish government. The study "Towards CO2-neutral industry in Flanders – the role of Carbon Capture, Utilisation & Storage (CCUS)" created momentum among policy makers and the Antwerp port community to move in this direction. A CCU-hub was founded within the Cleantech Cluster (see later). The initiative is supported by companies located in the port area with the Cleantech cluster adopting a facilitating role. Stad Gent et al. (2019) provides a detailed analysis of the possibilities for Carbon Capture & Utilisation for the port area of North Sea Port Flanders.
Status	In progress

Action	**Green sea lock operations**
Party	Port Authority
Initiative	Antwerp is testing the use of renewable energy for lock operations. The project consisted of testing a prototype model of a 3 bladed vertical axe waterturbine mounted in existing infrastructure of the lock at the left bank of the port. The idea of hydropower started in 2012 with the target to harvest electrical energy from intense water-stream around the locks. In 2017, the construction of a water-turbine was ordered to De Meyer (Belgium) and Water 2 Energy (Netherlands) after a public tender procedure. A prototype was developed, constructed and installed in December 2018. The feasibility of installing up to 5+ hydroturbines on the Kallo and Kieldrecht locks is currently under investigation. Tidal energy can then be integrated with the existing renewable power sources (solar panels and wind turbines) to a smart grid on the left bank of the port.
Status	In progress

2.3.4. Examples of initiatives in the area of 'green inland logistics'

Actions	**The organization of the use of the multimodal transport system** **Optimization of the use of each modality** **Smart planning**
Party	port authorities
Initiative	**Port of Antwerp Intermodal Solutions** is a collaboration within the Antwerp port community that offers concrete solutions to improve connectivity with the hinterland. The objectives of this initiative include the facilitation of new intermodal services; increase the frequency of existing intermodal connections;

	an optimal connection with the most important economic centers in Europe and beyond through the expansion of rail, inland shipping and road transport services; improving the connection with European growth regions that currently have little to no connections with Antwerp; promote greater visibility of trimodal transport options via the Port of Antwerp Connectivity Platform. With this in mind, the port authority is also developing numerous strategic partnerships with hinterland hubs and terminals. The **Port of Antwerp Connectivity Platform** was developed to better inform the customers about the various transport options and the most optimal way in which they can take their goods to their destination, depending on their needs. This tool maps the maritime and intermodal connections between Antwerp and overseas and European destinations in a uniform way through search functions. The Port of Antwerp Connectivity Platform is a portal that gives access to free information about maritime and intermodal solutions in the port through the use of an interactive map with an overview of all container terminals and their services in the port of Antwerp, an overview of all deep-sea and shortsea departure and arrival times in the port of Antwerp and an online route planner that offers a view of the intermodal connections between the port of Antwerp and 200 European hinterland terminals. About 200 container terminals and 70 intermodal transport operators from 15 European countries have connected to this platform. The **port of Rotterdam** has developed a similar tool: **Navigate**. This tool gives a complete overview of the most efficient connections via Rotterdam by deepsea, shortsea, rail or barge. The empty depot planner has been built in to reposition empty containers. In addition, Navigate includes a business directory with companies that are active in and around the port of Rotterdam. Navigate has been specifically designed for companies who want to use container transportation in smarter ways for their supply chain. The research organization SmartPort is investigating how to predict the amount of time that a barge vessel will stay in the port. The research was initiated based on the barge performance monitor that was launched by the Port of Rotterdam. It has been investigated whether this dashboard, which shows data about past performance, can be expanded with predictions for the future. They concluded that more data is needed to make reliable predictions about this. **TNO**, the Dutch organization for applied scientific research, worked together with companies to develop digital initiatives around synchromodality. An example is the collaboration with two inland terminals CTU and MCS. The three parties developed a synchromodal planning tool where users of both terminals could see each other`s planning and they could book slots in each other`s terminal. By doing this, both terminals were able to offer better services to their clients and increase the loading rates.
Status	Implemented or ongoing https://www.portofantwerp.com/nl/intermodal-solutions-connectivity-platform https://www.portofrotterdam.com/en/tools-services/navigate

Actions	**Pricing mechanisms and other instruments to spread traffic in time and space**
Party	Terminal operators

Initiative	Since March 2017, trucks coming to load or unload containers in the Deurganck dock in the port of Antwerp are also able to call at night thanks to **extended working hours at Antwerp Gateway and quay 1742**. By operating around the clock, the terminals seek to increase their capacity and spread out their handling volumes. By extending their opening hours the container terminals hope to offer better service for their customers. The initiative for the measure comes from the terminal operators, along with MSC, and is supported by the wider port community. Support from the shippers and logistics service providers is crucial, for example by also extending the opening hours of warehouses both inside the port and beyond it. The **Central Gate project** in North Sea Port is aimed at creating a decentralized parking facility in port area linked to a uniform automatic registration (biometrics). The location should act as a sustainable and innovative service location for truckers in the port area, prepared for developments in the logistics sector such as the energy transition, a platform that serves as a catalyst for developments and innovations in the field of sustainability and logistics.
Status	Implemented

Action	**Promoting the role of inland terminals and port-hinterland concepts in GSCM**
Party	Container terminal operators
Initiative	**Extended gate concept**: Inland terminals can be incorporated as 'extended gates' to seaport terminals and as such can help to reduce container dwell times on seaport terminals. Container terminal operator ECT in Rotterdam (part of HPH) follows an active strategy of acquiring key inland terminals acting as extended gates to its deepsea terminals. Through 'European Gateway Services', ECT offers shipping lines, forwarders, transport companies and shippers a variety of services to facilitate the optimal flow of containers between the deep-sea terminals in Rotterdam and the direct European hinterland. ECT bundles cargo, which allows for highly frequent inland barge and rail connections to various logistics hotspots in the European hinterland. The inland network includes the TCT Venlo rail and barge terminals (the Netherlands), DeCeTe terminal in Duisburg (Germany), TCT Belgium in Willebroek (Belgium), ACT in Amsterdam, MCT in Moerdijk, AVCT in Avelgem (Belgium) and LCT in Liège (Belgium). ECT is not the only deepsea terminal operator developing an active extended gate policy. The door-to-door philosophy of other companies such as APM Terminals and DP World has transformed these terminal operators into logistics organisations and or organizers/operators of inland services. Maersk Line wants to push containers into the hinterland supported by its terminal sister APM Terminals. DP World uses the concept of 'terminal operator haulage' from the Antwerp Gateway terminal to the hinterland. The terminal operator haulage concept is aimed at a more active involvement of the terminal operator in hinterland connections by establishing closer relationships with shipping lines and inland operators. Also neighbouring ports can act as extended gates. Amsterdam serves as an extended gate to Antwerp (mainly via PSA) and Rotterdam, while the three

	multimodal terminals in North Sea Port (DFDS, ITG/GCT and 3MCT – Vlaeynatie) also function as extended rail and barge gates of the two main ports in the Delta.
Status	Implemented

Action	**Smart planning** **Advanced and integrated traffic management systems for barge**
Party	Port Authority, terminal operators and barge operators
Initiative	Between November 2018 and end of January 2019, the Port of Antwerp has been testing a concept for the bundling of container volumes for barges by introducing a 'Minimum Call Size' in conjunction with a terminal hub system. This means that at some individual terminals, barges are only handled from a certain minimum quantity upwards. Vessels that do not reach this fixed handling quantity have to switch to selected hub terminals. The Minimum Call Size for the seaport terminals 869, 913, 1700, 1718 and 1742 was fixed at 30 handlings. If this number is not reached: containers for the seaport terminals 869, 913 have to be unloaded and loaded at Hub Terminal 667 and containers for the seaport terminals 1700, 1718 and 1742 have to be unloaded and loaded at Hub Terminal 364. ITG in the North Sea Port area acts as a transit hub between the mainports and the (French) hinterland, and thus supports the minimum call size project in the port of Antwerp. Also in the hinterland, hubs are selected. For example, barge operator Contargo selected Gorinchem, Moerdijk and the DeCeTe Terminal in Duisburg as hub terminals for the Rhine corridor. The hub terminals organise the handling and transfer of the containers to the originally-scheduled seaport terminals. Contargo coordinates this procedure. The introduction of the minimum call size concept is aimed at improving turnaround times in the seaport (and thus lower idle time) and reduce congestion and environmental impacts associated with barge operations.
Status	Implemented

Action	**Energy mix by use of modalities**
Party	Port Authority
Initiative	**Clean Barge Transportation**: The Port of Rotterdam stimulates a clean barge system by subsidizing projects of barge operators to reduce GHG emissions such as CO2, CH4, NOx and PM. The maximum amount of money was 25% for research projects and 75% for concrete project implementations. In total, the budget was 1,250,000 euro in total.
Status	Implemented https://www.portofrotterdam.com/nl/files/lng-in-rotterdam

Action	**Development of pipeline network (intra-port, inter-port and port-hinterland)**

Party	Port authorities, chemical companies and refineries
Initiative	The port of Antwerp has over 1000 kilometres of intra-port pipeline infrastructure at its disposal (57 different product pipelines), transporting over 100 products. Almost 90% of all liquid goods (petro-)chemicals within the port is transported by pipeline. The port of Rotterdam has an extensive network of over 1500 kilometres of pipelines to transport liquid bulk including crude oil, oil products, chemicals and industrial gases. The pipelines run between companies in the port. Both in Antwerp and Rotterdam dedicated pipeline corridors are available for the construction of new pipelines. Rotterdam and Antwerp are also connected to a network of pipelines to destinations in the Netherlands, Belgium and Germany. The pipelines are (largely) owned by chemical companies and refineries. Many pipelines are 'dedicated' connections that transport one product along a fixed route between two locations. There are also common carrier pipelines. For example, RC2 is a joint venture between ARG (Aethylen-Rohrleitungs-Geselschafft) and the Port of Rotterdam Authority and comprises a common carrier pipeline system for ethylene. This network connects the ports of Rotterdam and Antwerp and the German Ruhr region. Another example is the RAPL (Rotterdam Antwerp Pipeline) for the transport of crude oil. Vopak and the Port of Rotterdam Authority have developed the MultiCore pipeline bundle which comprises of 4 pipelines and runs along the most important chemical and petrochemical industrial areas in the port. MultiCore offers leasing options. The 'Clean Underground Sustainable Transport' study or CUST project is a joint initiative by North Sea Port, the City of Ghent, Smart Delta Resources, the Provinciale Ontwikkelingsmaatschappij Oost-Vlaanderen (East Flanders provincial development company), the Zeeland Province and the ministries of Economic Affairs and Climate and Infrastructure and Public Works in the Netherlands. The aim is to investigate the feasibility, design and rollout of a possible pipeline infrastructure in the port area of North Sea Port, for example to transport CO2, to distribute hydrogen or to use ArcelorMittal's residual gasses as raw materials at Dow Chemicals (Steel2Chemicals). The results should be available in the Summer of 2019. The industrial complex in Terneuzen (part of North Sea Port) is connected to the extensive product pipeline network in the Benelux, while Zeebrugge is a key hub in the European gas network. The port of Zeebrugge is connected to Norwegian gas fields via the Gassco Zeepipe pipeline and to the UK via the Interconnector.
Status	Implemented

Action	**Energy mix by use of modalities**
Party	Seventeen projects partners (including Antwerp Port Authority and North Sea Port)
Initiative	In the context of EU's **CLINSH project** (CLean INland SHipping) the emissions of a number of barges is closely monitored during this 4 year project (2016-2020) including 1 year extension. The vessels are to test various emissions-reducing technologies including the use of alternative fuels. The technologies to be

	tested include SCR-DPF (Selective Catalytic Reduction in combination with a Diesel Particulate Filter), Fuel Water Emulsion technology and hybrid power installations. Some vessels will be adapted to run on an alternative fuel such as Liquefied Natural Gas or Gas to Liquid Fuel. The data gathered will provide valuable information about their environmental performance and the operating costs. The overall purpose of the CLINSH project is to create a fully sustainable inland shipping sector, which entails reducing emissions of hazardous substances such as nitrogen oxides and fine particulates. A side project of CLINSH concerns fix and mobile On Shore Power supply.
Status	In progress www.clinsh.eu

Actions	**Green inland-focused port dues**
Party	Port Authority
Initiative	**Green Port dues inland vessels** The Port of Rotterdam implemented a port dues scheme that gives a discount in the case that a vessel is green. Vessel owners can get up to 30 percent discount when they have a "Green Award Certificate". This certificate is issued by the independent Green Award Foundation and is awarded to shipping companies that made additional investments in the vessel and crew in order to improve the environmental performance, safety and quality. In this way vessel owners are encouraged to invest in cleaner vessels which contributes to the greening of supply chains. North Sea Port also gives discounts for green inland shipping in the context of Green Award.
Status	Implemented

2.3.5. Examples of initiatives in the area of 'seaports and the circular economy'

Actions	**Industrial Ecology** **Seaports as hubs for recycle flows**
Party	Industry and Port of Rotterdam
Initiative	Pernis Restheat: Shell Pernis started to deliver rest-heat from their refineries to 16,000 households in the area Katendrecht in Rotterdam. The transformation from gas consumption to rest-heat from the refinery reduces the amount of Co2 with 35,000 tons annualy. Potentially the Port area can deliver enough heat for 500,000 households in the Netherlands.
Status	Implemented

Actions	**Industrial Ecology** **Seaports as hubs for recycle flows** **Use of renewable energy sources**
Party	Chemical company Covestry – port of Antwerp
Initiative	Covestry, a chemical company in the port, is one of the pioneering companies turning CO_2 into plastic. At the same time, the new method replaces much of the petroleum previously used to manufacture. A nondescript white powder

	is used as a catalyst for a chemical reaction with CO_2. Products made from CO_2 foam include mattresses and upholstered furniture. One of the central components in the mattresses is an innovative polyol called cardyon™ with a CO_2-content of 20%, which is safely bound in the material. Belgian manufacturer Recticel launched the first products on the market end of 2016. CO_2 is thus becoming a useful and sustainable raw material.
Status	In progress – https://www.co2-dreams.covestro.com/en

Actions	**Industrial Ecology** **Seaports as hubs for recycle flows** **Use of renewable energy sources**
Party	Steel producer ArcelorMittal Ghent (AM Gent) – North Sea Port
Initiative	AM Ghent is committed to reducing the CO_2 linked to steel production. First, the company engages in improving its energy-efficiency. An internal energy audit identified a number of energy-related projects which are being implemented. Second, AM Ghent focuses on recycling by further optimizing the use of scrap in the process. As a result, less iron ore is used per tonne of steel. The amount of scrap that can be used depends on different process variables. The challenge is to lose as little heat as possible so that scrap can be melted without adding extra energy. Third, with a view to creating a circular economy, AM Ghent is focusing on so-called Carbon Capture & Use techniques (CCU) so that CO_2 can be used as a raw material for numerous applications. On the one hand, CO_2 can be used in pure form, for example in the food industry or as a coolant. On the other hand, the CO_2 can also be used in production processes, for example as a basic raw material in the chemical industry, for the production of biofuels or after carbonation in building materials. A good example is Steelanol, a CCU project of AM Ghent in partnership with LanzaTech (who licensed the technology) focusing on the biological transformation of CO linked to the steel production process into bioethanol. The construction of a new installation for converting carbon-containing gas from blast furnaces into bioethanol started in June 2018 on the site of AM Ghent in the North Sea Port Port area. It is the first installation of its kind on an industrial scale in Europe. Commissioning and first production is expected by mid-2020.
Status	In progress - www.steelanol.eu/

2.3.6. Examples of initiatives in the area of 'Knowledge development, information sharing and exchange of best practices'

Actions	**Co-operation in the framework of port-related associations**
Party	Port authorities
Initiative	The ports in the Rhine -Scheldt Delta are all actively involved in **Ecoports** and **WSPS.** **EcoPorts** was conceived in 1997 and has grown into the main environmental initiative of the European port sector. EcoPorts has been fully integrated into the European Sea Ports Organisation (ESPO) since 2011. The overarching

	principle of EcoPorts is to raise awareness on environmental protection through cooperation and sharing of knowledge between ports and improve environmental management. EcoPorts provides a set of tools such as the Self Diagnosis Method (SDM) and the Port Environmental Review System (PERS). Ports which comply to certain environmental standards can obtain EcoPorts' environmental standard (PERS), certificate assessed by Lloyds Register. EcoPorts publishes an annual environmental report, a top 10 list of environmental priorities of EU Ports, the SDM review, etc. IAPH launched the **World Ports Sustainability Program (WSPS)** in Antwerp in 2017 together with The American Association of Port Authorities (AAPA), the European Sea Ports Organisation (ESPO), the International Association of Cities and Ports (AIVP) and the World Association for Waterborne Transport Infrastructure (PIANC). Using the 17 UN sustainable development goals as the foundation, the program wants to enhance and coordinate future sustainability efforts of ports worldwide and foster international cooperation with partners in the supply chain. Next to organising events, the WPSP program is developing a global database of port related projects on sustainable development to raise awareness, share experiences and provide inspiration. The World Ports Sustainability Program builds on the World Ports Climate Initiative that IAPH started in 2008 and extends it to other areas of sustainable development.
Status	Ongoing

Actions	**Co-operation in the framework of associations**
Party	Various parties
Initiative	The city of Rotterdam has established a program called the **Rotterdam Climate Initiative**, whose aim is to "create a movement in which governments, organizations, companies, knowledge institutes, and citizens collaborate to achieve a 50% reduction of CO2 emissions, adapt to climate change, and promote the economy in the Rotterdam region" (see site Rotterdam Climate Initiative). This program is developed as part of the global cooperation group C40 Climate Leadership Group, which is an international body aggregating several large cities wishing to fight against climate change. The objective of the Rotterdam Climate Initiative is to halve the CO2 emissions of the Rotterdam agglomeration in 2025 compared to 1990. In order to achieve that objective, the program involves in an integrated way the different important local actors: the municipality of Rotterdam, the local association Deltalinqs, the environmental protection agency DCMR Milieudienst Rijnmond and the Rotterdam port authority. The Rotterdam Climate Initiative is organized along five axes: sustainable city, energy city, sustainable transport, innovation laboratory and sustainable energy port. The port of Rotterdam adheres to this general policy and acts on two of these five axes: sustainable transport and sustainable energy port.
Status	Ongoing

Actions	**Sustainability reporting at company, port authority or port industry level**
Party	Port Authority and port community
Initiative	In early 2012, Antwerp for its first time published a **sustainability report** to communicate the progress and results of its environmental monitoring and

	performance to stakeholders. The Antwerp Port Authority and the Left Bank Development Corporation (for the public sector) and Alfaport Antwerp (representing the private sector) are the main driving forces behind the report. The report forms the basis for developing a sustainable port of and for people and identifies new joint projects and areas for further study and research. The report provides an in-depth view of the actions taken and the investments made by stakeholders within Antwerp in order to ensure sustainability as part of a future-oriented policy for the port. While the port authority is a key facilitator and actor involved in drafting the sustainability report, much of the progress made in the field of sustainability is the result of actions of market players or government agencies on matters beyond the port authority jurisdiction.
Status	Ongoing

Actions	**Environmental strategies of ports combined with or integrated in broader corporate social responsibility (CSR) strategies and stakeholder relations management.**
Party	Port authority and port community
Initiative	The Port of Rotterdam Authority launched the campaign 'Building a Sustainable Port' in August 2017 focusing on three key themes: a Safe & Healthy Environment, Climate & Energy and People & Employment. The other ports in the Delta have also developed a range of environmental and CSR initiatives in close collaboration and partnership with relevant stakeholders.
Status	Implemented

Actions	**Develop the local knowledge base on GSCM in ports**
Party	Port community
Initiative	The ports in the Rhine-Scheldt Delta are involved in or make use of a broad range of incubator initiatives. Some examples: • **BlueChem** is the incubator for sustainable chemistry located at Blue Gate Antwerp, a new innovative and sustainable industrial area south of the city center. BlueChem is the first incubator in Belgium who aims at stimulating innovation and entrepreneurship in the field of (1) valorisation of waste and secondary flows, (2) process optimization, (3) the development of renewable chemicals and (4) sustainable products. The incubator strengthens and accelerates startups, SME's and innovative project of large companies, by offering a number of services such as standardized or custom labs, offices, flexible offices, meeting rooms, go-to-market services, deep knowledge on chemistry, an (inter)national network and financial, tax and legal advice, etc. The first stone of the BlueChem complex was laid in 2018. The BlueChem site is planned to be operational by 2020; • The Port of Rotterdam Authority developed the **Rail Incubator** in view of facilitating new rail connections. The support ranges from co-invest in establishing new rail connections, provide assistance in finding potential partners and marketing support; • **PortXL** is the world's first Maritime Port Accelerator. The objective of PortXL is the acceleration of innovative technologies for the maritime, logistics, energy and chemical industry sectors in port regions across the world. In doing so, PortXL activates the largest possible ecosystem to

	stimulate entrepreneurship for all involved parties. The PortXL ecosystem comprises start-ups and scale-ups, investors and partners, and market leading companies, many of which are located in the port areas of the Rhine-Scheldt Delta. The port of Rotterdam is working closely with PortXL. As part of the Harbour of Things, PortXL International in Antwerp is working on scouting, matching and supporting businesses in the accelerated development of maritime and port-related start-ups. • The **Cleantech Cluster Ghent Region** was launched on 18 May 2016. The City of Ghent, North Sea Port, Ghent University, the Province of East Flanders, the Provincial Development Agency East Flanders and Clean Flanders joined forces for the sharing of knowledge and experience in the field of energy, materials, water and mobility. The Cleantech Cluster Ghent Region wants to connect economic, ecological and social considerations through clean technologies and to stimulate the transition from a linear to a circular economy. A recent study explored the possibilities for Carbon Capture & Utilisation for the port area of North Sea Port Flanders (Stad Gent et al., 2019). • **Smart Delta Resources** is an initiative taken by eleven energy- and feedstock intensive companies searching for a reduction in their use of energy and feedstock though industrial symbiosis. SDR companies in Steel, Energy, Chemical and Food Industry work together to create industrial connections and develop interesting business cases. The industrial symbiosis between the various sectors in the region has economic optimization as a starting point, but in time it also contributes to making their processes more sustainable. The platform is actively supported by the Province of Zeeland and North Sea Port. NV Economische Impuls Zeeland facilitates the platform. • In 2017, the Municipality of Rotterdam and the Port of Rotterdam Authority jointly launched '**BlockLab**', a field lab for the development of concrete applications and solutions based on blockchain technology. The lab is also supported by the regional development corporation InnovationQuarter. Possible applications include supporting the energy transition in the port and the city and to organise cargo flows more efficiently. In the field lab, theoretical blockchain ideas are developed, tested and worked out into concrete opportunities in a real-world environment, together with consortia of developers and users. In addition, the lab will serve as a knowledge centre for the regional private sector. • The **Beacon** in Antwerp brings together major technology providers in IoT, flexible start-ups and scale-ups and leading researchers at a single location. The Port of Antwerp is also investing in The Beacon, both financially and in terms of people. The Beacon is the result of a collaboration agreement Capital of Things between the City and University of Antwerp, IMEC and Agoria. The Beacon launched its first unique Smart City accelerator program in 2019, which focuses on Smart Mobility, Smart Energy & Smart Buildings. • A test platform has been realized off the coast of the port of Ostend. The test facility is part of the project Blue Accelerator, which involves the creation of a 'living lab' at sea aimed at testing innovation projects in the marine and maritime fields (e.g. wave, wind and tidal energy).

	The port has also been involved in the development of several wave energy convertors (i.e. Flansea, Laminaria & Nemos). Innovation and knowledge sharing is further stimulated through the 'GreenBridge Community' for business opportunities and the Maritime Research Center. Next to incubators, the ports in the Delta are involved in the organisation of Hackathons. For example, the **World Port Hackathon** is organised by Havenlab and Port of Rotterdam. Furthermore, the first-ever **chainPORT hackathon** was held in 2018 in the ports of Antwerp and Los Angeles. The **chainPORT project** is a unique collaboration between various port authorities around the world, including Antwerp, Barcelona, Busan, Felixstowe, Hamburg, Los Angeles, Montreal, Rotterdam, Shenzhen and Singapore. It aims to develop advanced processes and technologies that will shape the future of port activities. One of these initiatives is the chainPORT hackathon in which participants from all over the world collaborate on IT challenges facing ports globally and locally.
Status	Implemented or planned

Actions	**Develop the local knowledge base on GSCM in ports**
Party	Research institutes
Initiative	The ports in the Delta are actively involved in a wide range of **research projects** (European, national and regional) dealing with sustainability, green supply chains and green ports. Furthermore, they have developed strategic partnerships with key research institutes and universities. Some examples: • **SmartPort** is a collaboration between the Port of Rotterdam, Deltalinqs, Municipality of Rotterdam, TNO, Deltares, Erasmus University and the Technical University in Delft. By inspiring, initiating and forming alliances Smartport stimulates and finances scientific research for companies within the Rotterdam port area. The three main research themes within Smartport are: Smart Logistics, Smart energy & Industry and futureproof Port infrastructure. • **VIL** in Flanders was appointed by the Flemish government as the single point of contact for the logistics sector to create economic and social value for companies. VIL represents around 600 companies and works along leading strategic partners and a network at home and abroad. The VIL team can also provide customized advice. • **TKI-Dinalog** is a Dutch institute that was created in 2009 (as Dinalog) to boost joint innovation in logistics focused on open innovation. TKI (Top consortium Knowledge and Innovation) is the cooperation within which Dinalog, TNO and NWO act jointly to boost innovation in logistics. Dinalog was transformed into TKI-Dinalog to create a single clear point of contact for commerce for this cooperation.
Status	Implemented

2.4. Summary of findings

Ports, as clusters of economic actors and activities, have adopted real environmental role and function and in this way (should) contribute to the greening of supply chains in the context of GSCM. In business practice, the growing green reflex is mirrored in the many green initiatives of individual ports and the coordinated actions of the wider port community. The green port concept refers to a development characterized by healthy ecological environment, reasonable utilization of resources, low energy consumption and low pollution.

In this part of the report, we identified several fields of action for private and public actors involved in port-related activities to pursue GSCM objectives. A distinction was made between actions in the areas of green shipping; green port development and operations; green inland logistics; seaports and the circular economy; and, actions in the field of knowledge development and information sharing. The long list of initiatives, actions and projects for each of these domains illustrates that the port communities in the Rhine-Scheldt Delta are determined to reduce the environmental footprint of their activities and to make the transition to a more energy-efficient and circular economy.

However, port communities also understand that the challenges remain immense. The total cargo volumes handled in the ports in Rhine-Scheldt Delta are still increasing, and there are no signs that this growth pattern will reverse in the near future. In the past few years, the Delta ports have been very successful in attracting additional investments in industrial, semi-industrial, logistics and terminal activities in the port areas. These investments will bring additional pressures on the port systems in terms of emissions and freight mobility. Thus, the port ecosystems are challenged to drastically decrease their environmental footprints against a background of growth in volumes and investments. This requires drastic and large-scale solutions such as CCUS, a further push towards greener shipping, a strong modal shift and adoption of synchromodality, etc. While port authorities and port communities certainly have a role to play, they are part of much larger networks and chains. Many of the solutions will demand close co-ordination and co-operation between the actors involved in these networks and chains, thereby facilitated by technology, new governance and business models and facilitation and regulation by governments.

3 I SURVEY ON GSCM PRACTICES IN THE RHINE-SCHELDT DELTA PORT REGION

3.1. Set-up of the survey

3.1.1. Objective of the survey

The general objective of the study consists of the research into the main topics, trends and concepts for the sustainability and greening of supply chains. The objective of the survey consists of the assessment of the realisations, initiatives and expectations of the stakeholders in the field of greening of port logistics and the subsequent associated business models and innovations. The survey analyses the expectations of market players and port authorities in the Rhine-Scheldt Delta ports.

3.1.2. Survey structure

In part 1, the study analysed the main trends and concepts in the domain of increasing sustainability and greening of supply chains. Various technologies, initiatives and projects were identified and evaluated. In part 2, we proceeded to a qualitative analysis of the impact of such trends and concepts on the existing models of the port logistics companies and which instruments could be implemented to leverage the greening of supply chains.

The questionnaire was based on the insights developed in parts 1 and 2 and resulted in 22 questions that surveyed the relevance, the rate of implementation, the acceptance and support, specific activities, incorporation of the theme into company management, drivers and obstacles, balance of power, the role of government and administration, key performance indicators, commercial aspects and last but not least the current and future perceived role for each stakeholder in leading the way to green supply chains.

Specific survey software was used to process the answers and complete a first analysis. After mutual consultation a further and more refined analysis was launched with specific attention on the variance between respondent groups and the correlation of results between several questions.

3.1.3. Target groups and representativeness

The target group of the survey consisted of a wide range of companies including terminal operators, shipping companies, shipping agencies, logistics service providers, port industry companies, shippers, manufacturing companies, wholesalers and importers, freight forwarders, transport companies, etc.

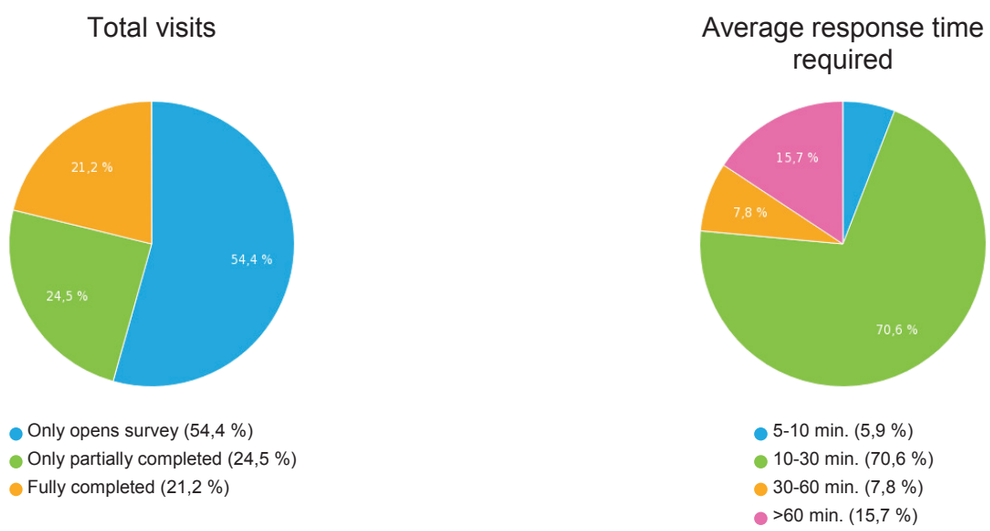
Individuals within a total of 650 companies were invited to participate in the survey. The list was compiled based on a selection of the members of VIL, input obtained from the port authorities of Antwerp, North Sea Port and Zeebrugge and mediation of the Erasmus Centre for Urban Port and Transport Economics and the ING customer database. Deltalinqs assisted in distributing the survey in the Rotterdam port community.

The target group was divided into following sub-categories under which the respondents could register:

- Transport companies
- Freight Forwarders
- 3PL logistics service providers
- Shipping companies: this group includes shipping companies, short sea shipping operators, inland navigation companies, shipping agencies and nautical service providers
- Terminal operators
- Retail, import/export wholesale companies
- Manufacturing / industrial companies
- IT-providers
- Service sector (banks, insurance, …)
- Other

The survey was made available to respondents through a web-based survey application and supported by an invitation letter. The number of visits to the web-based survey pages amounted to 248 visits. Figure 10 provides detail on the behaviour of site visitors.

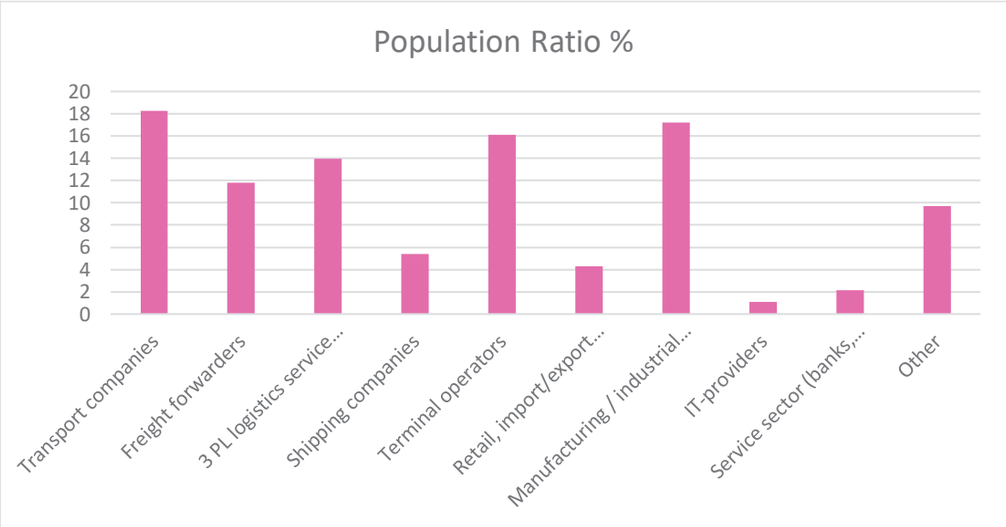
Figure 10. Respondent behaviour



Some doubles and tests by port authorities were not retained, as per mutual agreement within the steering committee of this study. 97 respondents, or 21% of the visitors, successfully completed the survey, but this contained several doubles. Of these doubles the senior position respondent within the company was retained. Most respondents (70.6%) spent between 10 and 30 min to complete the survey.

Finally, 93 responses were retained. The net response rate for the survey comes up to 14,3 %, with mainly transport companies, manufacturing/industrial companies, terminal operators, 3PL logistics service providers and freight forwarders as the groups best represented in the population.

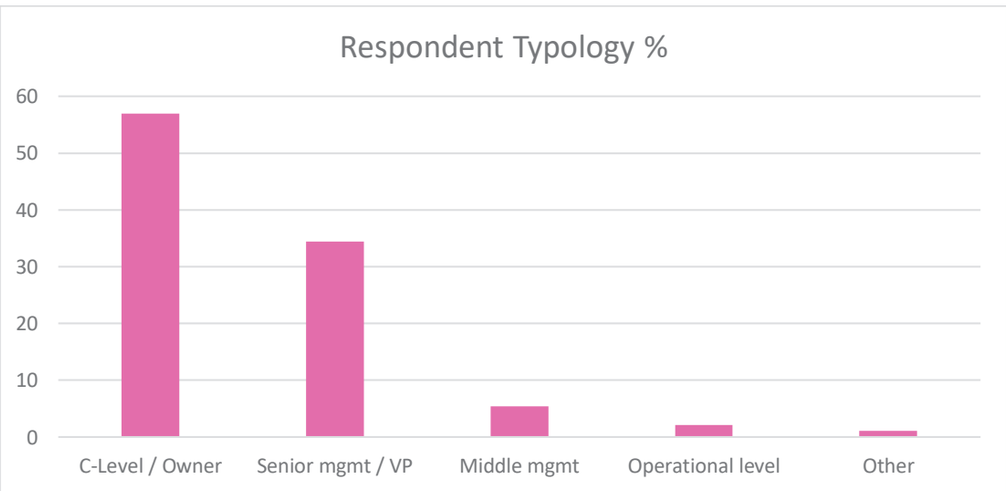
Figure 11. Survey response population ratio per category



Most questions were mandatory and presented several statements that either were subscribed or rejected. The results of these questions are represented in percentages. A limited set of open questions was also put forward. These have been carefully evaluated and processed. The answers were categorised, and graphs represent numbers rather than percentages.

The survey was sent mainly to C-level (CEO, CFO, CTO, etc.) or senior management positions. This was reflected in the answers. 57% of respondents were of C-level (or owner), 34.4% consisted of senior management or VP level and 5.4% was composed of people working at managerial level. One answer was returned incognito and two were completed by an operational collaborator.

Figure 12. Respondent typology ration per position within the company



3.2. Analysis of survey results

3.2.1. Introduction

The third part of the study focuses on the detailed and refined analysis of the answers provided by the survey's respondents. The results were drawn for the full group and subsequently separate reports were drawn for numerous variations of sub-groups; for the shippers, manufacturing and industrial companies, retail companies and import/export companies, the logistics service providers including transport companies, freight forwarding companies and 3PL companies, for the shipping companies, for the terminal operators and for the remaining companies consolidated.

Whenever substantial differences in responses were noted, this was mentioned in the respective elaboration of the respective statements. Separate graphs were drawn whenever deemed relevant.

All analytics were executed against the background of the key challenge of greening (port logistics) supply chains and how this can be leveraged for a more sustainable role for ports while also considering the ever-growing global economy in that respect.

3.2.2. Survey results

QUESTION: How much of a topic is greening for your company?

Figure 13. The relevance of greening

	Prior to 2010	Prior to 2015	Since 2016-2017	Since last year (2018)	We're starting (2019)	We will start next year(2020)	We are planning to start (2021-2022)	Not yet
Since when has greening been a topic ?	32 (34,4 %)	33 (35,5 %)	13 (14,0 %)	5 (5,4 %)	3 (3,2 %)	0	2 (2,2 %)	5 (5,4 %)
Since when has greening been included in your mission statement ?	21 (22,6 %)	24 (25,8 %)	18 (19,4 %)	7 (7,5 %)	5 (5,4 %)	1 (1,1 %)	0	17 (18,3 %)
Since when have you effectively expanded into actions ?	24 (25,8 %)	27 (29,0 %)	11 (11,8 %)	13 (14,0 %)	4 (4,3 %)	3 (3,2 %)	2 (2,2 %)	9 (9,7 %)

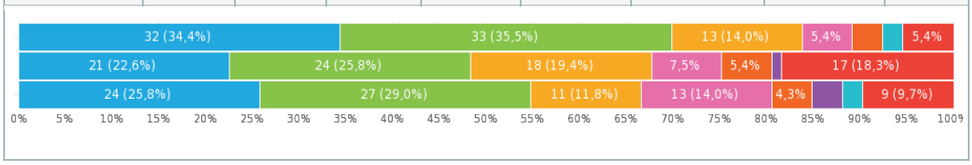


Figure 14. The relevance of greening – LSPs consolidated

	Prior to 2010	Prior to 2015	Since 2016-2017	Since last year (2018)	We're starting (2019)	We will start next year (2020)	We are planning to start (2021-2022)	Not yet
Since when has greening been a topic ?	18 (43,9 %)	14 (34,1 %)	5 (12,2 %)	1 (2,4 %)	0	0	1 (2,4 %)	2 (4,9 %)
Since when has greening been included in your mission statement ?	10 (24,4 %)	12 (29,3 %)	6 (14,6 %)	3 (7,3 %)	2 (4,9 %)	0	0	8 (19,5 %)
Since when have you effectively expanded into actions ?	13 (31,7 %)	14 (34,1 %)	6 (14,6 %)	3 (7,3 %)	1 (2,4 %)	0	0	4 (9,8 %)

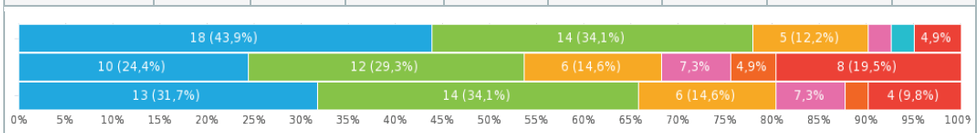
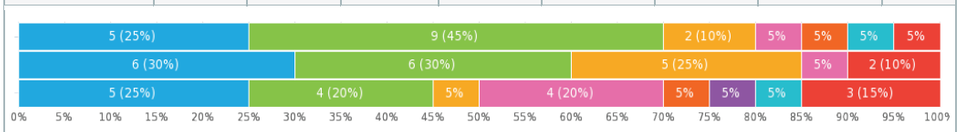


Figure 15. The relevance of greening – shippers and retailers consolidated

	Prior to 2010	Prior to 2015	Since 2016-2017	Since last year (2018)	We're starting (2019)	We will start next year (2020)	We are planning to start (2021-2022)	Not yet
Since when has greening been a topic ?	5 (25 %)	9 (45 %)	2 (10 %)	1 (5 %)	1 (5 %)	0	1 (5 %)	1 (5 %)
Since when has greening been included in your mission statement ?	6 (30 %)	6 (30 %)	5 (25 %)	1 (5 %)	0	0	0	2 (10 %)
Since when have you effectively expanded into actions ?	5 (25 %)	4 (20 %)	1 (5 %)	4 (20 %)	1 (5 %)	1 (5 %)	1 (5 %)	3 (15 %)



For almost 70% (69.9%) of the generic response group, greening has been a topic since before 2015. The same group (67.8%) included this in its mission and has expanded into real actions (66.6%) within two years after including it in their mission (2016-2017).

When having a closer look at the individual respondent categories it should be noted that the service-oriented companies (LSPs) have been significantly more aware (78% by 2015) and active (80.4% by 2016-2017). Actions speak louder than words here as only 68.3% of them had included greening in their company mission by 2016-2017.

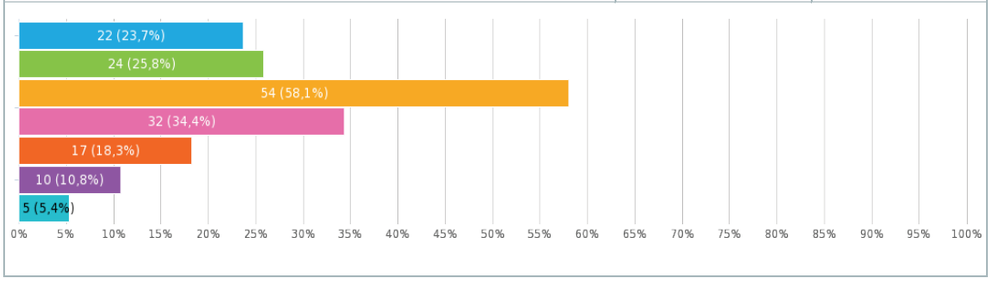
Strikingly, the producers, manufacturing (shippers) and retailers did not deviate from the generic response group by having it on the agenda (70% by 2015), but a stunning 85% had included it in their company mission by 2016-2017 even though only 50% claimed to have moved to real actions by then.

Also, important to note is that 1 out of 10 still must have a look at the topic (10.8% as from 2019 or not yet), and that even 1 in 5 still must get into gear (19.4% as from 2019 or not yet). Service oriented companies (LSPs) score significantly better with 7.3% (agenda) and 12.2% (action) respectively.

QUESTION: What is the level within your company that has been assigned with the responsibility of greening and how often does greening figure as a topic on the board or management meeting's agenda?

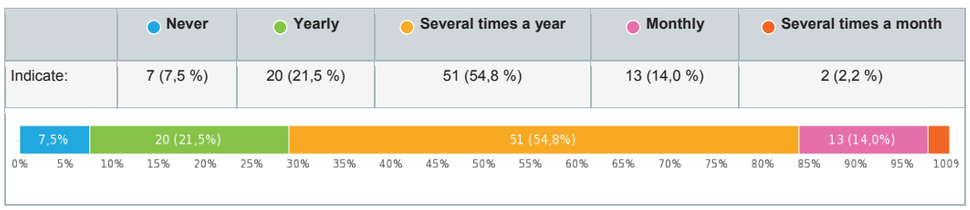
Figure 16. Ownership of greening within companies

Reply	Replies	Ratio
Operational level	22	23,7 %
Middle-Management level	24	25,8 %
Advanced Management level	54	58,1 %
CEO/top management	32	34,4 %
Board of directors	17	18,3 %
No one has been assigned specifcally	10	10,8 %
Other:	5	5,4 %



Greening is a topic that is typically assigned to higher or general management and the topic often (71%) is an individual topic at the board or management meetings, which in itself can be considered a good sign.

Figure 17. Rate at which greening is discussed within companies



At the same time the fact that only 23.7% of operations and 25,8% of middle management (multiple answers were possible) has direct responsibility for the topic can be regarded as somewhat disappointing.

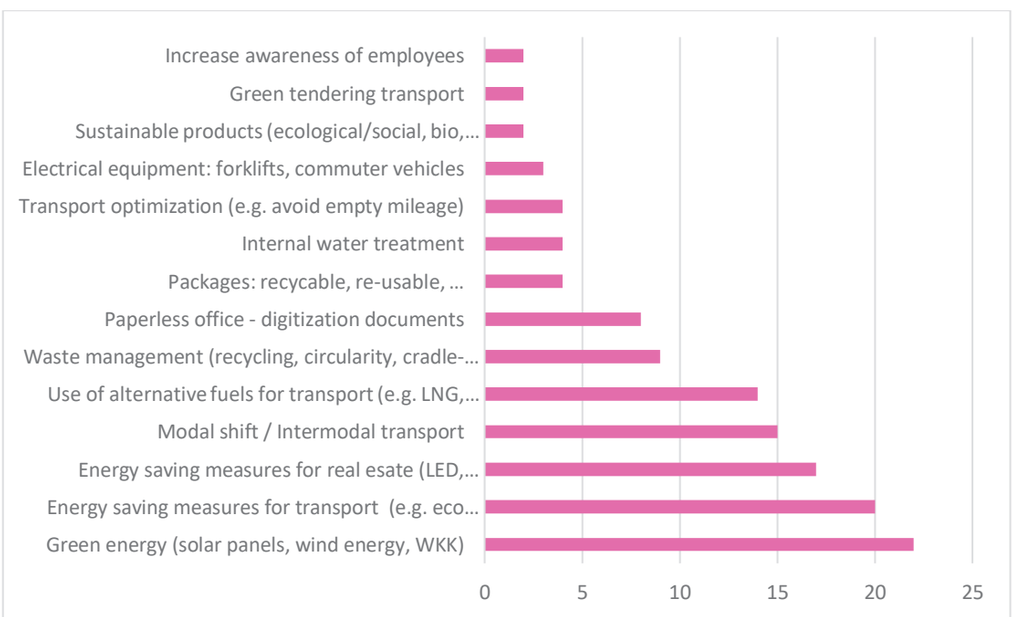
Upon scrutiny of the answers it can be noted that, where larger companies are concerned, virtually all responsibility levels score higher which means that greening is much more part of the company's DNA.

About 1 in 10 companies have not assigned the responsibility to anyone, which is consistent with the number of companies that do not yet consider greening a topic for their company. It is remarkable that for 7.5% it is never on the agenda and for another 21.5% only once a year. Combined this means that for 29% the topic is not a very hot one.

Key take-away: Greening is still very much a boardroom affair in larger companies.

QUESTION: Name the most obvious example of a green measure within your company? (open question)

Figure 18. Applied greening measures



This was the first of the open questions. The long list of answers was reduced to 14 categories amongst which 5 clearly yielded a significant number of answers:

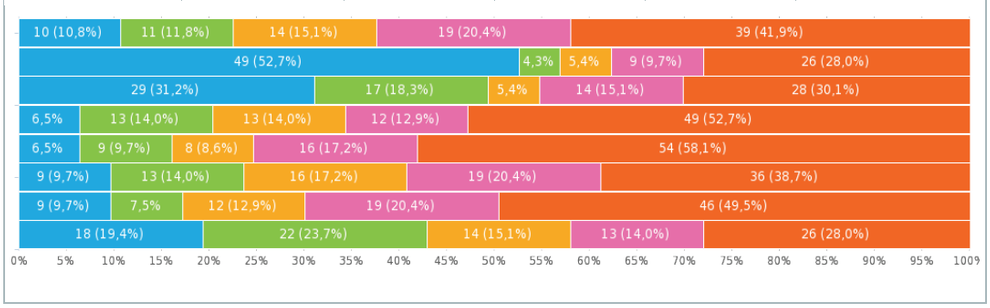
1. Green energy (22)
2. Energy saving measures for transport (20)
3. Energy saving measures for infrastructure (17)
4. Modal shift / intermodal transport (15)
5. Alternative fuels for transport (14)

The best scoring greening measures relate directly to existing legislation. Those measures that relate to a real change in behaviour or intrinsic motivators score substantially lower.

QUESTION: In which aspects of your company's management has greening and sustainability intentionally been incorporated?

Figure 19. Greening in management strategy

	Not relevant for my company	Greening not yet a topic	Greening is being prepared	Greening project has been initiated	Greening has been part of operational management for over a year
Procurement	10 (10,8 %)	11 (11,8 %)	14 (15,1 %)	19 (20,4 %)	39 (41,9 %)
Manufacturing	49 (52,7 %)	4 (4,3 %)	5 (5,4 %)	9 (9,7 %)	26 (28,0 %)
Planning	29 (31,2 %)	17 (18,3 %)	5 (5,4 %)	14 (15,1 %)	28 (30,1 %)
Transport and logistics	6 (6,5 %)	13 (14,0 %)	13 (14,0 %)	12 (12,9 %)	49 (52,7 %)
Innovation and investment policy	6 (6,5 %)	9 (9,7 %)	8 (8,6 %)	16 (17,2 %)	54 (58,1 %)
Quality management	9 (9,7 %)	13 (14,0 %)	16 (17,2 %)	19 (20,4 %)	36 (38,7 %)
Strategic management	9 (9,7 %)	7 (7,5 %)	12 (12,9 %)	19 (20,4 %)	46 (49,5 %)
Human Resources	18 (19,4 %)	22 (23,7 %)	14 (15,1 %)	13 (14,0 %)	26 (28,0 %)



There are clearly three domains in which greening has been incorporated for a longer time and for which either a greening project recently has started or has been running for over a year. The absolute front runners are:

1. Innovation and investment management (75.3%)
2. Strategic management (69.9%)
3. Transport and logistics (65.6%)

Even though most results correlate when comparing the two ends of the spectrum, a somewhat surprising 14% of respondents state that greening is not an actual topic in the field of transport and logistics. Scrutinizing the various respondent categories, it is noted that mainly shippers and retail state that it is not a relevant topic yet (20%). It is the only category in which there is a different top three, i.e. procurement is deemed to be the second most important management aspect in which greening has been incorporated. This however is consistent with the role of such actor in the supply chain.

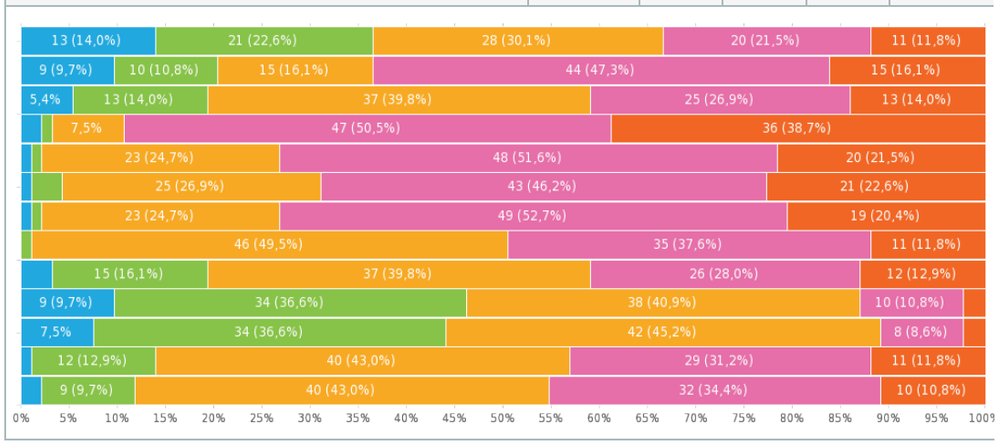
The service industry states that transport and logistics is the number one domain in which greening has been incorporated. This correlates with their response (question 2) to having moved to action where it concerns greening (80.4% effectively acting on it by 2016-2017).

The survey population was also queried about additional aspects but this produced no valuable feedback, except for two answers that hinted to more commercial and marketing aspects concerning the subject of greening.

QUESTION: What are the major motives for and barriers to greening of supply chains?

Figure 20. Major motives and barriers

	Major barrier	Barrier	Neutral	Motive	Major motive
Profitability of the company	13 (14,0 %)	21 (22,6 %)	28 (30,1 %)	20 (21,5 %)	11 (11,8 %)
Competitiveness of your company	9 (9,7 %)	10 (10,8 %)	15 (16,1 %)	44 (47,3 %)	15 (16,1 %)
Investment potential for your company	5 (5,4 %)	13 (14,0 %)	37 (39,8 %)	25 (26,9 %)	13 (14,0 %)
Reputation of your company (commercial)	2 (2,2 %)	1 (1,1 %)	7 (7,5 %)	47 (50,5 %)	36 (38,7 %)
Focus on greening as new value creation activity	1 (1,1 %)	1 (1,1 %)	23 (24,7 %)	48 (51,6 %)	20 (21,5 %)
Demand of customers	1 (1,1 %)	3 (3,2 %)	25 (26,9 %)	43 (46,2 %)	21 (22,6 %)
Influence from society	1 (1,1 %)	1 (1,1 %)	23 (24,7 %)	49 (52,7 %)	19 (20,4 %)
To attract a young(er) employees	0	1 (1,1 %)	46 (49,5 %)	35 (37,6 %)	11 (11,8 %)
Effective regulations	3 (3,2 %)	15 (16,1 %)	37 (39,8 %)	26 (28,0 %)	12 (12,9 %)
Uncertainty about continuity of funding and innovation stimuli from policy makers	9 (9,7 %)	34 (36,6 %)	38 (40,9 %)	10 (10,8 %)	2 (2,2 %)
Uncertainty whether the preferred greening solution is future proof	7 (7,5 %)	34 (36,6 %)	42 (45,2 %)	8 (8,6 %)	2 (2,2 %)
Climate ambitions on an international and European level	1 (1,1 %)	12 (12,9 %)	40 (43,0 %)	29 (31,2 %)	11 (11,8 %)
Climate ambitions on a regional and national level	2 (2,2 %)	9 (9,7 %)	40 (43,0 %)	32 (34,4 %)	10 (10,8 %)



The motives for greening of supply chains are very much economically driven. Amongst the top 5 drivers we only discern one societal driver:

1. Reputation of your company (89.2%)
2. Focus on greening as new value creation activity (73.1%)
3. Influence from society (73.1%)
4. Demand (68.8%)
5. Competitiveness (63.4%)

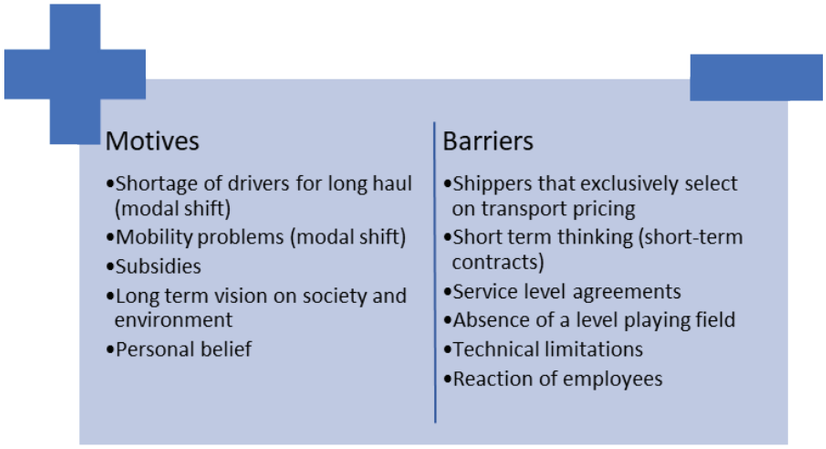
Also, it is remarkable that almost half of the respondents (49.4%) indicates it is important to attract young(er) employees.

When considering the barriers, it should be noted that the top 3 shows less pronounced results as those noted under drivers:

1. Uncertainty about continuity of funding and innovation stimuli from policy makers (46.3%)
2. Uncertainty whether the preferred greening solution is future proof (44.1%)
3. Profitability of the company (36.6%)

Even though 36.6% of respondents see greening as a barrier for the profitability of the company, almost an equal number (33.3%) see it as a motive. When also considering the fact that 63.4% of companies surveyed see competitiveness as a clear motive to engage in greening, it could be concluded that greening indeed is required to maintain one's competitive edge, but that at the same time not everyone is convinced that it contributes to the company's profitability.

Figure 21. Additional motives and barriers



Additionally, it can be noted that climate ambitions both on a local (national/regional) (45.2%) and international and European (43%) level are seen as drivers, even though they both have a large number of the population that is undecided (43%).

When looking at additional drivers or barriers a few 'honourable' mentions have been selected and listed in figure 21.

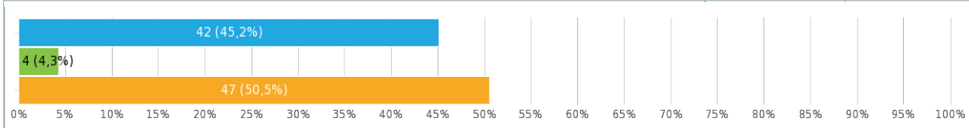
Key take-away: Economic considerations and the concern for competitiveness are the main drivers for greening one's supply chain.

QUESTION: Who is the driving force behind greening of supply chains?

This group of questions explores who the directing actor is when it concerns greening and how companies actively influence, or are influenced by, their supply chain partners.

Figure 22. The driver's seat

Reply	Replies	Ratio
We are at the wheel	42	45,2 %
We are being influenced by suppliers / clients	4	4,3 %
We are partly in control but are also being influenced by our suppliers / clients	47	50,5 %



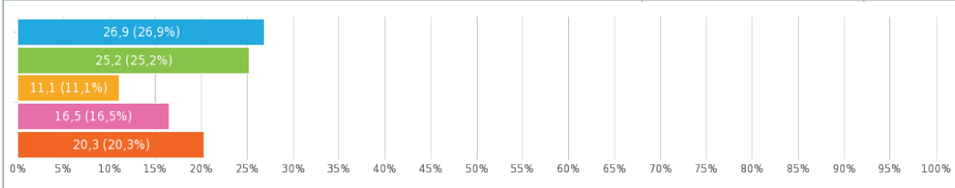
Virtually none of the respondents (4.3%) states they are a passenger where it concerns greening. However, almost half (45.2%) says they are fully in control, whereas the rest (50.5%) recognises that greening is a joint effort.

When looking at how companies actively direct greening efforts, the generic population top answers are:

1. Imposing specifications (26.9%)
2. Actively stimulating supply chain collaboration (25.2%)
3. Clearly stating that greening is an integral part of the evaluation process (20.3%)

Figure 23. Directing greening

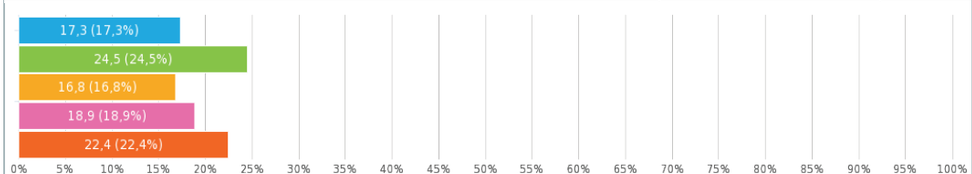
Reply	Assigned weight (average)	Ratio
By imposing (design) specifications	26,9	26,9 %
By actively stimultating supply chain collaboration with respect to greening	25,2	25,2 %
By imposing environmental audits (or executing them)	11,1	11,1 %
By imposing sustainability ratings/labels/certifcation (e.g. ISO 14001, Lean & Green, ...)	16,5	16,5 %
By clearly indicating suppliers that greening is an integral part of the evaluation process	20,3	20,3 %



Looking at the respective respondent categories the producers (shippers) and retailers, arguably the most influential group when actively leveraging the greening process, does not respond that differently. The same three levers score best, but in reverse order (1. Evaluation process; 26.8% 2. Collaboration; 24% 3. Specifications; 23.3%). For service-oriented companies (LSPs) the same top three again but now with Collaboration as number one (25.3%).

Figure 24. How is greening imposed?

Reply	Assigned weight (average)	Ratio
(Design) specifications are being imposed	17,3	17,3 %
We are being stimulated to supply chain collaboration with respect to greening	24,5	24,5 %
Environmental aurdits are being executed / imposed	16,8	16,8 %
Sustainability ratings/labels/certification are being imposed (e.g. ISO 14001, Lean & Green, ...)	18,9	18,9 %
Principals include their greening requirements into the evaluation process	22,4	22,4 %



When looking at how companies are being directed by their supply chain stakeholders, the top three reads as follows:

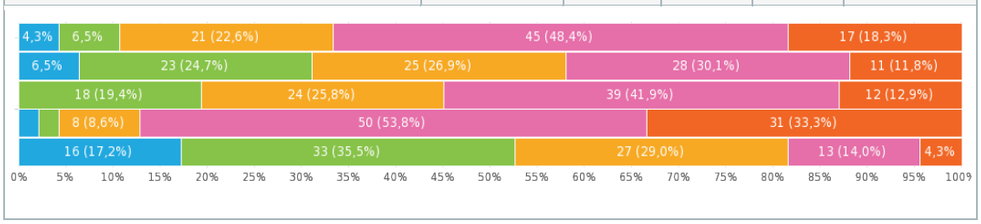
1. Being stimulated to collaborate (24.5%)
2. Greening as an integral part of the tendering/evaluation process (22.4%)
3. Sustainability ratings/labels/certification being imposed (18.9%)

It is striking that in general the pressure of product specifications is not perceived as such (-9.6%). The aspects focussing more on processes and auditing thereof seem to be found somewhat more imposing, but differences are small (Audits + 5.7%, sustainability certification + 2.4%). Upon further examination of the individual respondent groups, no significant inconsistencies between the various groups could be ascertained.

QUESTION: What role does government have to play when it comes to greening?

Figure 25. The role of government

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Government should sitmulate greening through subsidies	4 (4,3 %)	6 (6,5 %)	21 (22,6 %)	45 (48,4 %)	17 (18,3 %)
Government should stimulate greening through taxing	6 (6,5 %)	23 (24,7 %)	25 (26,9 %)	28 (30,1 %)	11 (11,8 %)
Government should impose minimum standards (e.g. certification)	0	18 (19,4 %)	24 (25,8 %)	39 (41,9 %)	12 (12,9 %)
Govenment shoudl inform industry about green solutions	2 (2,2 %)	2 (2,2 %)	8 (8,6 %)	50 (53,8 %)	31 (33,3 %)
Government should not get involved	16 (17,2 %)	33 (35,5 %)	27 (29,0 %)	13 (14,0 %)	4 (4,3 %)



The most striking result shows 87.1% of respondents stating that government has a role as information provider where it concerns greening. This is partially supported by the expectation that the administration should impose minimum standards. More than half (54.8%) supports this statement when at the same time not a single respondent (0%) thought this to be false. Strikingly all shipping companies (100%) supported this statement.

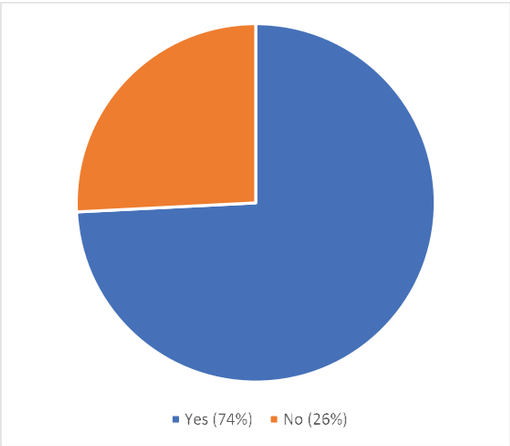
More than half (52.7%) also thinks some form of intervention of the administration is desirable, with only about 1 in 5 (18.3%) confirming they should not actively engage. Shippers and retailers are the most in favour with 80% pro.

Taxes as a tool to enhance the greening of supply chains is a contentious issue and this is confirmed by the results of the survey. Still, the group that recognises (41.9%) taxes as a tool is larger than the group that is opposed (31.2%). However, when government subsidies are mentioned there seems to be a small 'appetite' as 66.7% of respondents consider this beneficial to greening. Especially the consolidated logistics service providers (83.2%) show an interest.

Key take-away: Business wants government to be a soft enforcer. Companies want government to tell them how to proceed and to be stimulated to do so, but at the same time do not want to be punished too severely if they don't engage quickly enough.

QUESTION: Is your company doing more (related to greening of the supply chain) than what has been imposed by your clients?

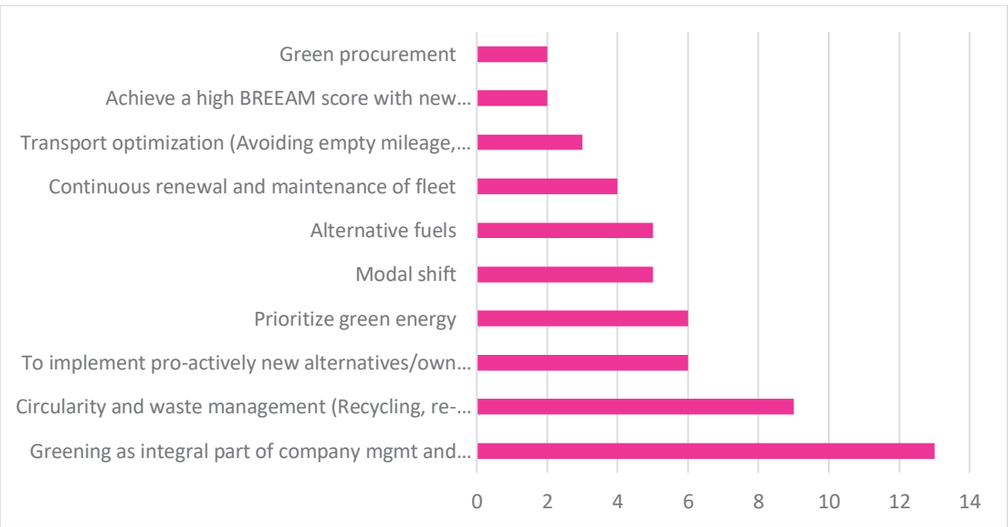
Figure 26. Meeting expectations



A clear majority (74%) estimates their company is doing more than what has been imposed by their clients. Of course, this answer is completely unrelated to the question whether this is enough or not. It is clear that for most companies greening is not just about image, but from the previous questions and respective answers it is clear that some government support is needed as on an individual level there is quite some uncertainty amongst companies.

QUESTION: What is your company doing more (related to greening of the supply chain) than imposed by your clients? (open question)

Figure 27. Additional greening activities



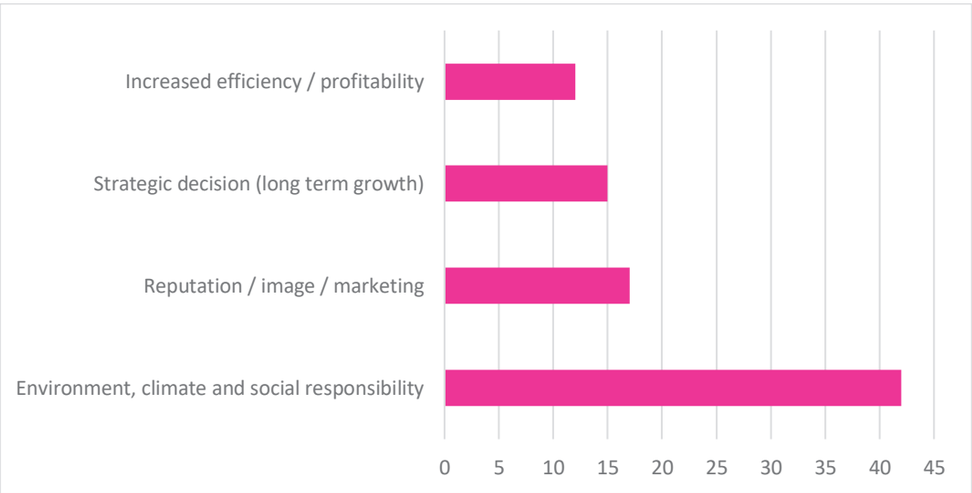
The respondents produced a long list of activities that was categorized and revealed two clear trends:

1. Greening is an integral part of internal company management and strategy (13)
2. Circularity and waste management (recycling, reuse, prevention of waste (9)

Also, the other categories show companies are engaging in a wide range of interesting activities to make greening happen.

QUESTION: What is the major motivation to do more? (open question)

Figure 28. Drivers to do more



In order to map the drivers that push companies 'to do more', again an open invitation to describe these drivers was included in the survey. Again, a categorization was made and four categories emerged.

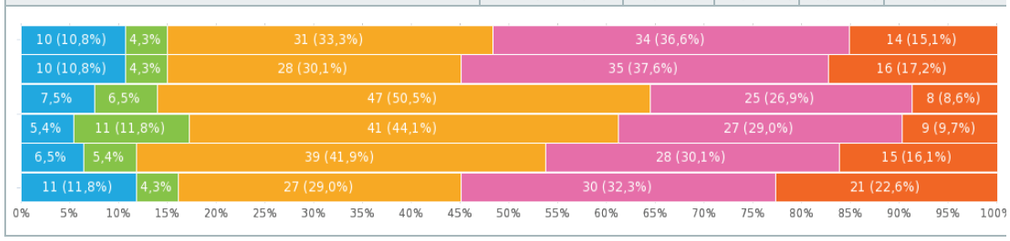
Looking at above table it can be noted that now the driver to do more has a wider dimension than the purely economic motives that were expressed under question "What are the major motives for and barriers to greening of supply chains?" earlier in the survey.

Also, the number of replies (42 or 45.1%) directly linked to 'environment, climate and social responsibility' massively outweighs the other motives to do more, it is proof of a certain voluntarism amongst the respondents.

QUESTION: What are the most relevant Key Performance Indicators (KPI's) for measuring and reporting the efficiency of green measures?

Figure 29. KPI's – all respondents

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Absolute emissions	10 (10,8 %)	4 (4,3 %)	31 (33,3 %)	34 (36,6 %)	14 (15,1 %)
Relative emissions per delivered performance (e.g. tonkm) or produced	10 (10,8 %)	4 (4,3 %)	28 (30,1 %)	35 (37,6 %)	16 (17,2 %)
Impact on sustainability rating/labels	7 (7,5 %)	6 (6,5 %)	47 (50,5 %)	25 (26,9 %)	8 (8,6 %)
Impact towards a green energy mix	5 (5,4 %)	11 (11,8 %)	41 (44,1 %)	27 (29,0 %)	9 (9,7 %)
Contribution to a green modal split	6 (6,5 %)	5 (5,4 %)	39 (41,9 %)	28 (30,1 %)	15 (16,1 %)
Impact on capacity use of vehicles	11 (11,8 %)	4 (4,3 %)	27 (29,0 %)	30 (32,3 %)	21 (22,6 %)



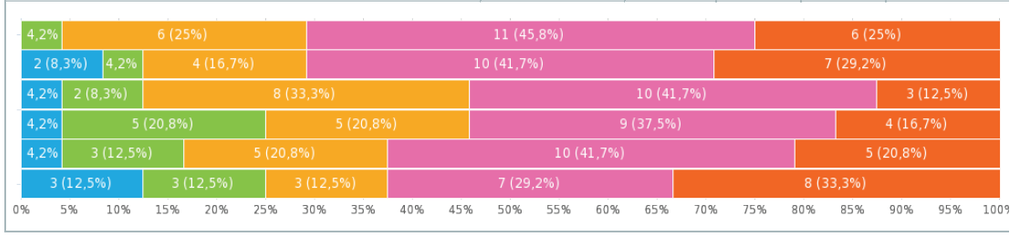
A clear top 3 emerges:

1. Relative emission per delivered effort (e.g. tonkm) or manufactured unit (54.8%)
2. Impact on loading factor of vehicles (54.6%)
3. Absolute emissions (51.7%)

The large groups of respondents expressing 'no opinion' however are somewhat disconcerting. It leads us to believe that these companies are not actively engaged in implementing and following up on KPI's within their companies. Considering the indicated barriers under 'What are the major motives for and barriers to greening of supply chains?': uncertainty about continuity of policies (46.3%), uncertainty about the future proof content of new technologies (44.1%) and profitability of the company (36.6%), some inconsistency can be ascertained.

Figure 30. KPI's – large companies

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Absolute emissions	0	1 (4,2 %)	6 (25 %)	11 (45,8 %)	6 (25 %)
Relative emissions per delivered performance (e.g. tonkm) or produced	2 (8,3 %)	1 (4,2 %)	4 (16,7 %)	10 (41,7 %)	7 (29,2 %)
Impact on sustainability rating/labels	1 (4,2 %)	2 (8,3 %)	8 (33,3 %)	10 (41,7 %)	3 (12,5 %)
Impact towards a green energy mix	1 (4,2 %)	5 (20,8 %)	5 (20,8 %)	9 (37,5 %)	4 (16,7 %)
Contribution toward a green modal split	1 (4,2 %)	3 (12,5 %)	5 (20,8 %)	10 (41,7 %)	5 (20,8 %)
Impact on capacity use of vehicles	3 (12,5 %)	3 (12,5 %)	3 (12,5 %)	7 (29,2 %)	8 (33,3 %)



It is no surprise that larger companies score quite differently, not where the top 3 is concerned, even though the ranking is somewhat different, but as to the level of implementation of such KPI's. The top 3 for the large companies:

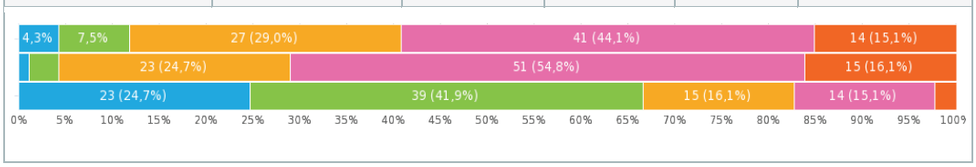
1. Relative emission per delivered effort (e.g. ton km) or manufactured unit (70.9%)
2. Absolute emissions (70.8%)
3. Impact on loading factor of vehicles (62.5%)

The editors' take on this is that also SMEs should define KPI's and implement them to increase their grip on the subject. When asking for other relevant key performance indicators there were no indicators that collected a significant number of replies. However, indicators such as 'waste produced', 'use of water', 'particulate matter' are worth mentioning.

QUESTION: Do greening measures also yield earning opportunities?

Figure 31. Economic opportunities

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Within current activities	4 (4,3 %)	7 (7,5 %)	27 (29,0 %)	41 (44,1 %)	14 (15,1 %)
In newly to develop activities	1 (1,1 %)	3 (3,2 %)	23 (24,7 %)	51 (54,8 %)	15 (16,1 %)
Greening is a cost only	23 (24,7 %)	39 (41,9 %)	15 (16,1 %)	14 (15,1 %)	2 (2,2 %)



More than two-thirds of the respondents see earning opportunities arising from newly to develop greening activities, and even though the group sees less chances into building on existing services and products, still some 60% (59%) believes one should not just get rid of the old. It is furthermore hopeful to note that two-thirds (66.6%) of the population does NOT consider greening to be a cost only.

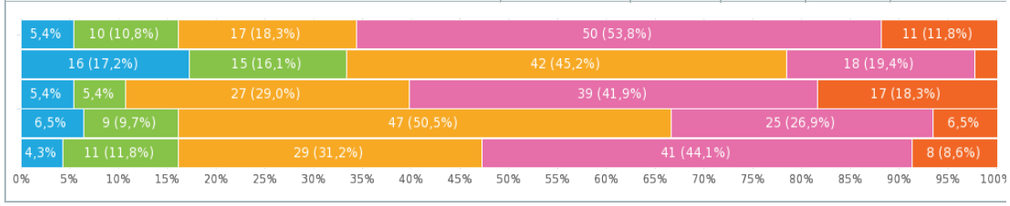
Looking more closely at the different respondent categories only revealed slight differences that can be attributed to the population sizes of the respective groups. Only the terminal operators are slightly more careful but even then, the replies do not deviate that much.

Key take-away: Two-thirds of industry and port logistics stakeholders believes there is money to be made from newly to develop activities in the field of green supply chains.

QUESTION: To what extent is competition between ports and companies influenced by greening actions?

Figure 32. The impact of greening on competition and competitiveness

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Greening supports my competitiveness	5 (5,4 %)	10 (10,8 %)	17 (18,3 %)	50 (53,8 %)	11 (11,8 %)
Greening influences my choice for a port	16 (17,2 %)	15 (16,1 %)	42 (45,2 %)	18 (19,4 %)	2 (2,2 %)
Greening influences my choice of transport mode	5 (5,4 %)	5 (5,4 %)	27 (29,0 %)	39 (41,9 %)	17 (18,3 %)
Greening influences my choice of (port)logistics service provider	6 (6,5 %)	9 (9,7 %)	47 (50,5 %)	25 (26,9 %)	6 (6,5 %)
Greening is not a domain for competition but an opportunity for collaboration	4 (4,3 %)	11 (11,8 %)	29 (31,2 %)	41 (44,1 %)	8 (8,6 %)



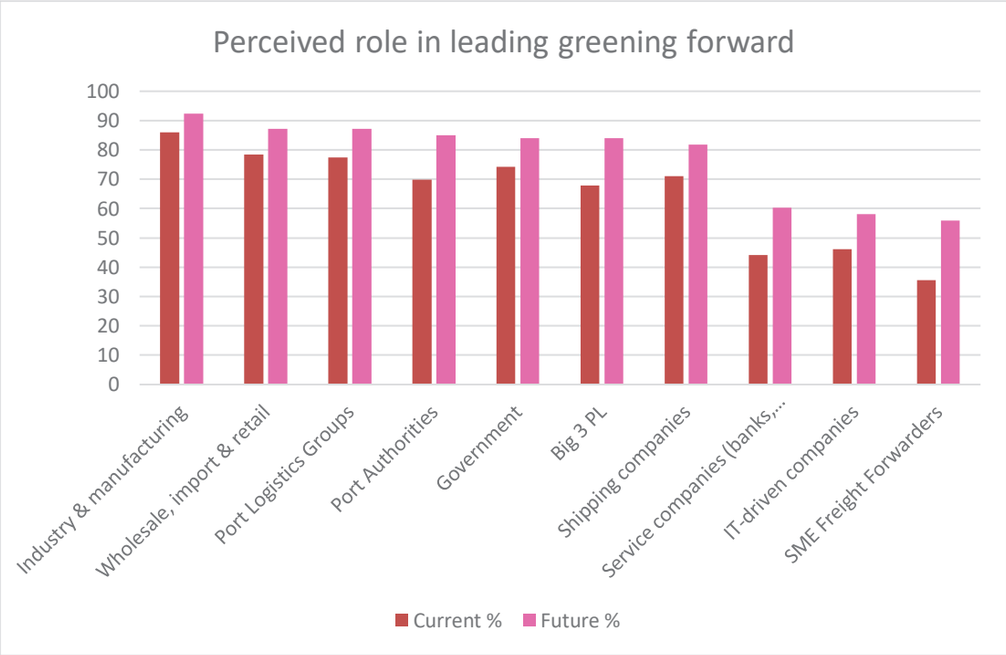
Respondents state that greening mainly has an influence on the company's own competitiveness (65.6%) and on the choice of the transport mode (60.2%). It is striking that one third of the respondents states it does NOT influence the choice of the port they use, even though the majority does not express an opinion on this statement (45.2%). A similar survey conducted for Port of Vancouver (Canada) showed similar results.

Another surprising result is the relatively low score (33.4%) for the statement 'greening influences my choice of (port)logistics service provider'. Upon closer examination a distinction can be made between large companies (37.5%), shippers and retailers (45%) and logistics service providers (41.4%) that subscribe to this statement, and more port related companies that remain neutral on the matter, such as the shipping companies (80%), terminal operators (73.3%) and others (81.8%).

About half (52.7%) of the respondents sees greening as an opportunity for collaboration.

QUESTION: Which actors are most suited in leading greening forward?

Figure 33. The perceived role of supply chain stakeholders



The survey group sees an increased role for every single stakeholder in the greening of supply chains. Even for the categories that score relatively low in the current perceived role this perception changes significantly to more than half of the respondents stating these stakeholders that are perceived less influential still will play an important role in greening activities.

The top categories are the following:
1. Industry & manufacturing (92.4%)
2. Wholesale, import & retail (87.1%)
3. Port logistics groups ((87.1%)

Behind this top three there is a cluster of stakeholders that also scores higher than 80% with respectively port authorities (84.9%), government (83.9%) big 3PL companies (83.9%) and shipping companies (81.8%).

Close examination of the various respondent categories shows little other appreciation of the roles. However, one specific group should be mentioned; the shipping companies are very explicit in their expectations towards port authorities (100%) and government (100%) which they expect to play an important role. They are equally ambitious however about themselves (100%).

From all the other results only one deviating response stands out; shippers and retailers expect a more important role in greening from SME freight forwarders (80%) than the other categories (average 55.9%). More is expected of them.

3.3. Summary of findings

Greening is a shared responsibility by all (port) supply chain stakeholders. Overall respondents see greening as a shared responsibility, and even though some actors are clearly more progressive than others, in general it could be said that reputation is the prime concern. The 'right' answer is readily provided but at the same time a certain level of suspicion towards profitability and opportunity can still be noted. Many remain hesitant.

At the same time, it is also clear that the fact that there is no hard framework to leverage actions, offers companies the opportunity to still get away with providing the 'correct" answer. Even though statements on greening are readily subscribed, a gap between words and actions can be ascertained as the group of respondents that is just starting, is planning to start or has not yet defined when they will expand into effective actions still is relatively large.

A clear strategy and vision on who is to take the lead is missing. However, one could consider that effectively there should not be a single leader in the matter of greening but that on the contrary it is a shared responsibility by all supply chain stakeholders.

4 I CONCLUSIONS AND RECOMMENDATIONS

4.1. Overall findings

This report dealt with the role of seaports in the greening of supply chains. The first chapter set the scene by analysing the concept and practical implementation of GSCM. Next to more theoretical considerations on the origins and components of GSCM, the chapter provided multiple examples on GSCM practices applied by a wide range of companies. Chapter 2 moved the focus to the role and function of seaports in GSCM. Several fields of action to pursue GSCM objectives were identified for private and public actors involved in port-related activities. We made a distinction between actions in the areas of green shipping; green port development and operations; green inland logistics; seaports and the circular economy; and, actions in the field of knowledge development and information sharing. The empirical application was focused on the ports of the Rhine-Scheldt Delta region, the most important port region in Europe in cargo throughput terms. Chapter 2 concluded with a detailed overview of green actions and initiatives developed by market players and port authorities in the Rhine-Scheldt Delta ports. A large-scale survey conducted in the Belgian and Dutch logistics and port industry formed the backbone of chapter 3. The survey questions were deducted from the themes discussed in chapters 1 and 2 of the report. The survey outcomes were analysed in detail.

This final chapter presents a summary of the findings and a set of recommendations for the business communities in the Rhine-Scheldt Delta region in view of advancing the implementation of GSCM practices in seaports.

Defining Green Supply Chain Management

Green supply chain management (GSCM) can be defined as integrating environmental concerns into the inter-organizational practices of SCM. The main idea behind GSCM is to strive for a reduction in environmental impacts by focusing on a series of R's throughout the supply chain: Reduce, Re-use, Recycle, Remanufacture, Reverse logistics, etc. The fields of actions in GSCM include product design, process design and engineering, procurement and purchasing, production, energy use and mix and logistics (incl. distribution and transportation).

Green logistics as part of GSCM

GSCM implies a green logistics approach to connect the environmental concern with transportation, warehousing and distribution activities. Goods will have to be transported in an economically, environmentally and sustainable manner. The main fields of actions in green logistics are related to eco-friendly packaging, eco-friendly transport mode choice and synchromodality, load and route optimization and green distribution networks and distribution hubs. Co-operation between supply chain partners and the use of digital and integrated data solutions are key to support the above fields of actions.

> *Survey result*: Green logistics is seen as a joint effort and shared responsibility by the majority of the respondents.

Green smart logistics and the circular economy

An important part of the success of the circular economy will hinge on the way smart logistics will enable the transparency needed to set up efficient and integrated fully circular supply chain networks. Thus, the circular economy will offer new opportunities for shipping and

logistics service providers but will also challenge them to enter into closer collaboration with industry stakeholders.

GSCM is clearly on the agenda of firms (mental shift and sense of urgency)

GSCM has gained increased attention within industry as there is a growing need for integrating environmentally sound choices into SCM practices. Tighter regulatory requirements and strong demands for a cleaner and more sustainable environment exerted by communities at large (e.g. Youth for Climate) are pushing GSCM practices to the next level. Actors involved in global supply chains are aware of the sense of urgency to move to greener supply chains. Since the early 2000s a slow mental shift is taking place from just being environment friendly to an integration of green initiatives as a way to achieve good business sense and higher profits. This mental shift seems to have accelerated in the past few years. We see shippers, logistic service providers (LSP) and other service providers undertake actions to develop a greener supply chain, as was illustrated by the many examples in chapter 1 of the report.

> *Survey result:* Greening has been put massively on the agenda by the firms between 2010 and now, with some 30% already earlier active (before 2010) and a small 8% not yet. However, one can still see a gap between words and actions as from the responding companies roughly one in five (1/5) is just or still must expand into effective action. And actions relate largely to 'easy' measures quite often related to regulation and less to serious new innovations or changes in behaviours or business models. Companies are keen to provide 'the right answer' but a diffuse image on the future as well as some fear for the company's profitability are holding some back.

Greening as a source of competitive advantage

Investments in greening can be resource saving, waste eliminating and productivity improving. Thus, the greening of supply chains does not have to be a burden but could constitute a potential source of competitive advantage.

> *Survey result*: More than two-thirds of respondents see earning opportunities arising from newly to develop greening activities. Even though the group sees less chances into building on existing services and products, still some 60% (59%) believes one should not just get rid of the old. It is furthermore hopeful to note that 2/3rds (66,6%) of the population does NOT consider greening to be a cost only.

Companies may show different approaches towards greening

Companies might opt for one of the following approaches:

- The reactive approach: Minimal resources are committed to environmental management and the focus is very much on just meeting compliance in terms of environmental regulation;
- The proactive approach: Companies following this approach start to pre-empt new environmental laws by realizing a modest resource commitment to, for instance, initiate the recycling of products, reverse logistics and designing green products.
- The value-seeking approach: In this case, companies integrate environmental initiatives and activities such as green purchasing and green transport as strategic initiatives into their business strategy.

> *Survey results*: A clear majority (74%) estimates their company is doing more than what has been imposed by their clients. Quite a few (14%) indicate that "Greening is an integral part of internal company management and strategy". Major driver for

doing more than asked for is environmental awareness and social responsibility, followed by reputation.

Diverse drivers and impediments towards the greening of supply chains

Companies might initiate the implementation of environmental practices due to motivational drivers such as sales to customers, and legislative and stakeholder institutional pressures. Commitment of senior management is key, followed by an intra-organisational sharing of the responsibility for good environmental practices. There are clear signs that not opting for green supply chains can negatively affect companies' cost base and profitability, and that a focus on GSCM is needed to secure revenue growth, achieve cost reductions, develop brand value and mitigate risks. However, companies cannot blindly roll out green initiatives as part of GSCM and not all market players see GSCM as a business value driver. Small operating margins and intense competition in the market can undermine the potential to move even faster towards the greening of supply chains. Also, inconsistencies and discontinuity in government policies can lead to uncertainty negatively affecting or delaying green investment decisions and the associated development of business cases. Logistics and supply chain managers have to balance efforts to reduce costs, improve service quality, increase flexibility and innovate while maintaining good environmental (ecological) performance. In other words, green initiatives should not only best support the green supply chain, but also make business sense. Otherwise, the competitive and financial position of the company might be negatively affected.

Survey result: Answers to the question on drivers and bottlenecks learn that positive contribution to reputation of the company is a major driver and in line with this also the ability to attract young employees. Striking is that companies seemingly are ambiguous on whether greening works positively on profits: as many companies see the profit perspective as a barrier as there are companies that see this as a driver. On the other hand, the potential that greening offers for developing new value drivers within the company is highly valued. And customer demand indeed scores high as a driver.

The steering actors in the greening of supply chains

GSCM initiatives often involve several to many departments within and between companies. Companies acting in supply chains are influencing and are influenced by their supply chains partners in the greening of the chains.

Survey result: Almost half (45.2%) of the respondent say that they are fully in control and also steer their partners, mainly in the form of indicating that greening is a condition for contracting, but also by pushing specifications or by trying to collaborate. The other half of the set of respondents recognises that greening is a joint effort.

The role of government and organizations

There is an important role for (inter)national governments and organizations in driving the developments in Green supply chains. Governments may or should act as catalysts for change. The environmental policies of governments and other public entities can have a significant impact on GSCM. These policies typically define the emission and energy targets (global, Europe, national) for economic activities. There are two major remarks to make here: 1) specific targets for emissions and specific objectives set for the industry may differ between countries and between specific regions impacting the level playing field; 2) bringing targets towards real actions and measurements agreed upon by stakeholders involved seems a difficult and slow process. For the public policy makers to help reaching the targets, a range

of instruments and intervention mechanisms are available: regulations, tax- and subsidy-incentives, penalties but also convincement and information provision.

> *Survey result*: More than half of the respondents thinks that some form of intervention of the government is desirable, with only about 1 in 5 confirming they should not actively engage. Taxes as a tool to enhance the greening of supply chains is a contentious issue and this is confirmed by the results of the survey. Still, the group that recognises (41.9%) taxes as a tool is larger than the group that is opposed (31.2%). 66.7% of the respondents consider subsidies beneficial to greening. Business wants government to be a soft enforcer; "tell us what to do and stimulate us… but do not punish us if we don't engage quickly enough…"

Ports are hotbeds for initiatives aimed at a further greening of supply chains

Ports, as clusters of economic actors and activities, have adopted a real environmental role and function and in this way (should) contribute to the greening of supply chains in the context of GSCM. In business practice, the growing green reflex is mirrored in the many green initiatives of individual ports and the coordinated actions of the wider port community. The green port concept refers to a development characterized by healthy ecological environment, reasonable utilization of resources, low energy consumption and low pollution.

The challenge of combining volume/activity growth with a further greening

The pressure is on as total cargo volumes handled in the ports in Rhine-Scheldt Delta are still increasing, and there are no signs that this growth pattern will reverse in the foreseeable future. In the past few years, the Delta ports have been very successful in attracting additional investments in industrial, semi-industrial, logistics and terminal activities in the port areas. These investments will bring additional pressures on the port systems in terms of emissions and freight mobility.

Port-related initiatives cover a wide range of functional domains in supply chains

Several fields of action for private and public actors involved in port-related activities exist to pursue GSCM objectives. A distinction was made between actions in the areas of green shipping; green port development and operations; green inland logistics; seaports and the circular economy; and, actions in the field of knowledge development and information sharing. The long list of initiatives, actions and projects for each of these domains illustrates that the port communities in the Rhine-Scheldt Delta are determined to reduce the environmental footprint of their activities and to make the transition to a more energy-efficient and circular economy.

> *Survey result*: Companies in the Rhine-Scheldt Delta indicate a varied and extensive list of actions they undertake to green the supply chains, of which the largest part is focused at alternative sources for energy and savings of energy:
> 1. Green energy (22)
> 2. Energy saving measures for transport (20)
> 3. Energy saving measures for buildings (17)
> 4. Modal shift / intermodal transport (15)
> 5. Alternative fuels for transport (14)

However, port communities also understand that the challenges remain immense and progress made is not at the same level in all domains of action. The port ecosystems are challenged to drastically decrease their environmental footprints against a background of growth in volumes and investments. This requires drastic and large-scale solutions such as

CCUS, a further push towards greener shipping, a strong modal shift and adoption of synchromodality, etc.

> *Survey result*: Respondents state that greening mainly has an influence on the companies' own competitiveness (65.6%) but at the same time that it offers a possibility for cooperation rather than competing. While the companies say that the focus on greening influences the choice of the transport mode (60.2%), it is striking that 1/3rd of the respondents states it does NOT influence the choice of the port they use, even though the majority does not express an opinion on this statement (45.2%).

Ports are part of larger networks and chains thus requiring co-ordination and co-operation
While port authorities and port communities certainly have a role to play, they are part of much larger networks and chains. Many of the solutions will demand close co-ordination and co-operation between the actors involved in these networks and chains, thereby facilitated by technology, new governance and business models and facilitation and regulation by governments.

4.2. Recommendations

More than ever, green supply chain management is on the agenda of companies and other port-related actors, not only as a result of tighter regulatory requirements and strong demands for a cleaner and more sustainable environment exerted by communities at large, but also because of the development of a sense of urgency in the corporate world and the pressure exerted by customers and partners in the supply chains. The positive green attitude of supply chain actors involved in ports and their commitment towards a further green development of their activities should be fully recognized and embraced.

The survey has learned that companies are sensitive for a feeling of 'doing good' and that they often see greening as very important for their reputation. A first recommendation following this is in identifying how to rightly tap upon that underlying wish or nice feeling while 'doing good' in order to accelerate actions and also to actively help exploit the positive impact of greening actions by companies on their reputation which may give a boost to their real actions.

Seaports are prime locations for logistics and industrial activities. The environmental impact of seaports is typically significant given the large concentration of activities and the available connectivity over land (barges, pipelines, rail, road transport) and via the sea (deepsea and shortsea vessels). However, the clustering of activities in one location can also exert strong environmental advantages. For example, 'ecologies of scale' are achieved in the chemical industry by which companies utilize each others' waste material or by-products such as heat. It would be far more difficult to achieve this when the plants concerned would be spatially scattered. It is imperative that these 'ecologies of scale' advantages are fully acknowledged in environmental policy.

The port and logistics sector is already communicating and exchanging ideas on plans and real achievements in the area of green supply chains, but it is expected this aspect is going to become even more important in the coming years. Next to communication and information provision, market actors will - more than ever - have to call out to other partners in the chains (including final customers) on how they can help companies to achieve green corporate and

societal objectives. The greening of supply chains is not only the responsibility of a few actors in these chains but demands a further mentality shift and joint commitment and dedication of all parties involved. In this vein, stakeholders in the business world and society are invited to approach initiatives towards green supply chains in a positive and co-operative attitude, as this will strengthen a common sense of ownership in terms of how to solve existing challenging towards greener supply chains.

While supply chain actors indicate that greening certainly is on their agenda's and sometimes already for quite long, real actions sometimes stay behind and especially those that imply new business processes and even more if this is in collaboration with other supply chain actors. Slow progress in the implementation of certain green initiatives in port-related supply chains does not point to unwillingness or ignorance of the relevant actors. It typically reflects the complexity and co-ordination needs linked to these initiatives and the corporate reality of the 'business case' approach.

Despite the focus on greening of supply chains, companies might face significant burdens to build competitive advantage through green initiatives. They often act in a position of short-term survival that limits their potential for completely new investments or business models that must bring their benefits rather at a longer term. In any case, new investments or the introduction of changes in business models bring uncertainty, especially if this takes place in a setting of interdependency in networks or clusters. This asks for a continuous joint attention for the concern of individual companies in terms of uncertainty, for the question on how their business cases can be improved, or where compensation can be found for a thin business case or for the risk that other actors stop cooperating.

This report identified and categorized several fields of action for private and public actors involved in port-related activities to pursue greener supply chains, i.e. actions in the areas of green shipping; green port development and operations; green inland logistics; seaports and the circular economy; and, actions in the field of knowledge development and information sharing. It is very difficult to prioritize actions in these areas. Still, there are some general considerations to be taken into account:

- The energy transition is very high on the port agenda as exemplified by the many initiatives focused on LNG, bio-fuels, (blue) hydrogen and solar and wind energy. There is still some uncertainty on which energy sources have the most potential to satisfy our (renewable) energy needs in the longer term. Therefore, it is important port ecosystems do not create a lock-in focusing on only one renewable energy source, but indeed explore and contribute to the development of a wide range of initiatives that support a transition to more renewable energy;
- Port ecosystems have development a keen interest in the large-scale application of Carbon Capture and Utilisation (CCU) and Carbon Capture and Storage (CCS) solutions. Given that port activity in the Rhine-Scheldt Delta area is expected to increase in the foreseeable future, we believe that CCU and CCS will be indispensable in view of meeting the CO2 reduction targets. The emerging cross-border and inter-port co-operation in this area is a positive step to bring its implementation to the next level;
- More and more supply chains are being redesigned to meet circular economy standards. Port ecosystems are expected to develop further into key locations for recycling activities and the re-use of materials in the context of the transition towards a circular economy. Ports should be given the possibility to fully adopt this role through an appropriate regulatory framework, knowledge development and infra- and superstructure;

- Many actors in the port-related supply chains are focusing on the greening of maritime and land transport operations by increasing the energy efficiency and reducing the emissions per tonkm. Some of the most common actions include the smart planning of the multimodal transport system (synchromodality), the use of greener vehicles and ships, a better energy mix, scale increases in vehicles, higher utilization rates of transport equipment, the promotion of the role of inland terminals and port-hinterland concepts in GSCM, and pricing mechanisms and other instruments to spread traffic in time and space. The success of the above initiatives typically depends on coordination and co-operation between the actors involved and the availability, use and sharing of data through appropriate (planning) platforms and systems. Risk and uncertainty are serious bottlenecks here, while trust between parties is an important enabler.

A last set of recommendations relates to the role of port authorities in the green debate. Port authorities in the Rhine-Scheldt Delta are very visible in facilitating the greening of supply chains and the transition to a circular economy and non-fossil fuel-based economy. Examples include voluntary programs to promote the development and use of green ships, extensive co-ordinated initiatives to enhance a modal shift and synchromodality in hinterland transport and a whole range of actions and plans in the area of CCU and energy transition. When considering of engaging in green initiatives, port authorities should evaluate whether they have a role to play (i.e. will their involvement likely lead to a superior outcome compared to no involvement?), what tools or instruments to use (e.g. pricing, knowledge development/sharing, investment, etc..) and whether they should act as facilitator or entrepreneur. In some cases, port authorities move beyond the pure facilitating role by entering into key investments, particularly in those cases where private investors show more reluctance to do so.

While port authorities are very active in materializing the green port concept, one should acknowledge that progress remains difficult in some areas. For example, cold ironing seems to be a straightforward solution to significantly reduce emissions of ships in port. However, the large-scale implementation of cold ironing solutions for deepsea vessels is very costly and demands the engagement of many ports and ship operators/owners to co-ordinate technological standards and investments. Furthermore, the environmental benefits of cold ironing are very dependent on the source of the shore power (fossil or renewable energy). Land management - including terminal concession procedures and agreements - is another potentially promising area for green initiatives. However, progress made in this area is rather underwhelming partly because of the legal and functional complexity of existing vs. new concessions. Port authorities and terminal operators are only able to fully benefit from initiatives toward the greening of concession procedures if these actions are embedded in a chain approach toward the environment (ship, port, terminal, warehouse, and inland transport). Green concession agreements miss their effect when treated in isolation. Any green concession policy should give incentives to firms to integrate environmental issues into their management practices, while avoiding making terminal operators victim of any unfair or ineffective green policies. Eventually, such an approach will benefit both the port authority and the terminal operating companies.

Where port authorities may pick up the role of stimulator and facilitator, they also have a rather limited position to really drive innovations and improvements here. Given the position of seaports as key nodes in global supply chains and logistics networks, it is tempting to push port authorities to take up a role as tax collectors for environmental damage caused throughout these chains and networks. As stated above, we believe that port authorities have a role to play to initiate, facilitate and co-ordinate a range of schemes to promote the greening of supply chains. However, port authorities should not be forced by policy makers at

supranational or national level to act as the convenient tax collectors for the greening of supply chains. In line with the 'polluter pays' principle, any internalisation of environmental costs should target the polluter at the source and cannot lead to an obligation for port authorities to punish for externalities or to reward environmental performance. Obviously, the above point does not imply that port authorities should refrain from launching such schemes on a voluntary basis individually or together with other ports.

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ABOUT THE PUBLICATION

This study deals with the role of seaports in the greening of supply chains. The first chapter sets the scene by analysing the concept and practical implementation of GSCM. Next to more theoretical considerations on the origins and components of GSCM, the chapter provided multiple examples on GSCM practices applied by a wide range of companies. Chapter 2 moves the focus to the role and function of seaports in GSCM. Several fields of action to pursue GSCM objectives were identified for private and public actors involved in port-related activities. A distinction is made between actions in the areas of green shipping; green port development and operations; green inland logistics; seaports and the circular economy; and, actions in the field of knowledge development and information sharing. The empirical application is focused on the ports of the Rhine-Scheldt Delta region, the most important port region in Europe in cargo throughput terms. Chapter 2 concludes with a detailed overview of green actions and initiatives developed by market players and port authorities in the Rhine-Scheldt Delta ports. A large-scale survey conducted in the Belgian and Dutch logistics and port industry forms the backbone of chapter 3. The survey questions were deducted from the themes discussed in chapters 1 and 2 of the report. The survey outcomes are analysed in detail. The final chapter presents a summary of the findings and a set of recommendations for the business communities in the Rhine-Scheldt Delta region in view of advancing the implementation of GSCM practices in seaports.

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FURTHER INFORMATION

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