CHALMERS

A step towards environmental performance metrics for transportation

– A case study at Mölnlycke Health Care

Master's thesis in the Master Degree Programme, Supply Chain Management

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CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2013
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Abstract

Logistics managers face increasing demand to consider the environment in decision making. Yet, there is no standardised procedure to assess the environmental impact of transport systems. The purpose of this thesis is to contribute to the environmental performance management research with metrics that fulfil both operational reporting and managerial decision requirements. The thesis has an abductive approach and is based on primary data collected through interviews and questionnaires. Performance management is the main theory of concern. The focus of this thesis lies upon the pre-analysis and pre-design of an environmental performance management system for freight transport operations at Mölnlycke Health Care, which includes three sections: 1) metrics, 2) calculations, and 3) dashboard. Empirical findings are analysed through a gap analysis and are compiled in a manner which allows the finalised results to be presented in a dashboard. The main conclusion incites further data collection from transport services providers to increase accuracy and transparency in order to initiate the implementation of environmental performance management systems for transportation. Further research to link environmental performance to financial performance, and behavioural change from organisations, are also suggested.

KEYWORDS: ENVIRONMENTAL MANAGEMENT, LOGISTICS, SUPPLY CHAIN, PERFORMANCE MANAGEMENT, METRICS, DASHBOARD, CARBON EMISSIONS FROM TRANSPORT

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This project has given me a deeper knowledge of the subject at hand and I am very grateful for having got this experience.

Aurélia Mulvet

Gothenburg, June 2013

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List of abbreviations

EU *European Union* EC *European Commission*

NGO *Non-Governmental Organisation*

GRI *Global Reporting Initiative*

NTM *Network for Transport and Environment*

MHC *Mölnlycke Health Care*

EMEA *Europe, the Middle-East, and Africa*

EHS *Environment Hygiene Safety*

CSR *Corporate Social Responsibility*

EPMS *Environmental Performance Management System* PM *Performance Management*

KPI *Key Performance Indicator*

LM *Logistics Management* L&T *Logistics and Transport*

SCM *Supply Chain Management*

DC *Distribution Center*

CCU *Cargo Capacity Utilisation*

FU *Functional Unit*

TEU *Twenty-foot equivalent unit*

1. INTRODUCTION

The introduction chapter starts with a background to the issue followed by problem discussion and purpose of the study leading to the research questions. The chapter also concerns the expected outcome and limitations and closes with an outline of the thesis.

1.1 BACKGROUND

The share of transport (including freight and passenger transport) emissions is 20% of total EU GHG emissions and freight transport accounts for approximately one third of total transport EU GHG emissions. Approximately 95% of total transport EU GHG emissions is accounted for by CO_2 emissions. Although the industry has been improving energy efficiency of freight transport, these gains have been counterbalanced by larger transport freight volumes, due to an increasing global trade and the enlargement of the EU. (McKinnon and CEFIC ECTA 2011)

Traditional logistics systems have focused on minimizing costs and maximizing profit in the private sector (Wu and C. Dunn 1995). Environmental aspects have played a subordinate role, if any role at all (Dobers *et al.* 2013).Yet Wu and C. Dunn (1995) argue that "because the nature of logistics management is cross-functional and integrative and since many logistical activities impact on the environment, it makes sense for logistics managers to take initiatives in this area" and to include the environment as a major factor in decision making.

Today's businesses are facing increasing pressure to consider environmental impacts from regulators, customers, and media. Proactive firms enhance their reputation and legitimacy (Sarkis 2009) while reactive firms try to prove their good faith by complying with environmental legislation (Sarkis 2012). The challenges of logistics managers is to determine how to incorporate environmental management principles into their daily decision-making process (Wu and C. Dunn 1995). Mönlycke Health Care (MHC) states that they are "committed to minimise their environmental impact without compromising the effectiveness and safety of their products."

At present firms do not have a standardised procedure to assess the environmental impact of their logistics systems (Dobers et al. 2013). There is no common standard for evaluating environmental initiatives (Hassini *et al.* 2012; Xu *et al.* 2013). The most cited reasons for this lack of knowledge are non standardised data, insufficient technological integration, geographical and cultural differences, and lack of agreed definition upon metrics (Hervani *et al.* 2005). More research is required in this area in order to provide directions for practitioners (Shaw *et al.* 2010; Björklund *et al.* 2012; Winter and Knemeyer 2012). There is a need for a standardised, usage-related, and comprehensive method (Dobers et al. 2013). Björklund et al. (2012) argue that three areas should be investigated; first the influence of the different stakeholders on the design, implementation, and use of performance measurement procedures; second the importance of the involvement of the strategic managerial level; and third the requirement for a concrete definition of the purpose of measurement systems in order to avoid the “too broad” measuring systems.

1.2 PROBLEM DISCUSSION AND PURPOSE

MHC is a supplier of single-use surgical and wound care products and services to 80 countries around the world. They have 7000 employees who are widely distributed among headquarters in Gothenburg, sales offices in over 30 countries, and manufacturing facilities in nine countries. MHC sells its products to hospitals and healthcare professionals worldwide. The company operates through two divisions:1) Surgical products, which generates 60% of its sales, and 2) Wound Care.77% of sales are generated in the EMEA (Europe, the Middle-East, and Africa) region, 19% from North America and 4% from the Asia-Pacific region.MHC states that they need a “reliable method to measure and report environmental performance of our transportation”. They wish to challenge the tools they currently use to measure emissions from transportation and to align calculations for the transport of goods between factories and distributions centres (DCs) and from DCs to the customers. Their main target is to be able to trace the environmental impact of a product throughout the whole chain. In addition, the company wants to be able to communicate progress to top management and customers. Hence, the purpose of this thesis is *to investigate how a procedure can be described to measure and report environmental performance of transportation*.

1.3 RESEARCH QUESTIONS

Like any project, the execution of an environmental performance management system (EPMS) can be divided into the following steps: analysis, design, development, implementation, and evaluation. The focus of this thesis lies upon the analysis and the design of an EPMS for transportation at MHC. These phases should encompass three sections: 1) metrics, 2) calculations, and 3) dashboard. Numerous stakeholders have an important role to play on the analysis and the design of the EPMS. Those include MHC and transport services providers. Low involvement of key actors in theses phases would result in problems during the development and the implementation phases. Working sessions that group together users of the EPMS result in higher understanding and commitment. When designing the metrics, attention should be given to flexibility. Indeed the metrics have to be flexible enough to integrate the needs of logistics managers, environmental and quality managers, and top executives. Those needs include operational monitoring and improvements introduction. Low adaptability or too high flexibility would lead to disinterest of users. Control and sharing of information is discussed among the users during working sessions. Stakeholders should decide on which information they want to disclose. In addition, the metrics should comply with reporting principles such as transparency and auditability. This approach leads to the three research questions of this thesis:

RQ1. Which metrics should be selected in order to fulfil stakeholders' requirements?

RQ2. What procedure should be suggested in order to calculate the metrics?

RQ3. What procedure should be suggested in order to report the metrics?

1.4 EXPECTED OUTCOME

The author suggests reliable assumptions and formulas to measure emissions related to transportation activities. Metrics are presented in a dashboard. The results are interesting for various actors: MHC and users of transport services, to increase their understanding of environmental impacts associated with transport networks; and transport providers, to get a clearer picture of the environmental requirements from users of transport services. Furthermore, the study has academic relevance due to the contribution in the research field of environmental measurement of transportation.

1.5 LIMITATIONS

In this thesis, the focus lies upon inbound and outbound distribution since transportation is often identified as the most environmentally damaging operation within logistics (Björklund and Forslund 2013). In addition, MHC currently focuses on CO_2 emissions associated with their transportation thus carbon emissions is the main concern of the thesis.

Since most of decisions for supply chain strategy are taken in MHC HQ in Gothenburg, interviews of MHC logistics and environmental managers are conducted in MHC HQ. Data is also collected from three of their transport providers through interviews of key account managers.

Automation of the procedure is not part of the thesis. The focus of this thesis is to provide MHC with a model of the dashboard.

The author does not consider EPMS systems of other organisations that are reputable for dealing with environmental issues.

1.6 DISPOSITION

Figure 1 shows a chapter by chapter breakdown of the thesis.

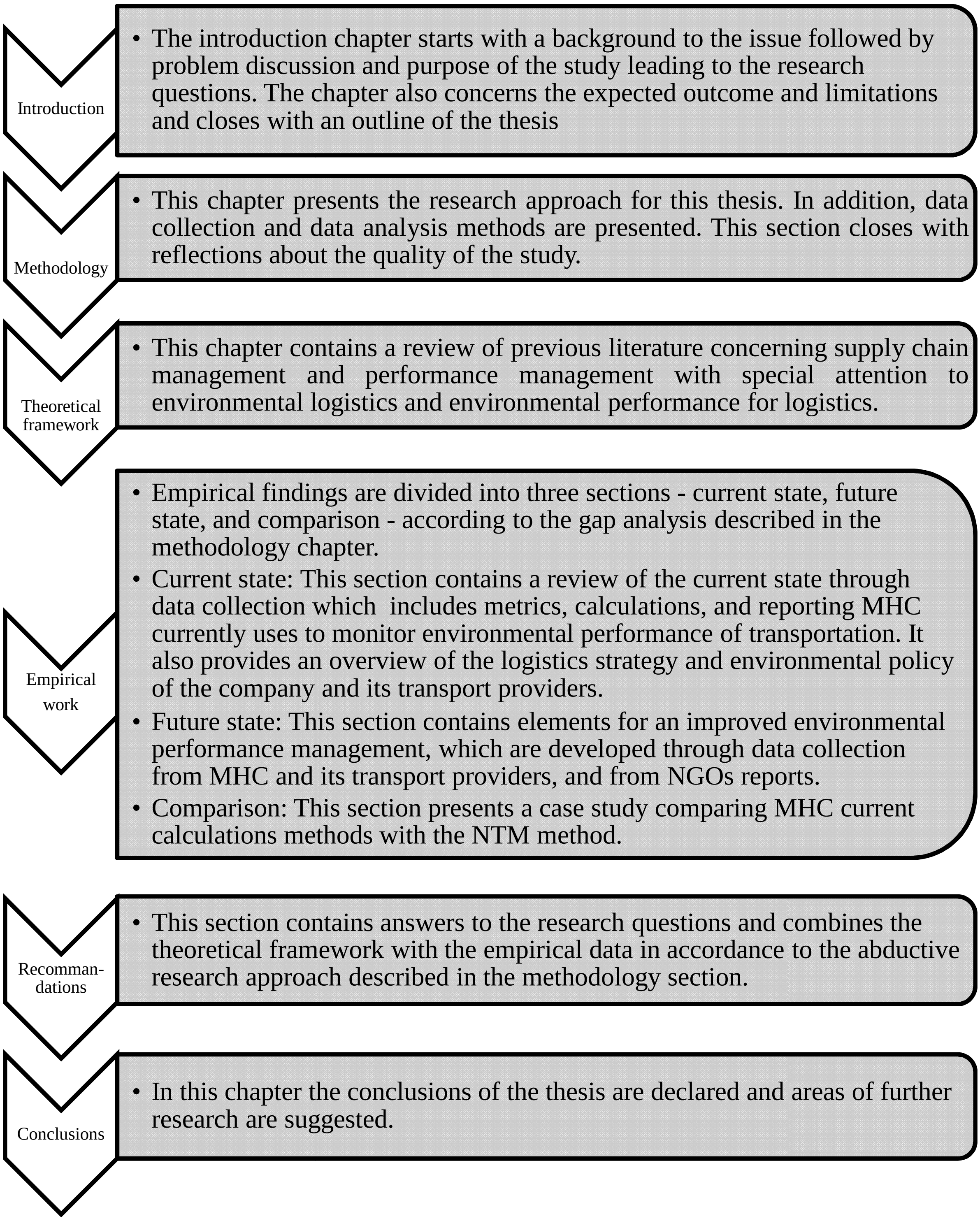


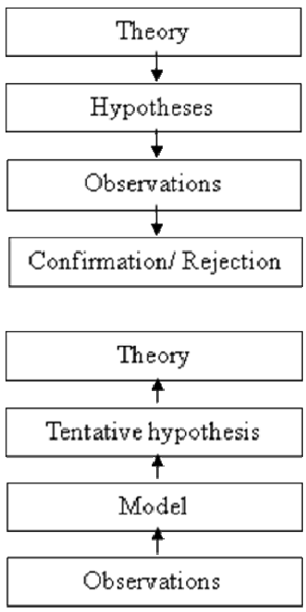
Figure 1 Outline of the thesis

2. METHODOLOGY

This chapter presents the research approach for this thesis. In addition, data collection and data analysis methods are presented. This section closes with reflections about the quality of the study.

2.1 RESEARCH APPROACH

Theory can either be assessed or built from collected data. The former refers to deductive theory whereas the latter refers to inductive theory (Figure 2).Deduction is identified as the ‘top-down’ approach. The researcher uses existing theory to build a specific conclusion which aims at confirming or rejecting hypotheses. He or she states whether the conclusion is valid. In contrast, induction which is sometimes called the ‘bottom-up’ approach implies analysis of specific cases to draw up broader generalisations and theories. He or she states that given the assumptions, the conclusion is plausible. This approach is more exploratory than the deductive approach especially at the first steps.(Bryman and Bell 2007)



Deductive research – theorytesting

Inductive research – theory generation

Figure 2 Deductive and inductive research processes (Bryman and Bell 2007)

Deductive and inductive approaches should rather be seen as tendencies than clear distinctions. The last step of a deductive approach can involve induction as the findings are added to the stock of theory and the research findings associated with a certain area of investigation. An inductive approach can be further investigated by creating deductively more hypotheses and collecting more observations in order to verify the conditions in which the theory is and is not valid. (Bryman and Bell 2007)

A third approach is suggested for logistics research; abduction (Kovács and Spens 2005) that can be seen as a combination of deduction and induction. Kovács and Spens (2005) emphasise that abduction allows creativity which is necessary to go beyond the constraints of deduction and induction which are both delimited to establish relations between known constructs. The abductive research process is illustrated in Figure 3. Like induction, abductive reasoning is initiated with real-life observations though the researcher constructs some pre-perceptions and theoretical knowledge. The abductive approach starts with empirical observations that cannot be explained with the prior theories(Kovács and Spens 2005).Thereby an iterative process called "theory matching" or "systematic combining" aiming at matching theory and reality starts(Dubois and Gadde 2005).Theories in the form of hypotheses (H) or propositions (P) are developed. The abduction process closes with the application of the H/P in an empirical setting which can be identified as a deductive part.

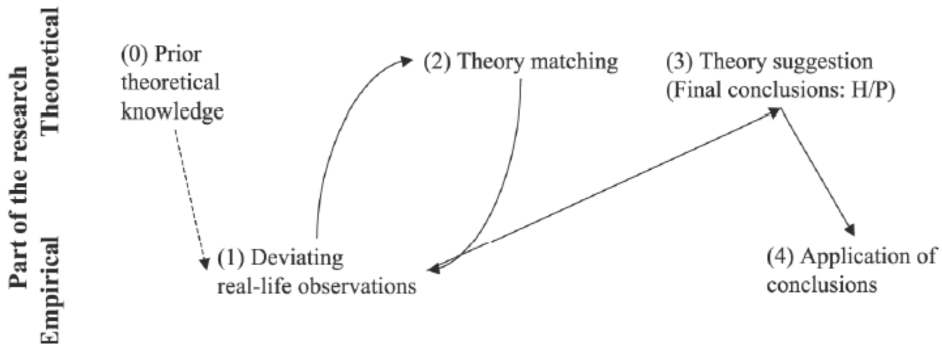


Figure 3 Abductive research process (Kovács and Spens 2005)

Case studies allow a deep understanding between a phenomenon and its context (Dubois and Gadde 2005). According to Yin (2004), three types of case studies can be distinguished. Descriptive case studies are conducted to purely describe a phenomenon and its specific context. Explanatory case studies seek to investigate and explain in depth the characteristics of the phenomenon and links with its effects *i.e.* doing causal investigations. Exploratory case studies are conducted to explore entirely new research areas to define research questions and hypotheses. The author conducts a descriptive case study in this thesis. "Systematic combining" used for case studies is a process where theory, empirical findings, and case analysis evolve simultaneously and theory is developed(Dubois and Gadde 2005). This process enables the author to gain the level of understanding required to answer the research questions. This thesis which focuses on the case study of MHC takes an abductive approach. Having a general knowledge about logistics, performance and environmental management, the author starts with empirical observations at MHC. The process of "systematic combining" is then used throughout the thesis work which allows emergence of new theory.

Another aspect to consider is that research methods are usually divided into quantitative and qualitative methods. Qualitative research is defined a way of gathering an understanding and deeper knowledge of the studied problems. On the other hand, quantitative research is based on the gathering and analysis of numbers and statistics. As opposed to the quantitative approach, the base in qualitative research is that reality is subjective and needs to be interpreted rather than measured(Sharan B. 1994).The type of research approach gives an indication: quantitative method is more suitable for deductive approach and qualitative method is proper for inductive approach. This thesis presents elements of both induction and deduction thus both quantitative and qualitative methods are used.

2.2 DATA COLLECTION

Data can be classified into two categories. Primary data is collected for unique purpose and can be performed by telephone, personal interviews, questionnaires, and observation. Reanalyzing data that have already been collected by some other purposes is known as secondary data. Some examples are governments' publications, academics' surveys, voice recording *etc.*(Saunders *et al.* 2007). Furthermore, Dubois and Gadde (2005) underline that observations during meetings, working sessions, or conferences for instance contributes primary data that would not have appeared otherwise. It can generate new questions for future interviews, further development of the framework, and eventually a new vision of the phenomenon itself.

Primary data, on which this thesis is based, consists of interviews (telephone and face to face) and questionnaires. An unstructured interviewing consists of a few broad questions that the interviewer asks and the interviewee can respond freely. The interviewer might pick up on some ideas or topics. For the structured interview, the researcher has a list of questions related to specific topics that need to be covered during the interview, though the order of the questions may not follow exactly the planned schedule. The interviewer might ask questions that are not in the interview guide. (Bryman and Bell 2007) In this thesis the author conducts structured interviews. Before the interview, questions are prepared to increase the possibility to get the right information. The questions are sent in advance to interviewees in order to give them time to gather relevant information. A transcript is written thus information remains and is easy to access. Additional questions, further explanations, and contact details are asked if necessary. Information has been collected through interviews of and questionnaires sent to (see Appendices 7.1, 7.2, 7.3, and 7.4):

- Global Logistics Director at MHC,
- EHS (Environment Hygiene and Safety) Manager at MHC,
- EMEA Logistics Director at MHC,

- IT specialist at MHC,
- Control Tower officer for MHC at DSV,
- Key Account Manager for MHC at DSV,
- Key Account Manager for MHC at Scan Global Logistics (SGL),
- Quality and Environmental Manager at SGL,
- Key Account Manager for MHC DHL,
- Quality Manager at DHL, and
- CSR (Corporate Social Responsibility) Senior Manager at DSV.

Sources that are used in order to collect secondary data are scholar articles, books, and corporate reports and websites. Scholar articles are located through Chalmers library databases. Corporate reports and websites are located through the search engine Google. Information has been collected through MHC website and Sustainability magazine, and DSV, SGL, and DHL websites. In addition to the gathered data, reports from the European Commission (EC) and from NGOs (Non-Governmental Organisations) such as the Global Reporting Initiative (GRI) are used.

2.3 DATA ANALYSIS

Empirical findings are analysed through a gap analysis which aims at identifying the tasks to be completed in order to bridge the gap between the 'as-is' situation and the desired future state. For this thesis, the first step of the gap analysis involves review of the current state through data collection. It includes metrics, calculations, and reporting MHC currently uses to monitor environmental performance of transportation. It also involves data collection about the environmental policy of transport providers. In the second stage, requirements for the desirable state are developed through data collection from MHC and its transport providers, and from NGOs reports. The current and future states are compared in the third phase of the process. The last step provides recommendations. The process is depicted in Figure 4.

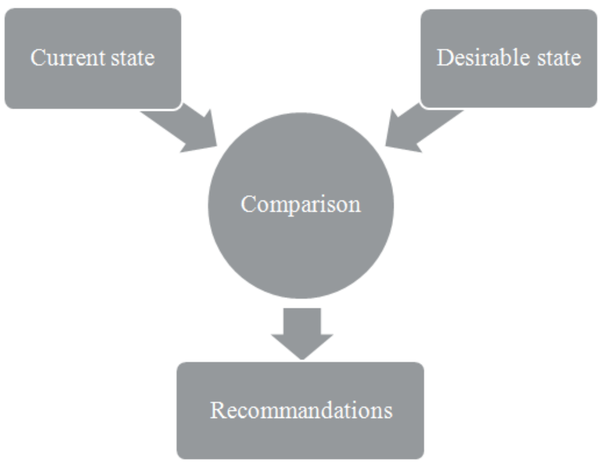


Figure 4 Gap analysis process

2.4 RESEARCH QUALITY

Yin (2004) provides researchers with a model to judge the quality of their case studies. It includes four tests to apply throughout the case study process: 1) construct validity identifies correct operational measures for the concepts being studied; 2) internal validity establishes a causal relationship, 3) external validity addresses issues such as determining whether the study's findings are generalisable beyond the case study; and 4) reliability ensures that, if later investigators follow the same procedures and conduct the same case study again, they are able find out the same results. It aims at minimizing the errors and biases in the study. Table 1summarises tactics provided by Yin (2004) covering the tests (internal validity is not acceptable for this thesis since the author conducts a descriptive case study). It also indicates the actions taken by the author to respond to these recommendations.

Test	Tactic	Research phase	Action
Construct validity	Use multiple sources of evidence	Data collection	Various interviews Discussions with both consultancy firms and researchers Critical point of view while reviewing literature
	Have key informants review the draft case study report	Data collection	Interviewees able to view transcripts of interviews Examiner and researchers feedback
External validity	Use theory (single-case studies)	Research approach	In-depth review of literature Discussions with researchers
Reliability	Use case study protocol	Data collection	Detailed procedures that can be easily repeated by later investigators Consistent set of preliminary questions used in each interview
	Develop a case study database	Data collection	Information electronic save Interviews notes and transcripts

Table 1 Case study tactics and actions(Yin 2004)

3. THEORETICAL FRAMEWORK

This chapter contains a review of previous literature concerning supply chain management and performance management with special attention to environmental logistics and environmental performance for logistics.

3.1 LOGISTICS MANAGEMENT

Logistics management (LM) encompasses management of the flows of products and information through a business, from the raw materials suppliers to the delivery of the final product (Christopher 2011). Inbound logistics can be described as the receiving and warehousing of raw materials and their distribution to manufacturing, and outbound logistics as the warehousing and distribution of finished goods.

Christopher (2011) emphasises the fact that there is an important distinction to be made between Supply Chain Management (SCM) and LM. The concept of linkage and coordination is extended to suppliers (upstream) and customers (downstream) thus SCM can be defined as the management of relationships with suppliers and customers in order to deliver superior customer value at less cost to the supply chain as a whole (Christopher 2011). Christopher (2011) highlights that the word “supply” should be replaced by “demand” since the chain should be driven by the market. In addition Christopher (2011) states that the word “network” should be used rather than “chain” since multiple suppliers, suppliers’ suppliers, multiple customers, and customer’s customers are involved in the system. Therefore a more accurate definition of SCM is “A network of connected and interdependent organisations mutually and co-operatively working together to control, manage and improve the flow of materials and information from suppliers to end users” (Christopher 2011). Figure 5 gives the example a manufacturer with two tiers of suppliers and two tiers of customers.

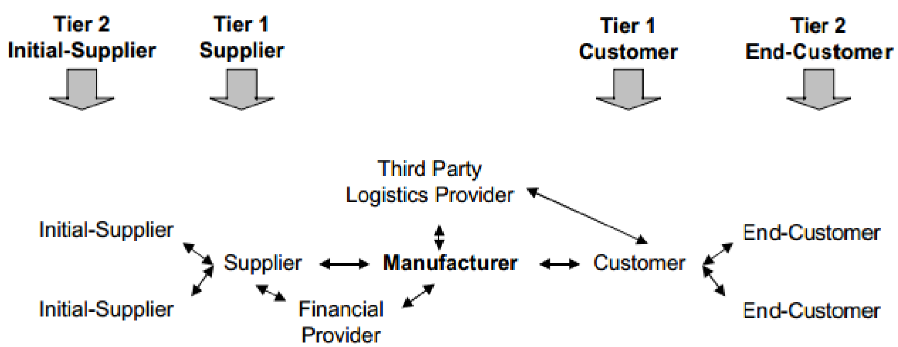


Figure 5 Extended supply chain (Winter and Knemeyer 2012)

3.2 ENVIRONMENTAL LOGISTICS

Environmental impacts can be defined as “any changes to the environment, whether adverse or beneficial, wholly or partially from an organisation activities, products or services”(AFNOR 2000). Logistics activities have a considerable environmental impact. Wu and C. Dunn (1995) suggest an adapted view of the Porter’s value chain concept and put forward that every component of the value chain is responsible for minimizing the firm total environment impact (Figure 6). Most of the environmental impacts of logistics come from transport operations (Björklund and Forslund 2013). As a key component of LM, transport involves different modes including road, sea, air, and rail. Road transportation provides flexibility and ability to reach far out to costumers, security of goods, and most advanced technology in terms of emissions control. Main challenges include dependence on fossil fuels, high CO_2 emissions levels, high PM emissions levels from road dust and tyres, and rather low load rates. Shipping is the most efficient transport mode in large volumes and low speed. Low flexibility, low adaptability, few door-to door solutions, long handling times in port, and high sulphur content in fuel are some of the challenges that need to be dealt with. Air transport provides high speed and worldwide access. An important improvement option is fuel efficiency. Railway is the most energy efficient land transport mode. Environmental advantages are reduced if diesel driven locomotives are used and if the electricity is produced from fossil fuels. Drawbacks are identified as being limited flexibility, limited adaptability, the structure with one direction and weight restrictions, national technical constraints (electrical systems, signaling systems etc.), high fixed costs (rail racks, bridges, terminals etc.), goods damages, and long lead times. (Lumsden 2006; NTM 2008; Blinge 2012)

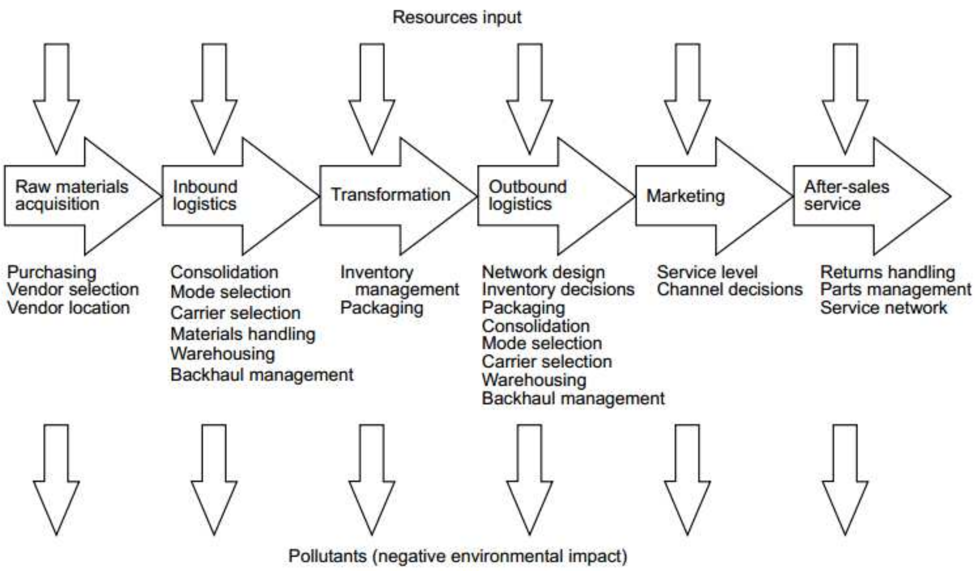


Figure 6 Logistics decisions that affect the environment (Wu and C. Dunn 1995)

3.3 PERFORMANCE MANAGEMENT

Performance management (PM) allows companies to have visibility on their core processes (Riff 2011). It is defined as the process of quantifying the efficiency and effectiveness of actions (Hultkrantz 2011) where efficiency stands for 'doing things right' and focusing on processes, and effectiveness for 'doing the right things' and focusing on the outcome. Organisations need to combine both efficiency and effectiveness in order to be successful. According to H. James Harrington, measurement is a pre-requisite that leads to control and improvement. "If you can't measure something, you can't understand it. If you can't understand it, you can't control it. If you can't control it, you can't improve it" (Hultkrantz 2011). "Many managers believe that what is measured gets done" (Wu *et al.* 2012).

Performance measurement can be used to plan, design, implement, and monitor systems (Hervani et al. 2005). On top of that, it can be used for benchmarking against competitors or industry leaders (Shaw et al. 2010) thus it facilitates comparison across organisations (GRI 2006). Furthermore, focus of measuring can be historical in order to report performance and evaluate performance (Björklund et al. 2012). It can be focused on present in order to understand processes, identify problems and bottlenecks, confirm what is already know, reveal what is not known (Björklund et al. 2012), and identify areas of improvement (Shaw et al. 2010). It can be future-focused to elaborate objectives and set priorities (Björklund et al. 2012). Performance measurement integrates continuous improvement which includes five steps: 1) definition of objectives, 2) measurement, 3) cause analysis of the deviation from the objectives, 4) corrective actions and measurement, and 5) adjustment (Riff 2011) (Figure 7).

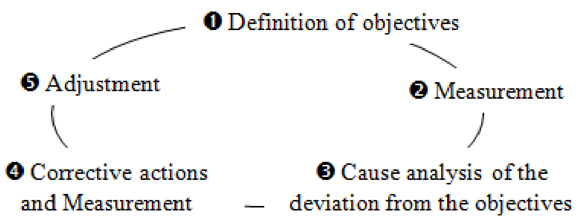


Figure 7 Continuous improvement in performance management (Riff 2011)

KPIs allow managers to monitor progress towards a goal in real time and to prioritise actions (Riff 2011). KPIs features and method for definition are presented in Figure 8. Dashboards are used to monitor operational processes and scorecards to monitor progress towards strategic goals (Eckerson 2011) (Figure 9). A performance dashboard is an information delivery system that parcels out information visually using charts or tables, and alerts to users on demand so they can measure, monitor, and manage business performance more effectively (Eckerson 2011). Riff (2011) suggests five parameters to be used for KPIs displayed in a dashboard; planned value, earned value, variance, reasons, and possible solutions.

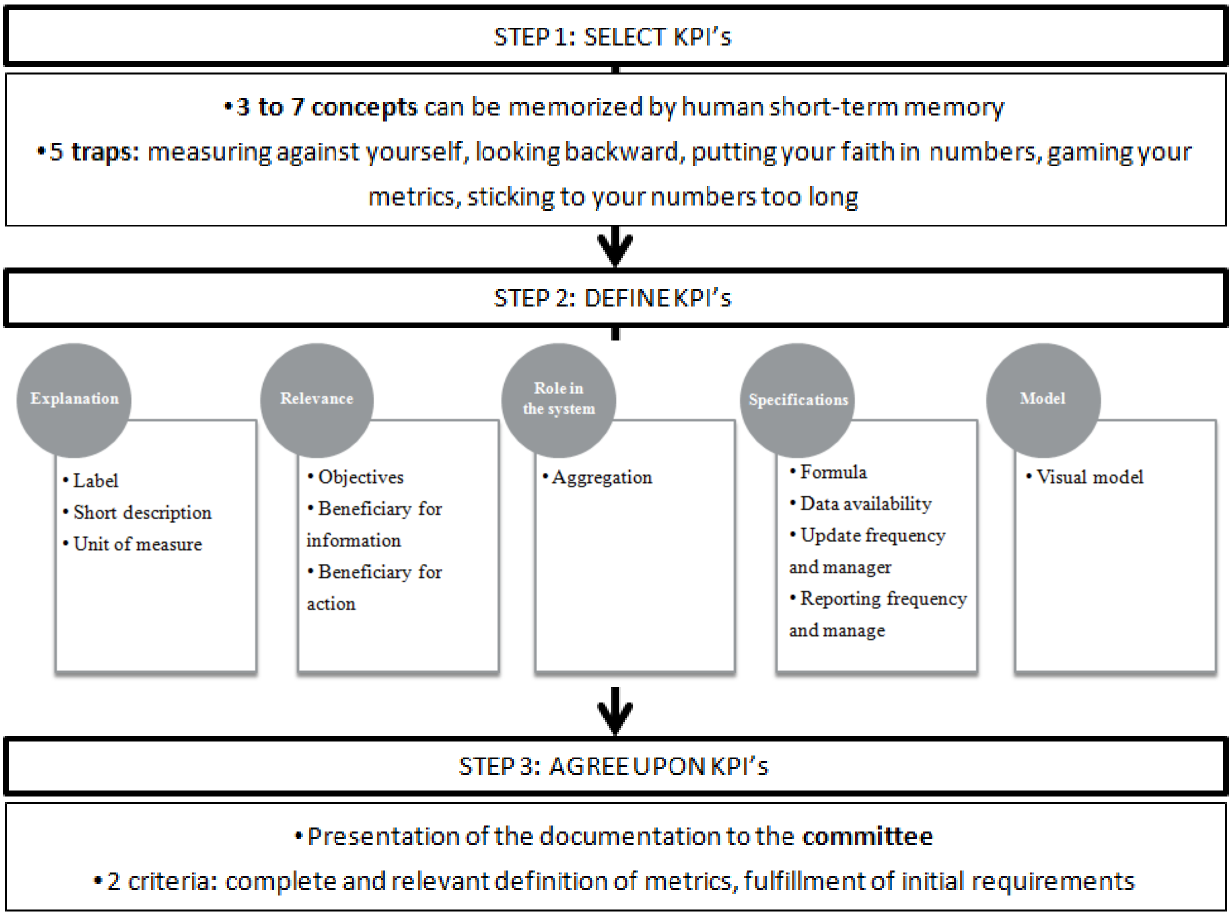


Figure 8 KPIs selection and definition (Hultkrantz 2011; Riff 2011)

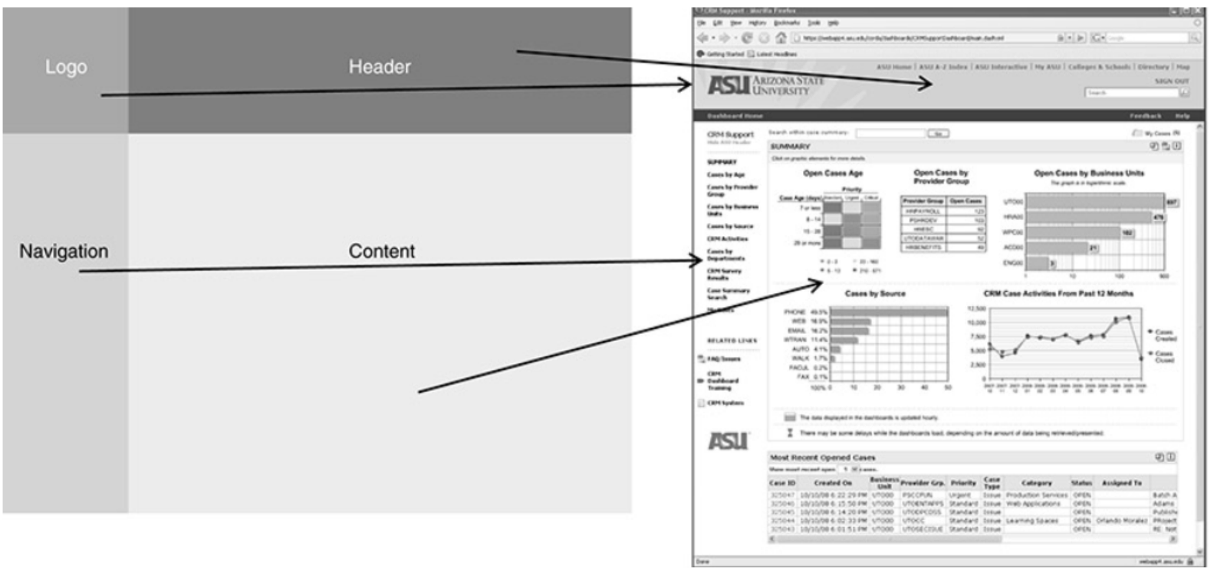


Figure 9 Dashboards patterned after common Web site templates(Eckerson 2011)

4. CURRENT STATE: LOGISTICS AND ENVIRONMENTAL MANAGEMENT AT MHC AND TRANSPORT PROVIDERS

This section contains a review of the current state through data collection which includes metrics, calculations, and reporting MHC currently uses to monitor environmental performance of transportation. It also provides an overview of the logistics strategy and environmental policy of the company and its transport providers.

4.1 MHC

4.1.1 SUPPLY CHAIN MANAGEMENT

The SCM department is one of MHC corporate functions and reports to the CEO. It is divided into five divisions: Supply Chain Controlling, Global Distribution, Customer Service, Supply Chain Planning, and Supply Chain Development (Figure 10 and Figure 11). New strategy for Supply Chain Management is being implemented between 2009 and 2013.Challenges include increased transparency throughout the supply chain, reduced complexity in network and processes, standardised operations and processes, increased flexibility and established scalability, and use of metrics to ensure sustainable progress (Li *et al.* 2011).The Global Distribution division launched a project dedicated to the reduction of local European warehouses to a regional structure being supported by three DCs. MHC CEO states that "This will support not only the Logistics and Supply Chain strategies but also provide the foundation for our overall company strategy. This is a critical component for the success and the expansion of MHC in the future."

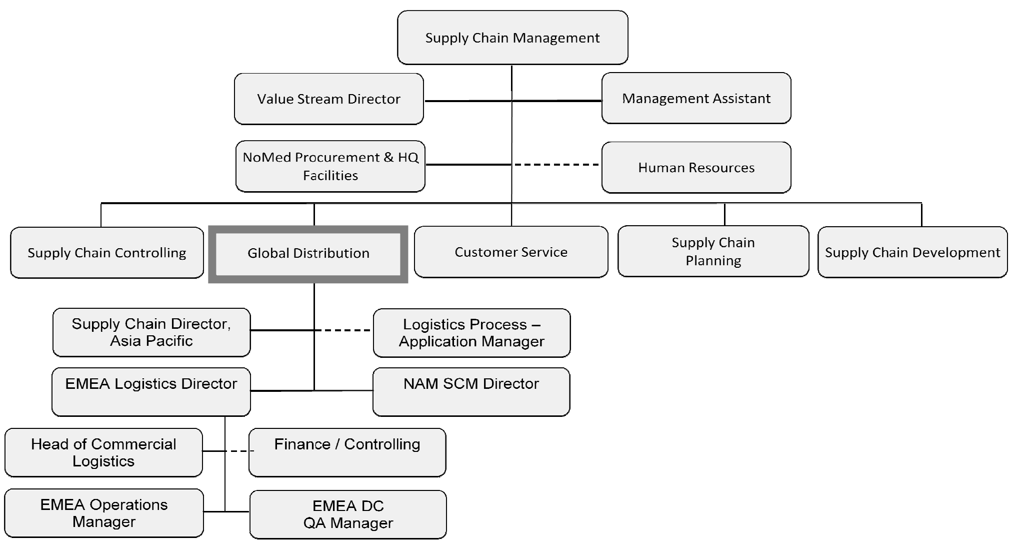


Figure 10 SCM organizational structure at MHC

4.1.2 ENVIRONMENTAL POLICY

Interviewees classify MHC as good citizen and they think that reducing environmental footprint is part of MHC DNA. Nevertheless, main drivers of MHC logistics strategy are cost and lead time and do not include environmental issues. MHC's corporate environmental focus areas encompass reduction of waste, consumption of energy, CO_2 emissions from transport, and removal and replacement of chemicals that are classified as hazardous to the environment (Mölnlycke Health Care 2012). The EHS Manager, as part of the Corporate Quality Affairs Department, is responsible for managing environmental issues. She participated to CleanMed Europe 2012, which is an event dedicated to new sustainable solutions for healthcare. MHC complies with the requirements of the GRI and uses the GRI Index for the Sustainability Magazine (Figure 12). This magazine is a combination of an annual Sustainability report and corporate brochure. CSR initiatives and Code of Conduct can also be found in the magazine. All MHC production facilities are ISO 14001. Policy, objectives, and targets have to be reviewed every three years. Factories report waste, energy, and recycling rates monthly. CO_2 emissions from transport from suppliers to factories, factories to sterilisation plants, and sterilisation plants to DCs are reported quarterly by the factories. Emissions from transport from DCs to customers are calculated through the FTC-Cube since 2012 and reported by the EMEA Logistics Director to the EHS manager. The EHS Manager uses the E-tool since 2012 to consolidate the data and to calculate the metrics. Figure 11 presents a view of MHC transportation flows within Europe and the tools that are used for environmental measurement of transportation.

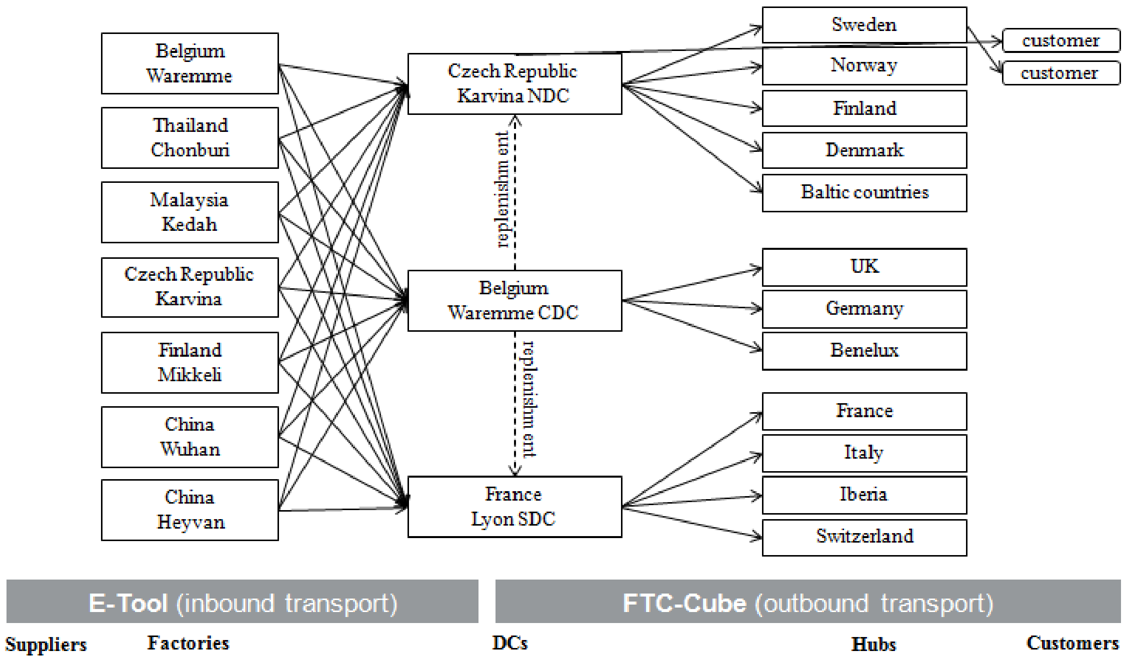


Figure 11 MHC transportation flows and environmental performance tools

MÖLNLYCKE HEALTH CARE 360
ENVIRONMENT 55

EMISSIONS

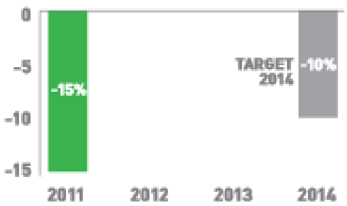
We are firmly committed to reducing greenhouse gas emissions. In order to do so, local targets for reducing greenhouse gas emissions from transports have been established. We are actively working to reduce air freight and increasing the fill rate of trucks by optimizing routes and deliveries to our customers.

When it comes to greenhouse gases, we measure the amount of carbon dioxide emitted from the transport of raw materials to the factories, the transport of goods between factories, and the transport of finished goods from the factories to the warehouses. This is done in collaboration with the freight companies used for such transport.

TARGET 2011-2014

- The emissions of carbon dioxide from transports in relation to the produced weight of finished goods shall be reduced by 10%.
- There were no air freights at all from Waremme during 2011 which meant a reduction in carbon dioxide emissions by 75%.
- The Karvina factory in the Czech Republic has reduced emissions by 22%.

CARBON DIOXIDE REDUCTION



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GRI INDEX

GRI INDEX

ENVIRONMENTAL (P54-55)

EN1 Materials used by weight or volume.

EN4 Indirect energy consumption by primary source.

EN5 Energy saved due to conservation and efficiency improvements.

EN7 Initiatives to reduce indirect energy consumption and reductions achieved.

EN8 Total water withdrawal by source.

EN16 Total direct and indirect greenhouse gas emissions by weight.

EN17 Other relevant indirect greenhouse gas emissions by weight.

EN18 Initiatives to reduce greenhouse gas emissions and reductions achieved.

EN20 NOX, SOX, and other significant air emissions by type and weight.

EN21 Total water discharge by quality and destination.

EN22 Total weight of waste by type and disposal method.

EN26 Initiatives to mitigate environmental impacts of products and services, and extent of impact mitigation.

Figure 12 Extract from MHC Sustainability Magazine (Mölnlycke Health Care 2012)

4.1.3 ENVIRONMENTAL PERFORMANCE MEASUREMENT

As stated earlier, MHC currently uses the E-Tool and the FTC-Cube to measure emissions from transport. These tools are explained in this section.

4.1.3.1 E-TOOL –INBOUND TRANSPORTATION

The Excel file contains seventeen categories including transport of raw materials, transport of finished and semi-finished goods, and emissions to air and water. For the transport of finished and semi-finished goods, users should choose among eight transport methods which are air (long haul and short haul), sea (small bulk carrier and large bulk carrier), rail, road (petrol, diesel, and LPG). Users should choose long haul for Asia, Australia, the Americas, Middle and Far East; short haul for an average of 500 km. They shoud select small bulk carrier for transports between countries in Europe and large bulk carrierfor intercontinental transports. Formulas to be used to calculate emissions from road and sea transport are depicted inFigure 13 and Figure 14.

Table 2: Freight Road Mileage Conversion Factors

Type of lorry	Total km travelled	x	Litres fuel per km	x	Fuel conversion factor		Total kg CO_2
Articulated		x	0.35	x	Petrol	0.63	
				x	Diesel	0.73	
				x	LPG (Natural gas)	0.45	

Source: Continuing Survey of Road Goods Transport 1997.

Figure 13 E-Tool Formulas for emissions from road transport

Table 3: Other Freight Mileage Conversion Factors

Freight transport mode		Tonne km	x	Factor	Total kg CO_2
Shipping[2]	small bulk carrier		x	0.014	
	large bulk carrier		x	0.007	

Source: Lloyds Register Marine Research Programme 1990.

Small ro-ro - 1,268 deadweight tonnes, max speed 16.2 knots
Large ro-ro - 4,478 deadweight tonnes, max speed 23.2 knots
Small tanker - 844 deadweight tonnes, max speed 8.2 knots
Large Tanker - 18,371deadweight tonnes, max speed 15 knots
Small Bulk carrier - 1,720 deadweight tonnes, max speed 10.9 knots
Large Bulk carrier - 14,201 deadweight tonnes, max speed 11.2 knots

Figure 14 E-Tool Formulas for emissions from sea transport

4.1.3.2 FTC-CUBE –OUTBOUND TRANSPORTATION

The FTC-Cube has been established in order to populate MHC databases with operational order information from DSV. Five FTC reports are produced including the Nordics (Norway, Sweden, Denmark, Finland, Estonia, Lithuania, and Latvia), Germany, France, the UK, and Benelux (Belgium, Luxemburg, and the Netherlands). Among others, the FTC metrics report provides information about CO_2 emissions including Hub emission coefficient g/km, Hub distance, Hub CO_2 footprint kg, Distribution emission coefficient g/km, Distribution distance, and Distribution CO_2 footprint kg (Table 2). Every 15th of the month, DSV uploads data on the server which is downloaded by MHC and uploaded to COGNOS. As previously explained reports are then forwarded to MHC EHS Manager. Figure 15, Figure 16, and Figure 17 show printscreens of reportsobtained in COGNOS.

Hub emission coefficient g/km	830,1 g/km
Hub distance km	Per hub, a fixed distance (in km) is given (from DC in bird's eye view)
Hub CO_2 footprint kg	Hub distance * hub emission coefficient/1000 gives the total CO_2 emissions (kg) for this entire truck, for its hub transport. But further breakdown is needed: the FTC file is on shipment level. Many shipments make a full truck. A relative share, shipment weight to truck entire weight, must be multiplied with Hub CO_2 footprint kg, to give shipment its CO_2 in kg.
Distribution emission coefficient g/km	830,1 g/km
Distribution distance km	Each zip code in each EU country is X, Y plotted (longitude, latitude). Distribution distance is distance (in bird's eye view) between centre of zip code from hub city to centre of zip code from deliver city (to customers)
Distribution CO_2 footprint kg	It is assumed that complete truck is filled with MHC cargo. Per destination country, number of trucks and total weight are counted which gives countries average truck weight. Same calculation as for Hub CO_2 Footprint kg. Only replace value truck entire weight with countries average truck weight.

Table 2 FTC-Cube Formulas for emissions from road transport

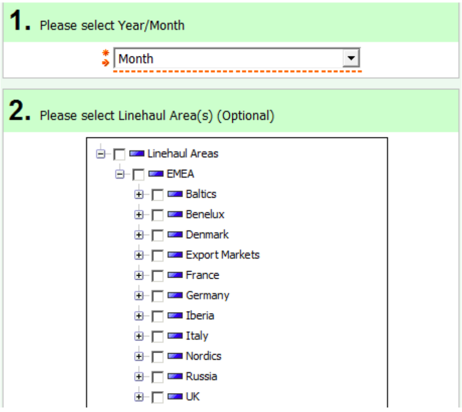
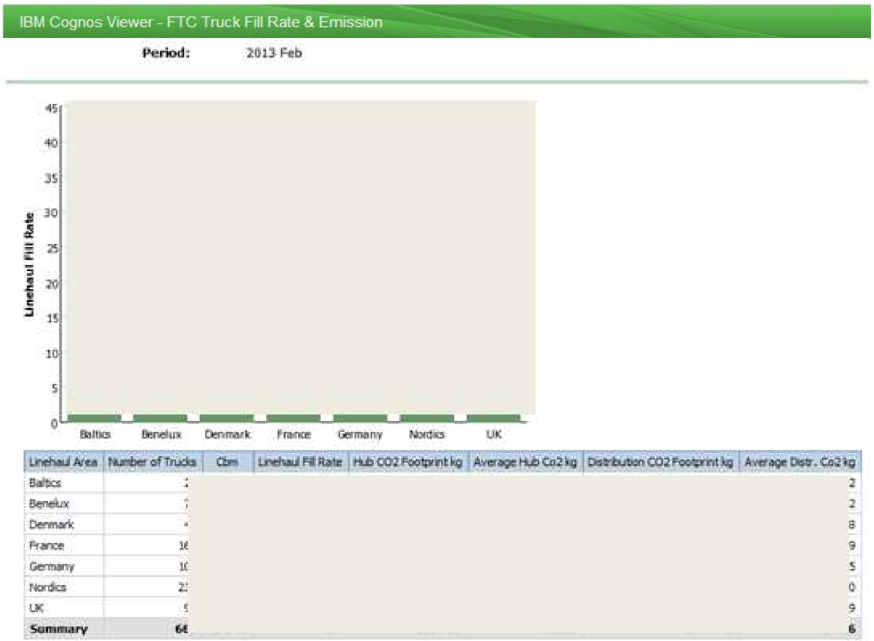


Figure 15 FTC-Cube Linehaul areas



Linehaul Area	Number of Trucks	Cbm	Linehaul Fill Rate	Hub CO2 Footprint kg	Average Hub Co2 kg	Distribution CO2 Footprint kg	Average Distr. Co2 kg
Baltics	[illegible]						2
Benelux	7						2
Denmark	4						8
France	[illegible]						9
Germany	[illegible]						5
Nordics	[illegible]						0
UK	[illegible]						9
Summary	[illegible]						6

Figure 16 FTC-Cube Truck fill rate and emissions for each linehaul area

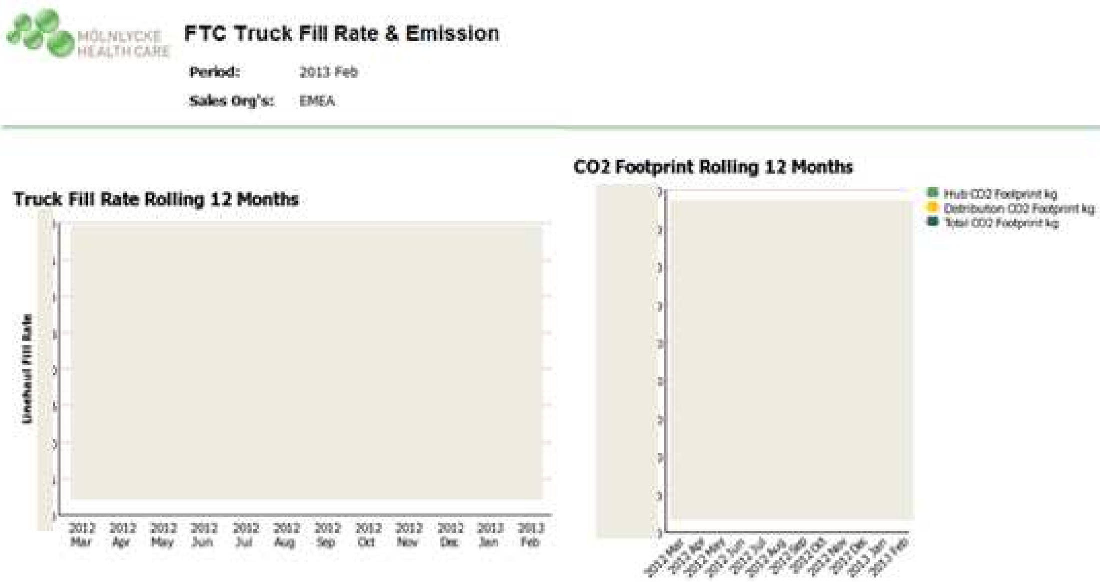


Figure 17 FTC-Cube Truck fill rate and emissions rolling 12 months

4.2 TRANSPORT SERVICE PROVIDERS

MHC mainly operates with three main transport providers: DSV, SGL, and DHL.

4.2.1 DSV–ENVIRONMENTAL POLICY

DSV is a global supplier of transport and logistics solutions and is divided into DSV Road, DSV Air & Sea, and DSV Solutions. They have offices in more than 70 countries all over the world and an international network of partners and agents. In 2012, 75% of DSV trucks and trucks of their subcontractors were classified as Euro standard 4, 5 or 6(see previous Table 2). DSV is a member of Green Freight Europe, a working group brings together more than 100 companies including shippers, carriers, and retailers that populate a common database with operational data necessary to calculate, validate and benchmark the environmental performance of their transport operation; and Clean Shipping Index, a user friendly and comprehensive tool used by international cargo owners to evaluate the environmental performance of their providers of sea transport. In addition DSV ECO is a pilot project to reduce fuel consumption currently being tested in selected markets. Better planning aims at obtaining maximum utilisation of the trucks and minimum fuel consumption per ton of cargo driven leading to reduced CO_2 emissions and freight costs. Interviewees classify DSV as good citizen. Main drivers of DSV corporate strategy are cost and lead time and do not include environmental issues though on a communication level. Much more attention has been given to environmental issues before the 2008-2009 crisis than today, especially at a high level (for instance ISO 14001 and environmental policy).

4.2.2 SGL–ENVIRONMENTAL POLICY

SGL is a global logistics organisation with employees and partners all over the world. Their global transportation network has offices in more than 187 countries. SGL is a member of the Network for Transport and Environment (NTM). The NTM working group for freight transport and logistics is a Swedish non-profit organisation that helps companies and their customers to evaluate the environmental performance of their transport activities. The group provides methods to perform calculations, and relevant default data to use if not situation-specific data is available. SGL is a member of Clean Shipping Index. SGL has internal reporting and control for electricity consumption, combustible waste, consumption of copy paper, cardboard waste, and heat consumption, focusing on Denmark. The company does not report environmental performance of transportation. Environmental reporting is tailored to customers' needs. For instance they calculated emissions for one shoe level for ECCO, a Danish shoes manufacturer. In addition, they set specific requirements for Euro classes for their trucks and trucks of their subcontractors. They conduct audits of their largest carriers.

Interviewees classify SGL as good citizen. Main drivers of SGL corporate strategy are cost and lead time and do not include environmental issues though on a communication level. More and more customers want to include environmental issues in contracts with transport providers. Nevertheless they are not willing to pay more for taking care of the environment.

4.2.3 DHL–ENVIRONMENTAL POLICY

DHL is a logistics company present in over 220 countries with 283,000 employees which provides solutions for logistics needs. DHL is part of Deutsche Post DHL and encompasses three divisions: DHL Express, DHL Global Forwarding, Freight and DHL Supply Chain. DHL corporate environmental strategy GoGreen aims at reducing CO_2 emissions by 30% between 2007 and 2020. It is composed of five pillars which include transparency through measurement and reporting, efficiency through focus on quick wins and pilot projects, mobilisation of employees, generation of some value through carbon reports, carbon off-setting and people training, and demonstration of leadership through knowledge sharing and carriers' training. DHL set specific requirements for trucks of their subcontractors (not older than 8 years and Euro 3, 4 or 5). They conduct audits of the largest carriers once a year. DHL is also an active member of Green Freight Europe and Clean Shipping Index. Today DHL faces lack of precise data for emissions from transportation which accounts for 82% of their total CO_2 emissions. They believe that the Green Freight project will help them to improve data collection from carriers (mainly transported tons, used fuel, and driven distance) and calculations of CO_2 emissions within two years. Their plan is to implement actions such as drivers training, speed limit, and telematics to reduce both CO_2 emissions and freight costs. *Do* Interviewees classify DHL as movers and shakers. Main drivers of DHL corporate strategy are cost and lead time and do not include environmental issues. Demand for sustainable transport is increasing though it is important to mention that customers require CO_2 reporting or off-setting and are not really interested in concrete solutions to reduce their emissions. Perceived added costs are the main barrier for implementation of such actions.

4.3 SUMMARY

The author has spotted two issues: 1) MHC does not control the data received from factories and transport providers, and 2) There are no clear assumptions for the value of the CO_2 factor, both for the E-Tool and the FTC-Cube. SGL has extensive knowledge of NTM Sea method. DSV already reports CO_2emissions through the FTC-Cube. DHL is working on improving accuracy received from carriers, and has implemented the GoGreen strategy. Transport providers reported that their customers ask for CO_2 reporting but not for real solutions to reduce their environmental impact. They are not ready to pay extra costs.

5. FUTURE STATE: ELEMENTS OF IMPROVED ENVIRONMENTAL PERFORMANCE MANAGEMENT

This section contains elements for an improved environmental performance management, which are developed through data collection from MHC and its transport providers, and from NGOs reports.

5.1 MHC REQUIREMENTS

As previously stated, MHC needs a "reliable method to measure and report environmental performance of their transportation". They mainly aim at tracing the whole environmental impact of a product.

5.1.1 METRICS

MHC requires metrics to be associated with: 1) an object, 2) a source, and 3) a procedure, and recommends the use of the GRI Index (see Figure 12) since it is already a basis for MHC Sustainability Magazine.

5.1.2 CALCULATIONS

MHC needs the current FTC-Cube and E-tool to be challenged. They need reliable assumptions and formulas to calculate emissions. They emphasize the fact that a standardised procedure for both inbound and outbound transportation should be suggested. They emphasise that they need guidance for the CO_2 emissions factor and that the author should definitely not calculate CO_2 emissions of the whole transportation network. MHC recommends the use of the NTM methodology preferably since parts of it have been used when designing the E-Tool. In addition, SGL Assistant Director Sea freight for Global Procurement is very familiar with the NTM method for sea transport. SGL is an active member of NTM workshops. Furthermore, DSV, SGL, and DHL take part in the Clean Shipping Index hence accuracy of the data communicated to MHC for sea transport will be improved in the future.

5.1.3 REPORTING

MHC emphasizes the fact that priority should be given to designing a dashboard to measure quantitatively emissions in order to allow further study of environmental improvements. They express strategic objectives as: 1) short-term actions, as creating a model of the dashboard, and 2) long-term actions, as including environmental requirements into tenders and aligning suppliers, conducting research about possible improvements, implementing solutions, and communicating about environmental performance with customers. He divides those objectives into market level, including measuring, monitoring, and reporting, and brand level, including communicating progress.

5.2 EXPERTS RECOMMANDATIONS

5.2.1 ENVIRONMENTAL PERFORMANCE OF LOGISTICS

Logistics performance is assessed through logistics cost, delivery service, and tied-up capital (Björklund and Forslund 2013). Environmental performance is increasingly being added to these variables (Björklund and Forslund 2013). According to Hervani et al. (2005), firms have to measure, monitor, and report their environmental practices for several purposes; internal analysis, to track progress; internal control, to be audited by external agencies; and external reporting, to serve as benchmark. Shaw et al. (2010) argue that benchmark is becoming one of the major elements in environmental management of organisations mainly due to the increasing pressure from governments, customers, competitors. Benefits from benchmark include best practices to be incorporated, stimulation and motivation, and a force for change (Shaw et al. 2010). The main challenge is to develop an appropriate measurement system that companies can disclose and share in a benchmark process (Shaw et al. 2010). Control and sharing of information is critical since disclosure issues can affect image and international regulatory agreements (Sarkis *et al.* 2011).

Purpose of the EPMS is often an issue while implementing performance measurement systems. It differentiates successful businesses which aim at managing the system better, from unsuccessful businesses which goal is to improve the measures. It is commonly argued that the overall goal of the system should influence the design of environmental performance measurement systems (Hervani et al. 2005; Björklund and Forslund 2013). Björklund et al. (2012) argue that a concrete definition of the purpose of the measurement systems should be provided in order to avoid the “too broad” measuring environmental logistics.

Shaw et al. (2010) stress the importance of identifying the key stakeholders concerned by the measurement system at the very beginning of the project. Organisations with different goals and objectives would argue for metrics (Hervani et al. 2005). Report should credibly address issues of concern stakeholders (GRI 2006). Furthermore, boundaries of report (countries/regions, products/services, *etc.*) and specific limitations on the scope should match the strategy and projected timeline in order to provide complete coverage (GRI 2006).

Hervani et al. (2005) suggest a list of questions top management should address before starting the design of the EPMS:

- What are the goals of the MS?
- How does the MS fit within the strategy of the logistics department?
- How should stakeholders concerns and preferences be integrated?
- What metrics levels and decomposition should be included?
- Who should design the metrics?
- How should monitor the metrics?
- How should information generated by the MS be used and disseminated?
- How should information from the MS be linked up to internal and external performance measurement systems, environmental management systems, and information systems?
- What are the relationships between MS metrics and customer satisfaction?

Difficulties arise when determining which indicator to use, when to measure it, and how to measure it (Hervani et al. 2005). Managers and suppliers have to collect and manage a large set of information and can face overload of measures and metrics (Bai *et al.* 2012) which are often not aligned with the company strategy (Shaw et al. 2010). It leads to confusion and “paralysis by analysis”. Therefore a trade-off between technically sophisticated indicators and indicators that can be reasonably implemented by the company at that time is required (Hassini et al. 2012). A “balance between sufficient coverage and sufficient focus” (Andersen and Fagerhaug 2004) makes the process easier and less costly (Shaw et al. 2010). Hervani et al. (2005) state a number of concerns in applying EPMS: information systems not designed to integrate such metrics, difficulty in deciding where to begin, and difficulty in linking measures to customer value. It is commonly agreed that CO_2 emissions are one of the most common metrics used by companies that wish to incorporate environmental performance in transport contracts. Others frequent environmental metrics include loading factor and consolidation, technology used (information systems and computer models), age of vehicles, engines, air emissions, and energy use (Björklund and Forslund 2013). Selection of suppliers is a key issue when implementing environmental logistics systems (Xu et al. 2013). One issue is that companies do not necessarily consider measurement of environmental performance and management of non-compliance (Björklund and Forslund 2013). The length of collaboration and contracting between partners also affects short-term and long-term management issues (Sarkis 2012). Trust in data sharing, acquisition, and monitoring needs to be built (Hervani et al. 2005). Greater interaction can help reducing asymmetry (Sarkis et al. 2011).

Lastly, documenting is necessary for internal and external purposes. Indeed, driving continuous improvement and reporting to regulatory agencies cannot be done without clear documentation of environmental metrics. (Hervani et al. 2005)

5.2.2 METRICS

The GRI developed the GRI Logistics and Transportation (L&T) Pilot Sector Supplement in 2006. Metrics suggested for road and sea transport are displayed in Figure 19 and Figure 20.

ROAD TRANSPORT

A. Vehicle type	B. Total number of fleets	C. Age of fleet (specify)	D. Engine			E. Retrofit	F. Average fuel consumption
			National regulation (specify)	Supra-national regulation (specify)	Other (e.g., hybrid, electric) (specify)	(specify)	(specify)
Truck/ tractor							
Vans							

A. Vehicle type	G. Total distance driven	H. Total fuel consumption						
		Diesel	Gasoline	LPG	CNG	Bio fuel	Hydrogen	Other (Specify)

Item	Explanation	Purpose
A. Vehicle type	Vehicle fleet type broken down by empty load weight. Reporting organisations are expected to use national or supra-national standards for the breakdown. Reporting organisations may further breakdown type of vehicle into subcategories. For example, vehicles above 7.5 tonnes are categorised as trucks/tractors and below 7.5 tonnes as vans under the EU regulation.	Indicates the extent and scale of impacts.
B. Total number of fleets	Total number of owned, hired, or leased fleets broken down by type.	Indicates the extent and scale of impacts.
C. Age of fleet (specify)	Reporting organisations need to specify how to report on age (e.g., number of trucks that are older than 5 years at the time of reporting or average age of fleets per type).	Indicates the extent and scale of impacts. It is assumed that new fleets would have better environmental performance.
D. Engine	Number of fleets per type of engine. For example, Euro 4 and EPA 2004 are emission standards in EU countries and the United States.	Indicates adoption of new technology for reducing greenhouse gas emissions and air pollution.
E. Retrofit	Number of fleets with retrofits such as soot filters and catalysts.	Provides information on pollution abatement measures implemented on existing fleets that do not meet the latest emsssion standards.
F. Average fuel consumption	Average fuel consumption per type of vehicle. Report in joules per unit. Units may be km, tkm, etc.	Provides information on fuel efficiency.
G. Total distance driven	Total distance driven per type of vehicle per year. Report in kilometres.	Indicates the extent and scale of impacts.
H. Total fuel consumption	Total consumption of fuel per type of vehicle per year. Report in joules.	Indicates the extent and scale of impacts. It is assumed that the reduction in the total amount of fuel consumption would lead to a reduction on greenhouse gas emissions (i.e., decreasing the impact on climate change) and other emissions related to urban pollution.

Figure 18 Extract from the GRI Index for L&T – Road transport (GRI 2006)

SEA TRANSPORT

A. Vessel type	B. Total number	C. Conditions	D. Pollution prevention	E. Fuel	F. Average fuel consumption
		Detention during past year	(specify)	Average sulphur contents	

Item	Explanation	Purpose
A. Vessel type	Breakdown of fleet based on type of vessel category (e.g., container ships, general cargo ship, oil/ chemical/ LPG/CNG tankers). Reporting organisations may further breakdown type of vessels by dead weight of vessels (reporting organisations need to specify the weight category).	Indicates the extent and scale of impacts.
B. Total number	Total number of controlled vessels per type.	Indicates the extent and scale of impacts. Note linkage to LT1.
C. Conditions	Number of vessels detained by port authorities during the reporting period.	Provides information on the maintenance condition of the vessel with respect to international maritime standards. Note linkage to LT13.
D. Pollution prevention	Number of vessels with pollution prevention measures, such as a double hull. Measures to be specified by reporting organisations.	Provides information on technical measures in place on existing fleets to prevent pollution.
E. Fuel	Average sulphur contents of fuel used per type of vessel.	Relevant for calculating information on air emissions contributing to the regional acidification. Note linkage to EN10.
F. Average fuel consumption	Average fuel consumption per type of vessel. Report in joules per unit. Units may be sea miles, ton/miles, etc.	Provides information on fuel efficiency.

Figure 19 Extract from the GRI Index for L&T – Sea transport (GRI 2006)

5.2.3 CALCULATIONS

Emissions from road transport include Carbon dioxide CO_2 (greenhouse gas GHG), Methane CH_4 (GHG), Nitrous Oxide N_2O (GHG), Carbon monoxide CO, hydrocarbons HC, Nitrogen oxides NO_X, and Particle matters PM (EC 2008; Blinge 2012). Although catalytic converters are effective at removing hydrocarbons and other harmful emissions, CO_2 emissions cannot be cleaned with catalysts (Blinge 2012). Table 3 shows EU legislation for emissions of CO, HC, NO_X, and PM. There was no EU law which limited the amount of CO_2 emissions produced by cars until 2007 when the European Parliament set an emissions cap of 130 g/km by 2015 and 95g/km by 2020 (EC 2012). In addition, the EC is currently working on a strategy to reduce CO_2 emissions from HDVs (heavy-duty vehicles including trucks and buses) in both freight and passenger transport (EC 2012).

Euro class	In force from	CO [g/kWh]	HC [g/kWh]	NOx [g/kWh]	PM [g/kWh]	Smoke [g/kWh]
1	1992, < 85 kW	4.5	1.1	8.0	0.612	
	1992, > 85 kW	4.5	1.1	8.0	0.36	
2	1996.10	4.0	1.1	7.0	0.25	
	1998.10	4.0	1.1	7.0	0.15	
3	1999.10, EEVs only	1.5	0.25	2.0	0.02	0.15
	2000.10	2.1	0.66	5.0	0.10 0.13[a]	0.8
4	2005.10	1.5	0.46	3.5	0.02	0.5
5	2008.10	1.5	0.46	2.0	0.02	0.5
6*	2013.04[b]	1.5	0.13	0.4	0.01	

* Proposal (2007.12.21)

a - for engines of less than 0.75 dm^3 swept volume per cylinder and a rated power speed > 3000 min^{-1}

b - 2014.10 for all models

Table 3 Euro classes (NTM 2008)

Two methods can be used to calculate CO_2 emissions:1) the activity-based approach, presented in Figure 21 and 2) the energy-based approach, presented in Figure 22 (McKinnon and CEFIC ECTA 2011). McKinnon and CEFIC ECTA (2011) argue that the energy-based calculation method is the most accurate way for transport companies to calculate their transport emissions. Nevertheless, since many organizations outsource their freight transport operations, they do not have direct access to energy or fuel consumption data. In that case, they can estimate CO_2 emissions by using the activity-based approach. (McKinnon and CEFIC ECTA 2011) In addition, McKinnon and Piecyk (2011) stress the fact that average CO_2 emissions are very sensitive to vehicle loading and empty running. There is much debate about the value of the average CO_2 emissions factor per ton-km for road transport. McKinnon recommends 0,062 kg CO_2/ton-km for all types of road vehicles (McKinnon and CEFIC ECTA 2011), the NTM group 0,04 kg CO_2/ton-km for a semi-trailer (NTM 2008), and Maersk 0,05 kg CO_2/ton-km for a heavy truck (Maersk 2012).Various values of the average CO_2 emissions factor per ton-km for sea transport can also be found. McKinnon recommends 0,008 kg CO_2/ton-km for a deep-sea container (McKinnon and CEFIC ECTA 2011), the NTM group 0,004 kg CO_2/ton-km for a container ship (NTM 2008), and Maersk 0,00748 kg CO_2/ton-km for container vessel of 11000 TEU (twenty-foot equivalent unit) and 0,00836 kg CO_2/ton-km for container vessel of 6600 TEU (Maersk 2012).

CO_2 emissions = Transport volume by transport mode x average transport distance by transport mode x average CO_2-emission factor per tonne-km by transport mode

[Tonnes CO_2 emissions = tonnes x km x g CO_2 per tonne-km / 1.000.000]

Figure 20 Activity-based formula (McKinnon and CEFIC ECTA 2011)

CO_2 emissions = fuel consumption x fuel emission conversion factor

[Tonnes CO -emissions = liters x kg CO_2 per liter fuel / 1.000]

Figure 21 Energy-based formula (McKinnon and CEFIC ECTA 2011)

Figure 23 and Figure 24 gives an adapted view of the methods to calculate emissions from road and sea transportation suggested by the NTM. McKinnon and CEFIC ECTA (2011) argue that the NTM has gained a solid reputation and is a reliable source of transport emissions values since in most cases the values have been obtained from transport operators.

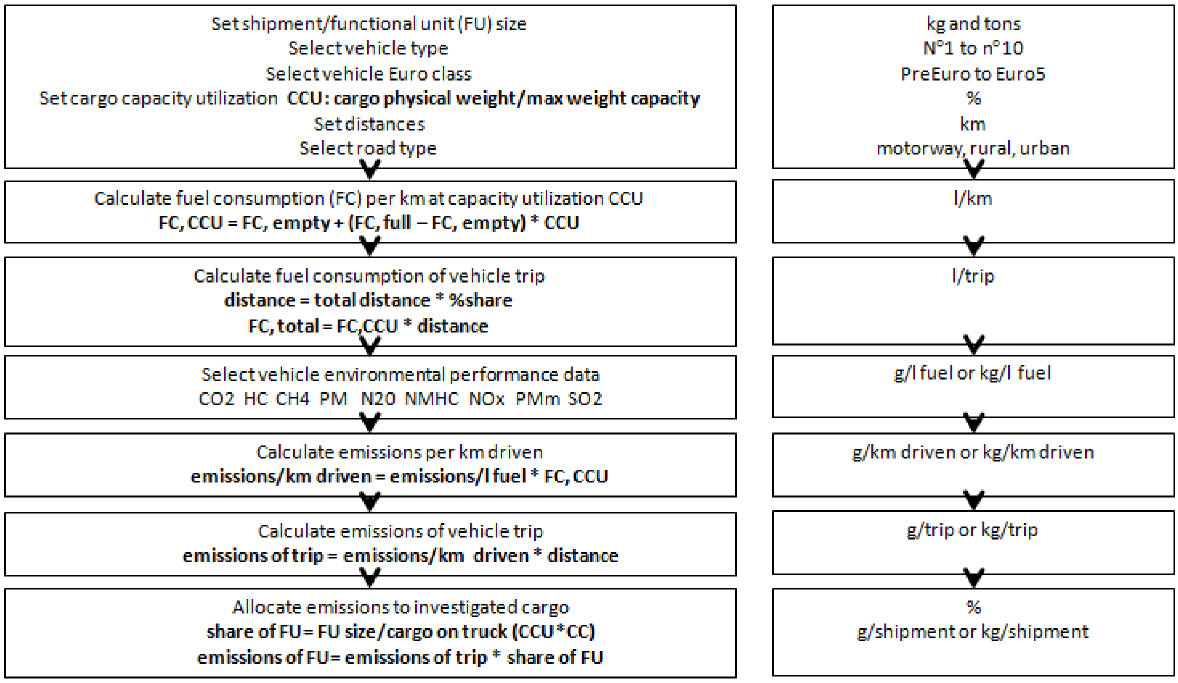


Figure 22 NTM calculation method for road transportation (NTM 2008)

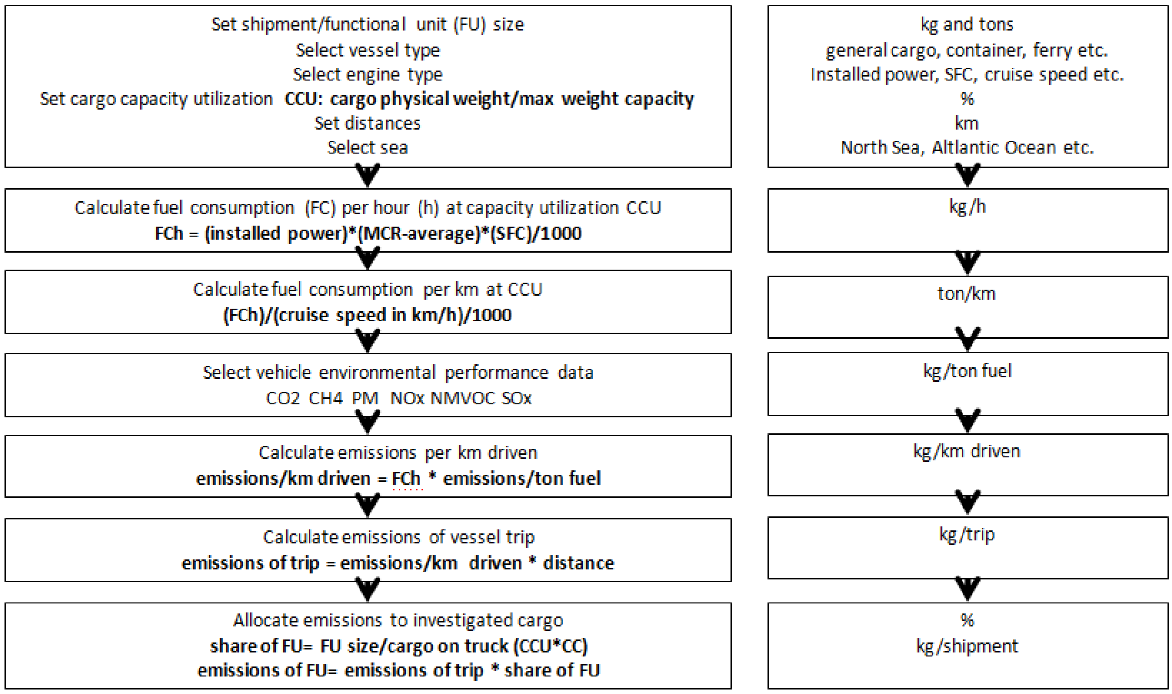


Figure 23 NTM calculation method for sea transportation (NTM 2008)

5.2.4 REPORTING

The GRI provides guidance for common issues related to the design and presentation of reports (GRI 2006), following are presented some of these guidelines.

“Metrics: reported data should be presented using generally accepted international metrics (e.g. kilograms, tones, litres), calculated using standard conversion factors. When other metrics are used, reports should provide conversion information to enable international users to make conversion.”

“Absolute/normalized data: as a general principle, reporting organizations should present indicator data in absolute terms and use ratios or normalized data as complementary information. Providing only normalized data may mask absolute figures, which is the information of primary interest to some stakeholders. However, if absolute data are provided, users will be able to compile their own normalized data analysis […] Ratio data may be useful in conjunction with absolute data for communicating performance trends or articulating performance across two or more linked dimensions of sustainability.”

“Data consolidation and disaggregation: reporting organizations will need to determine the appropriate level of consolidation (aggregation) of indicator data. For example, indicators could be presented in terms of the performance of the organization worldwide or broken down by subsidiaries, countries of operations, or even individual facilities. […] Consolidation of information can result in loss of a significant amount of value to users, and also risks masking particularly strong or poor performance in specific areas of operation. In general, reporting organizations should disaggregate information to an appropriate and useful level as determined through consultation with stakeholders. The appropriate level of consolidation/disaggregation may vary by indicator.”

“Graphics: the use of graphics can enhance the quality of the report. However, care should be taken to ensure that graphics do not inadvertently lead readers to incorrect interpretations of data and results. Care is needed in selection of axes, scales, and data (including conversion of raw data to ratios and indices for graphic purposes), and the use of colours and different types of graphs and charts. Graphics should be a supplement to – not a substitute for – text and narrative disclosure of information. […]”

“Executive summary: GRI encourage the inclusion of an executive summary. […]”

5.3 SUMMARY

There is no standard for vehicle categorisation and for the value of the CO_2 emission factor though some NGOs provide organisations with guidelines.

6. COMPARISON: CASE STUDY

This section presents a case study comparing MHC current calculations methods with the NTM method.

6.1 CASE DEFINITION

The studied system encompasses transportation activities from a factory in Thailand to the DC in Belgium to a hub and a customer in Germany (Figure 25). Assumptions for CCU have been made from MHC interviews and NTM data. The chosen product, wound dressings, is packed in small boxes of 30 (9*5*10 cm) and the weight of one box is 400 g. These small boxes are then packed into large boxes (40*80*25 cm, 50 kg) consisting of 128 small boxes. This large box is the functional unit for the study. Fifteen large boxes (768 kg) can be loaded onto an EU pallet which presents the following features: width and length 800*1200 mm, empty weight 25kg, and maximum height 1,8m, leading to a total weight of 790 kg. Attention is given to CO_2 emissions. No consideration is given to the environmental impact caused by the transport of raw materials to the factory in Thailand. Different impacts on environment caused by manufacturing processes within the factory are not investigated. Additionally, no consideration is taken to the impacts of packaging activities, inside terminal transportation, road construction, vehicle manufacturing, and fuel production. CO_2 emissions have been calculated for the whole trip and allocation has been made to the functional unit.

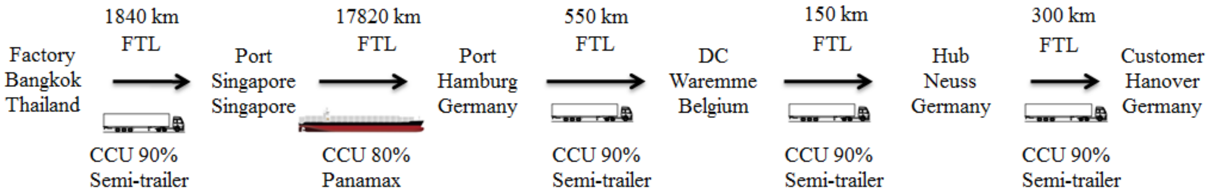


Figure 24 Transport chain for fictive case

6.2 RESULTS: CO_2 EMISSIONS

The three methods previously presented, NTM, E-Tool, and FTC-Cube, have been adapted in order to compare them through a fictive case. Results are presented in Table 4 and Table 5.

City From	City To	kg CO_2 obtained with NTM	kg CO_2 obtained with E-Tool & FTC-Cube	Ratio results obtained with NTM and E-Tool & FTC-Cube
F Bangkok	P Singapore	3,60	1,02	**0,28**
P Singapore	P Hamburg	1,95	7,45	**3,82**
P Hamburg	DC Waremme	1,08	0,98	**0,91**
DC Waremme	H Neuss	0,29	0,27	**0,91**
H Neuss	C Hanover	0,59	0,53	**0,91**

Table 4 Case study results

Factory – Port: The method used is the same for the NTM and the E-Tool. The CO_2 emissions factor in kg CO_2/km is obtained by multiplying the fuel consumption in litre fuel/km and the fuel CO_2 emissions conversion factor in kg CO_2/litre fuel. The CO_2 emissions factor is multiplied by the distance to obtain the CO_2 emissions for the whole trip. The NTM suggests a formula to determine the fuel consumption which is FC, CC = FC, empty + (FC, full - FC-empty)*CCU. Given the parameter CCU (assumed to be 90%) and the vehicle type (assumed to be a semi-trailer), tables are provided by the NTM to select average fuel consumption. No assumptions are disclosed in the E-Tool documentation concerning values of fuel consumption and fuel CO_2 emissions conversion factor. The unit for the latter has been deduced by the author by studying the units in the formula. This has to be further discussed with MHC EHS Manager. There is large difference between total CO_2 emissions obtained with the NTM method and with the E-Tool. It can be explained by the fuel CO_2 emissions conversion factor which value is 2,62kg CO_2/litre fuel for the NTM and 0,73 kg CO_2/litre fuel for the E-Tool. When checking sources for raw data used in the E-Tool, it seems that the unit for 0,73kg CO_2/litre should rather be fuel kg CO_2/km. This has to be further discussed with MHC EHS Manager.

Port – Port: The NTM method calculates the CO_2 emissions factor in kg CO_2/km by multiplying fuel CO_2 emissions conversion factor with fuel consumption. When multiplied by the distance, it gives kg CO_2 emissions for the whole trip. The E-Tool multiplies the volume transported in tons by the average distance to obtain the total goods transported in ton-km. When multiplied by the CO_2 emissions factor, it gives kg CO_2 emissions for the whole trip. No assumptions are disclosed in the E-Tool documentation concerning the value of the CO_2 emissions factor. One issue is that this factor is set for small and large bulk carrier, though according to MHC EMEA Logistics Director, the vessels used are container ships. On top of that, they are used for MHC semi-finished and finished goods and not bulk goods. This has to be further discussed with MHC EHS Manager. There is large difference between CO_2 emissions obtained with the NTM method and with the E-Tool. It can be explained by the CO_2 emissions per ton-km factor which value is 0,004 kg CO_2/ton-km for the NTM and 0,008 kg CO_2/ton-km (large bulk carrier) and 0,014 kg CO_2/ton-km (small bulk carrier) for the E-Tool.

Port – DC, DC – Hub, Hub – Customer: The NTM method is the same as previously. The FTC-Cube multiplies the distance in km with the CO_2 emissions factor to obtain kg CO_2 emissions for the whole trip. No assumptions are disclosed in the FTC-Cube documentation concerning the CO_2 emissions factor in kg CO_2/km. Total kg CO_2 emissions obtained by the NTM method and by the FTC-Cube are similar. It can be explained by the CO_2 emissions factor which value is 0,9 kg CO_2/km for the NTM and 0,8 kg CO_2/km for the E-Tool.

ROAD Factory - Port

NTM	volume transported	23	ton	CC*CCU with CC = 26T and CCU = 90%
	distance	1840	km	
	goods transported	43056	ton-km	
	emissions per liter fuel	2,6	kg CO2/l	semi-trailer
	fuel consumption	0,3	l/km	FC, empty (0,226) + (FC, full (0,360) - FC-empty)*CCU
	emissions per km	0,9	kg CO2/km	
	emissions of the trip per truck	**1684**	kg CO2	
	share of the functional unit	0,002	%	weight of functional unit = 50kg = 0,05T
	emissions per functional unit	**3,6**	kg CO2	
	emissions per ton-km	0,04	kg CO2/ton-km	
E-Tool	distance	1840	km	
	fuel consumption	0,4	l/km	
	emissions per liter fuel	0,7	kg CO2/l	
	emissions of the trip	**470**	kg CO2	
	share of the functional unit	0,002	%	
	emissions per functional unit	**1,0**	kg CO2	

SEA Port - Port

NTM	containers on board	3440	TEU	CC*CCU with CC = 4300 TEU and CCU = 80%r
	volume transported	79120	ton	one FTL 23 tons goods in 2 TEU (one 40-feet container)
	distance	17820	km	
	fuel consumption	0,1	ton fuel/km	container ship
	emissions per ton fuel	3179,0	kg CO2/ton fuel	container ship
	emissions per km	346,5	kg CO2/km	
	emissions of the trip per ship	**6174826**	kg CO2	
	emissions per 2 TEU	898	kg CO2	containers on board/emissions of the trip/2
	share of the functional unit	0,002	%	
	emissions per functional unit	**1,95**	kg CO2	
	emissions per ton-km	0,004	kg CO2/ton-km	
E-Tool	tons transported	86000	tons	
	distance	17820	km	
	total tonne-km	1532520000	ton-km	
	emissions per ton-km	0,008	kg CO2/ton-km	large bulk carrier
	emissions of the trip per ship	**12811867**	kg CO2	
	share of the functional unit	0,000001	%	
	emissions per functional unit	**7,4**	kg CO2	
E-Tool	emissions per ton-km	0,014	kg CO2/ton-km	small bulk carrier
	emissions of the trip per ship	**21455280**	kg CO2	
	emissions per functional unit	**12,5**	kg CO2	

ROAD Port -DC

NTM	volume transported	23	ton	CC*CCU with CC = 26T and CCU = 90%
	distance	550	km	
	goods transported	12870	ton-km	
	emissions per liter fuel	2,6	kg CO2/l	semi-trailer
	fuel consumption	0,3	l/km	FC, empty (0,226) + (FC, full (0,360) - FC-empty)*CCU
	emissions per km	0,9	kg CO2/km	
	emissions of the trip per truck	**503**	kg CO2	
	share of the functional unit	0,002	%	weight of functional unit = 50kg = 0,05T
	emissions per functional unit	**1,1**	kg CO2	

	emissions per ton-km	0,039	kg CO2/ton-km	
FTC-Cube	distance	550	km	
	emissions per km	0,8	kg CO2/km	
	emissions of the trip per truck	**457**	kg CO2/km	
	share of the functional unit	0,002	%	
	emissions per functional unit	**1,0**	kg CO2	
	ROAD DC - Hub			
NTM	volume transported	23	ton	CC*CCU with CC = 26T and CCU = 90%
	distance	150	km	
	goods transported	3510	ton-km	
	emissions per liter fuel	2,6	kg CO2/l	semi-trailer
	fuel consumption	0,3	l/km	FC, empty (0,226) + (FC, full (0,360) - FC-empty)*CCU
	emissions per km	0,9	kg CO2/km	
	emissions of the trip per truck	**137**	kg CO2	
	share of the functional unit	0,002	%	weight of functional unit = 50kg = 0,05T
	emissions per functional unit	**0,3**	kg CO2	
	emissions per ton-km	0,039	kg CO2/ton-km	
FCT-Cube	distance	150	km	
	emissions	0,8	kg CO2/km	
	emissions of the trip per truck	**125**	kg CO2/km	
	share of the functional unit	0,002	%	
	emissions per functional unit	**0,3**	kg CO2	
	ROAD Hub - Customer			
NTM	volume transported	23	ton	CC*CCU with CC = 26T and CCU = 90%
	distance	300	km	
	goods transported	7020	ton-km	
	emissions per liter fuel	2,6	kg CO2/l	semi-trailer
	fuel consumption	0,3	l/km	FC, empty (0,226) + (FC, full (0,360) - FC-empty)*CCU
	emissions per km	0,9	kg CO2/km	
	emissions of the trip per truck	**275**	kg CO2	
	share of the functional unit	0,002	%	weight of functional unit = 50kg = 0,05T
	emissions per functional unit	**0,6**	kg CO2	
	emissions per ton-km	0,039	kg CO2/ton-km	
FCT-Cube	distance	300	km	
	emissions	0,8	kg CO2/km	
	emissions of the trip per truck	**249**	kg CO2/km	
	share of the functional unit	0,002	%	
	emissions per functional unit	**0,5**	kg CO2	

Table 5 Case study detailed calculations and results

6.3 SUMMARY

The case study has revealed that: 1) the E-Tool and NTM use the same formulas respectively for road and sea transport, but there is a large difference in the values of the CO_2 emissions factors, and 2) the method and assumptions used by the FTC-Cube and NTM for road transport are similar.

7. RECOMMANDATIONS

This section contains answers to the research questions and combines the theoretical framework with the empirical data in accordance to the abductive research approach described in the methodology section.

7.1 RQ1. METRICS

RQ1. Which metrics should be selected in order to fulfil stakeholders' requirements?

Metrics from the GRI MHC Index, the GRI Index for L&T for road transport and sea transport, the E-Tool and the FTC-Cube are taken into account. Parts of the method suggested by Riff are used to define the metrics. Table 6 presents metrics that have been selected for MHC case. Figure 26 presents aggregation of emissions for the whole chain.

Metric	Explanation	Role (aggregation)
Transport volume	Tons	Inbound Leg F – DC including F – Port, Port – Port, Port – DC Aggregated at the DC level *i.e.* DC CO_2 footprint= $\sum CO_2$ emissions legs F – DC Outbound Leg DC – DC Leg DC – H Aggregated at Hub level *i.e.* Hub CO_2 footprint= $\sum CO_2$ emissions legs DC – DC + $\sum CO_2$ emissions legs DC – H Leg H – D Aggregated at Linehaul areas level *i.e.* Distribution CO_2 footprint= $\sum CO_2$ emissions legs H – D With legs H – D: 11 EMEA linehaul areas
Transport distance	Road km Sea km	
Goods transported	Road Ton-km Sea tons-km	
Vehicle type	Road (NTM) Sea (NTM)	
CO_2 emissions factor	Road kg CO_2/ton-km Sea kg CO_2/ton-km	
CO_2 emissions	Road kg CO_2 Sea kg CO_2	

Metric	Relevance	Specifications Update and Reporting	Specifications Data availability	Specifications Formula	Model
Transport volume	Beneficiaries for information: transport providers (Environmental and Logistics managers). Beneficiaries for action: MHC (Environmental and Logistics managers).	Calculations performed byfactories, transport providers and results sent to MHC via the FTC-Cube. Data uploaded by MHC Analyst on COGNOS. Dashboard populated by COGNOS reports.	Yes	See Calculations	See Dashboard
Transport distance			Yes		
Goods transported			To be calculated		
Vehicle type			To be collected		
CO_2 emissions factor			To be determined		
CO_2 emissions			To be calculated		

Table 6 Metrics for MHC dashboard

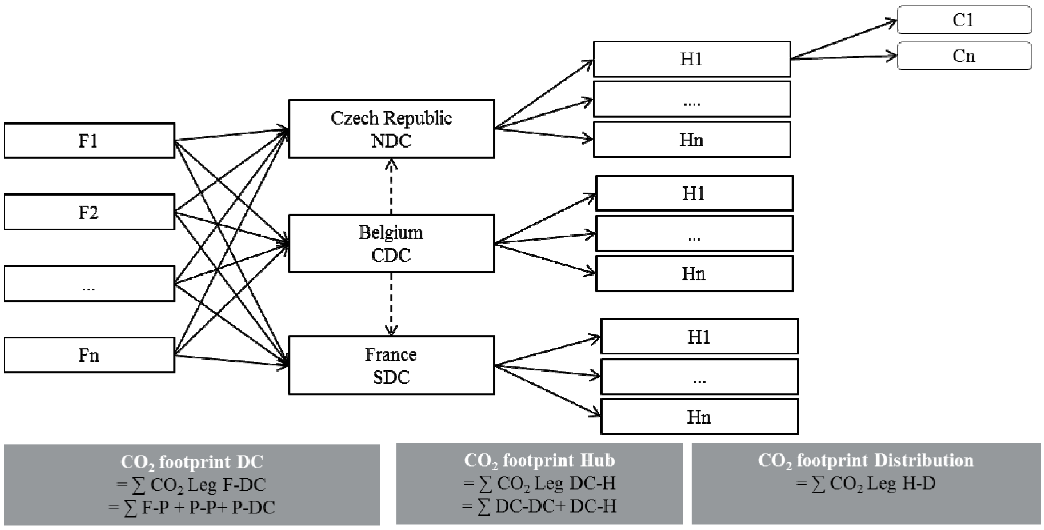


Figure 25 Aggregation for MHC dashboard

7.2 RQ2. CALCULATIONS

RQ2. What procedure should be suggested in order to calculate the metrics?

Results from the case study have been discussed with MHC EMEA Logistics Director. As cited previously in the theoretical background, the energy-based formula is seen as the most accurate way to calculate CO_2 emissions from freight transportation. Nevertheless, DSV already reports elements of environmental performance (distance and volumes) to MHC through the FTC-Cube and they account for the largest part of MHC transportation. Therefore it could make sense to keep using data from this collaborative tool. The activity-based formula could be kept, and assumptions improved (CO_2 emissions factor in kg CO_2/ton-km). Calculations could be automatised and performed by transport providers through the FTC-Cube, particularly for sea transport with SGL. DHL is willing to collect data from their carriers in the coming years (including transported tons, used fuel, and driven distance). SGL is committed to help MHC if this project would be carried out and they are known for being highly agile. Hence they should also be able to obtain data from their carriers. In addition, MHC needs a standardised method which aligns inbound and outbound transportation. It could make sense to transfer the responsibility of calculating emissions from inbound transportation *i.e.* factories to DC's from the E-Tool to the FTC-Cube. Emissions from transportation from raw material suppliers to factories could still be calculated in the E-Tool. MHC EMEA Logistics Director emphasises that he needs guidance for the CO_2 emissions factor. He also highlights that a balance should be achieved between extremely and poorly accurate assumptions. The author suggests the use of assumptions provided by the NTM as a first step. Work sessions with transport providers should then be organised to collect data about truck and ship types, load factors, *etc.* The CO_2 emissions factor in kg CO_2/km is obtained by multiplying the fuel consumption in litre fuel/km and the fuel CO_2 emissions conversion factor in kg CO_2/litre fuel. For road transport, the fuel consumption given by the NTM in litre fuel/km depends on the vehicle type and the load factor (CCU).Assumptions about the vehicle load factor are based on interviews from MHC EMEA Logistics Director and NTM tables: tractor and semi-trailer, and CCU 90% for inbound and for outbound. The result is 0,3litre fuel/km. The fuel CO_2 emissions conversion factor is set as 2,6 kg CO_2/litre fuel for Diesel within Europe by the NTM. For sea transport, NTM provides data for fuel consumption and CO_2 emissions factor depending on the type of vessel. For a container ship, the NTM recommends 0,1 ton fuel/km and 3179 kg CO_2/ton fuel. The CO_2 emissions factor in kg CO_2/ton-km is obtained by dividing the CO_2 emissions factor in kg CO_2/km by the volume transported in tons. General methodology, formulas and assumptions to calculate emissions are suggested by the author in Figure 26.

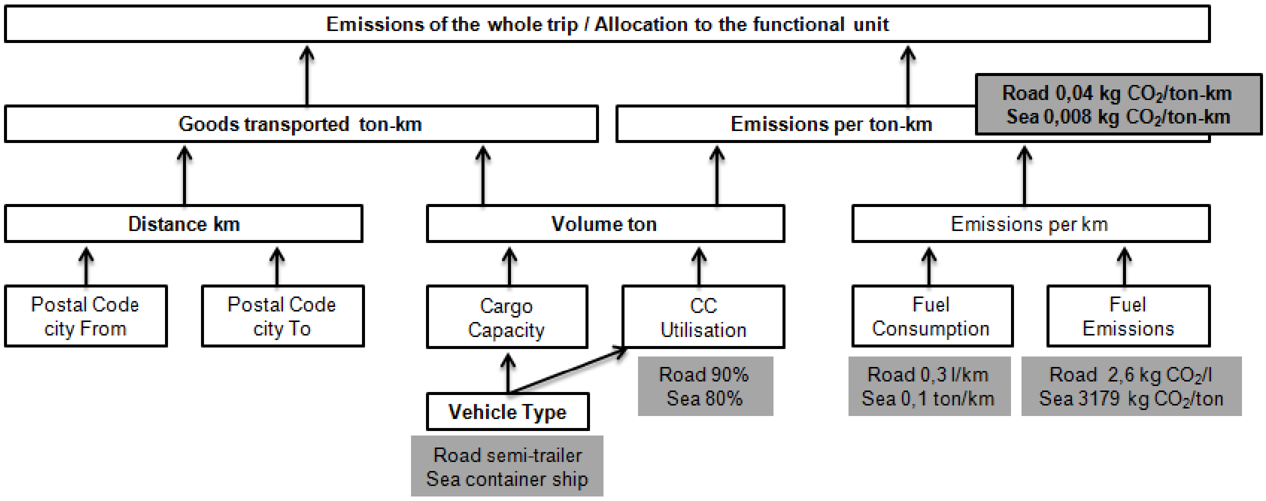


Figure 26 Calculations for MHC dashboard

7.3 RQ3. REPORTING

RQ3. What procedure should be suggested in order to report the metrics?

Table 7 shows an extract of the model of the dashboard. It contains all the supply chain legs of the diagram of MHC main flows presented in section 4.1.2 though not all of them are shown in the figure. Three sections should be completed with raw data and automatic calculations: 1) Inbound transport activities, 2) Outbound transport activities, and 3) Summary. Table 8 shows data for one supply chain leg. YTD stands for Year-To-Date, PCF for Postal Code city From, PCT for Postal Code city To, CC for Cargo Capacity, FC for fuel consumption, and FE for fuel emissions. The user can choose between different combinations of transport mode/vehicle type by scrolling down on the dedicated cell. The CO_2 emissions factor in kg CO_2/ton-km, goods transported in ton-km, and emissions of the whole trip are automatically calculated according to the methodology described in section 7.2.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	Summary																		
2		Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12							
3																			
4																			
5	Inbound																		
6																			
7	FBEL - NDC	PCF	PCT	Mode & Vehicle	CC	CCU	FC	FE	CO2 ton-km	Goods transported ton-km					Emissions of the whole trip kg CO_2				
8										Jan-12	Feb-12	...	YTD	2011	Jan-12	Feb-12	...	YTD	2011
9																			
10																			
11																			
12																			
13																			
14																			
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23																			
24																			
25																			
26	FBEL - CDC																		
27	FBEL - SDC																		
44	FCHI2- CDC																		
45	FCHI2 - SDC																		
46																			
47	Outbound																		
48																			
49	NDC - Cust																		
50	NDC - HSWE																		
51	NDC - HNOR																		
52	NDC- HFIN																		
53	NDC - HDEN																		
54	NDC - HBAL																		
55	CDC - Cust																		
56	CDC - NDC																		

Table 7 Model of MHC dashboard

PCF	PCT	Mode & Vehicle	CC	CCU	FC	FE	CO2 ton-km	Goods transported ton-km					Emissions of the whole trip kg CO2				
								Jan-12	Feb-12	...	YTD	2011	Jan-12	Feb-12	...	YTD	2011

Table 8 Reporting for MHC dashboard

7.4 DISCUSSION

In this section several areas of study related to the design, implementation and management of EPMS are further discussed. It covers involvement of strategic managerial level, influence of stakeholders, requirement of a concrete definition of purpose, and issues related to assumptions and formulas, transparency, and responsibility.

The involvement of strategic managerial level is a key issue for the successful implementation and management of the EPMS (Section 1.1). Yet there is no real interaction between environmental managers and top management. Interviews at MHC transport providers reflected that environmental managers have little or no influence over the board of direction, and that they report figures and graphs during one or two meetings throughout the year. Logistics strategies optimise costs for the short term, without recognition of the long-term consequences for the environment and the society (Section 1.1).External costs from environmental damages are moved away from top management consideration since companies do not have to pay for such costs that are, in addition, not easily calculable. MHC transport providers seem to use the environment to commercialise their actions that primarily aim at reducing costs such as optimised route planning and increased fill rates. Environmentally-friendly actions seem to be drivers to ease consciences rather than key evaluation criteria for long-term solutions which integrate the environmental dimension. Several reasons can explain such behaviour such as first mover disadvantage, continuous financial uncertainties, and lack of visibility and coordination across the supply chain. In addition, success or failure is determined in the marketplace. As stated by the interviewees, there is a growing demand for sustainable logistics. Nevertheless, customers look for measurement systems rather than concrete solutions, and they do not seem ready to pay extra costs. Hence green demand need to be further studied for green supply to get aligned. On top of that, the absence of clear links between environmentally-friendly logistics solutions and economic performance surely represents the main barrier to implementation of EPMS. Many anecdotal examples can be observed but no pilot studies or experiments have been performed thus it has not been possible to measure the potential benefits.

Key stakeholders for the design, implementation, and use of the environmental performance management system should be identified and involved in the first steps of the project (Section 3.3.1). Interviews have been conducted with MHC transport providers (DSV, SGL, and DHL) and MHC EHS manager primarily to collect data about environmental policy. This process has also created awareness among Account managers for MHC and Environmental, Quality, and CSR Managers about MHC commitment for environmental performance of their transportation. Supply chain planning, packaging, purchasing, and customers' relationships departments should also be informed of and involved in the project in order the break the "intra-organisational silos".

Purpose of the EPMS is another key challenge identified in the literature (Section 3.3.1). The author sees three phases to reach a concrete definition of the purpose of the EPMS at MHC. There are mainly derived from requirements for the thesis work expressed by the EMEA Logistics Director, as "What is measured gets done" (Section 3.3). Hence the first step aims at building a user-friendly and comprehensive dashboard to measure emissions from both inbound and outbound transportation. Issues related to calculations and data sources are developed in the following sections. Some researchers argue that unsuccessful companies are those who measure (Section 3.3.1). Nevertheless the author believes that it can rather be considered as a first move. The second stage involves setting up an action plan which is described as managing the system better in the literature. Some researchers argue that successful organisations are those who reach this phase (Section 3.3.1).The EPMS fits in the LM and PM of the organisation. Realistic targets are agreed upon; studies on environmentally-friendly solutions that reduce both costs and emissions from transportation are conducted. These can include eco-driving, despeeding the supply chain, telematics implementation, increased fill rate, considerations to last mile, collaborative forecasting, and switch from road to less polluting transport modes *etc.* Collaboration with transport providers is crucial. MHC draws up a list of environmental requirement for transport providers. In addition, progress is monitored, and achievements are reported. MHC takes part into benchmarking sessions to share best practices and to present solutions that prove links between economic and environmental performance. The third step links environmental efforts to customer value in order to get clear idea of the environmental demand from customers. It is considered as a very tricky process. A way suggested by MHC EMEA Logistics Director is to display environmental information in invoices such as the total kg CO_2 emissions for the trip and the total kg CO_2 emissions that would have been released if more environmentally-friendly solutions have been chosen by the customer.

Assumptions and formulas for calculations have a large influence in the final results displayed in corporate reports (Section 5.4). The E-Tool might contain an inaccurate fuel CO_2 emissions conversion factor in kg CO_2/litre fuel for road transport, and in kg CO_2/ton-km for sea transport. Furthermore, assumptions and formulas are not clearly described in the E-Tool and the FTC-Cube documentation (Section 6.4).The author suggests MHC to review the current tools used to measure emissions from transportation. In addition, the NTM has a very strong reputation worldwide and is used by many organisations thus the author suggests the use of NTM data and methodology for road and sea transportation. Efforts are focused on obtaining accurate data from transport providers and carriers. Emissions are calculated with the suggested methodology and assumptions. It can be argued that a complete set of assumptions and methodologies are needed so that users are provided with methodologies that fit any situation. Nevertheless, the author suggests simplifying the NTM method and using simple formulas. As highlighted by one of the interviewees, calculating CO_2 emissions can be done at leg (supply chain) level rather at a product/shipment level that can be a time consuming and expensive process. Nevertheless, it has previously been argued that aggregation of information may result in masking particularly strong or poor performance in specific areas of operation hence bringing uncertainty (section 5.4). Only CO_2emissions have been calculated and compared. Emissions from the air pollution environmental impact category such as NO_x, HC, CH_4, PM, NMVOC, and SO_2 could be added in later stages of the project.

Many of the users of transport services that outsource transportation do not have a direct access to the raw data for transportation (Section 3.3.2). They have to find other means to calculate their carbon footprint. At MHC factories report CO_2 emissions for inbound logistics and DSV for outbound logistics. One issue is that consistency of reported numbers is not controlled by MHC. As suggested earlier in the report, it could be more accurate to obtain data such as transported tons and distance driven from the transport providers both for inbound and outbound transportation. CO_2 emissions could be calculated by transport providers following a standardised procedure with transparent assumptions and method for calculations. Maximum transparency should be encouraged for reliable sources of raw data and consistency of the numbers to avoid derivation from black boxes. Another interviewee emphasises the fact that attention should be given to MHC influence and power on the source of raw data.

A discussed topic in the literature and in the media is responsibility across the supply chain MHC has a clear delimitation for responsibility for transportation: it starts when finished products are being produced at the factories. Transportation from the first tier of raw material suppliers and further down tiers are not included in calculations of CO_2 emissions. In addition, data is collected through transport providers but no control is performed by MHC on sub-contractors and further down carriers and shippers. Interviewees argue that a limit needs to be agreed upon to set up a transparent method to measure and report emissions. As for transport providers, requirements are set for sub-contractors such as age and Euro class of the trucks. Audits are carried out once a year on the largest carriers and shippers to check compliance with environmental requirements. An extreme way to check compliance is the breaking of a scandal in the media.

7.5 SUMMARY

In Figure 28, the author presents a visual summary of the recommendations divided into short-term (top figure) and long-term (bottom figure) recommendations. It aims at providing MHC Global Logistics Director, EMEA Logistics Director, and EHS Manager with the next steps to follow in a very concise way.

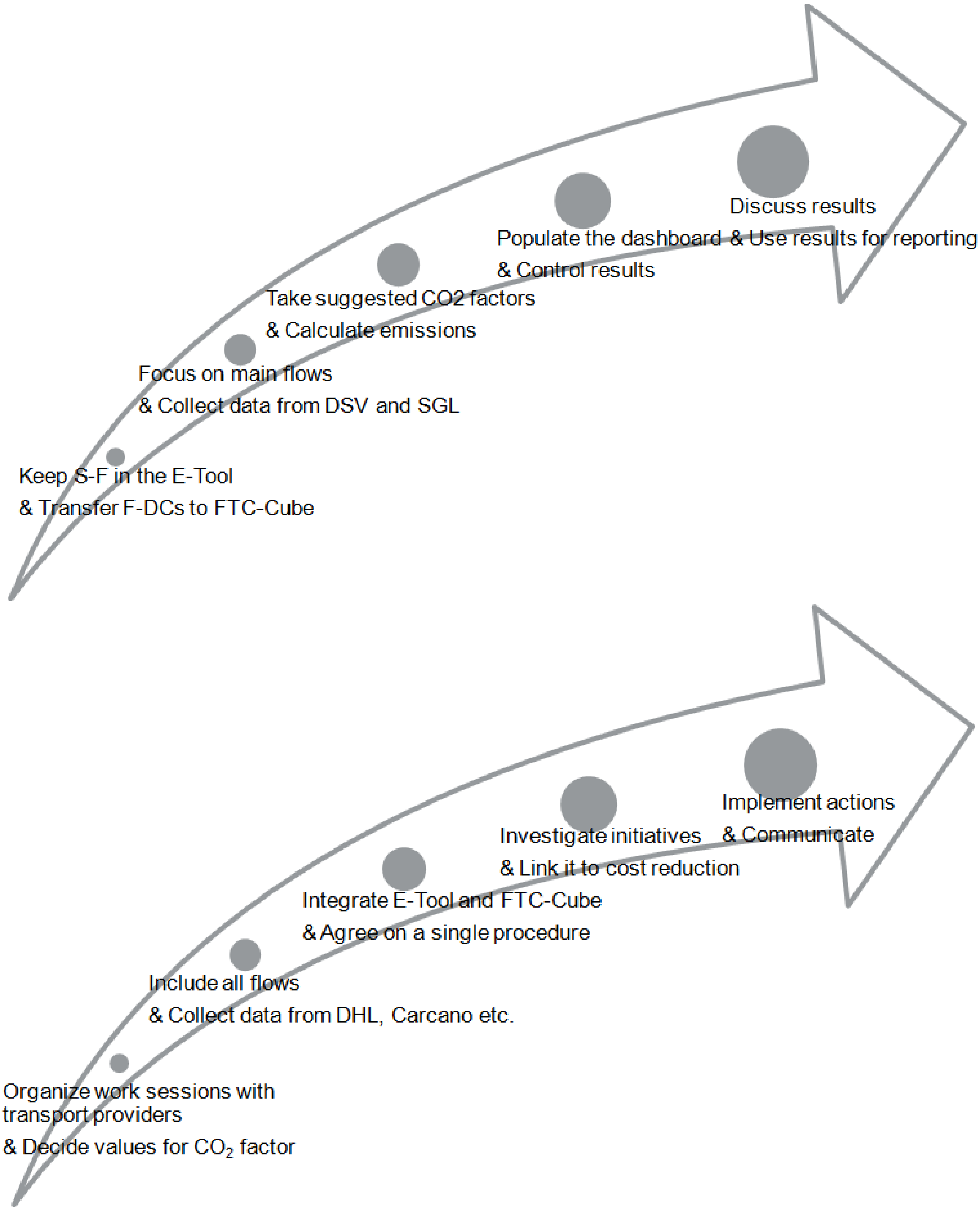

Figure 27 Summary of recommendations

8. CONCLUSIONS

In this chapter the conclusions of the thesis are declared and areas of further research are suggested.

The main purpose of the thesis is *to investigate how a procedure can be described to measure and report environmental performance of transportation*. Logistics managers face increasing demand to consider the environment in decision-making. Yet, there is no standardised procedure to assess the environmental impact of transport systems. Therefore the purpose of the thesis is to contribute to the environmental performance management research with metrics that fulfil both operational reporting and managerial decision requirements.

The thesis work can be seen as the premises of a project dedicated to the design and implementation of an EPMS for transportation at MHC. The recommendations part is divided into three sections - metrics, calculations, and dashboard - which answer the three research questions. Awareness has been raised among key stakeholders that have been met including MHC Global Logistics Director, MHC EMEA Logistics Director, MHC EHS Manager, Account managers for MHC, Environmental, Quality, and CSR Managers at DSV, SGL, and DHL. The current and desirable states have been analysed. A solution that bridges the gap has been suggested including metrics to be selected, calculations to be followed, and a model of a dashboard to be used for reporting. Further data collection is required from transport providers to increase accuracy and transparency in order to initiate the implementation of the EPMS at MHC. Values of CO_2 emissions factors should be further investigated in collaboration with MHC EHS Manager for both road and sea transport.

Future research is needed in three areas. There is a need to build platforms that provide users of transport services with reliable raw data for calculations of emissions from transportation. Secondly, the link between environmental performance and financial performance has to be tested, actions to be structured, initiatives to be capitalised and communicated through reports and benchmark sessions. It could enhance the ‘snowball effect’ of decarbonisation among supply chains actors. Thirdly, environmental costs of the future will be related to congestion, noise, accidents, land use *etc.* It will affect traffic, reliability delivery, and time delivery thus will lead to extra costs for companies. This thesis has focused on CO_2 emissions. Therefore further research including first a larger panel of environmental damages and second costs for organisations is needed. Successful companies are those who will anticipate future regulation such as congestion fees. Some researchers argue that there is a need for behavioural change from organisations rather than end-of-pipe solutions such as catalytic converters.

9. REFERENCES

AFNOR (2000). "NF EN ISO 14031."

Andersen, B. and T. Fagerhaug (2004). "Green performance measurement." International Journal of Business Performance Management **1**(2): 171.

Bai, C., J. Sarkis, X. Wei and L. Koh (2012). "Evaluating ecological sustainable performance measures for supply chain management." Supply Chain Management: An International Journal **17**(1): 78-92.

Björklund, M. and H. Forslund (2013). "The inclusion of environmental performance in transport contracts." International Journal of Physical Distribution & Logistics Management **24**(2): 214-227.

Björklund, M. and H. Forslund (2013). "The purpose and focus of environmental performance measurement systems in logistics." International Journal of Productivity and Performance Management **62**(3): 230-249.

Björklund, M., U. Martinsen and M. Abrahamsson (2012). "Performance measurement in the greening of supply chains." Supply Chain Management: An International Journal **17**(1): 29-39.

Blinge, M. (2012). Emissions transport modes Chalmers

Bryman, A. and E. Bell (2007). Business Research Methods. Oxford, Universtity Press.

Christopher, M. (2011). Logistics and Supply Chain Management. Harlow, Pearson Education Limited.

Dobers, K., R. Röhrig, D. Rüdiger and M. Schneider (2013). Green logistics: Comparability of the environmental effects of logistics services. Efficiency and Logistics. U. Clausen, M. ten Hompel and M. Klumpp. Berlin Springer**:** 134-148.

Dubois, A. and L.-E. Gadde (2005). "Systematic combining: an abductive approach to case research." Journal of Business Research **55**(1): 553-560.

EC (2008). "Handbook on estimation of external cost in the transport sector." Retrieved 15 January 2013, from http://ec.europa.eu/transport/themes/sustainable/doc/2008_costs_handbook.pdf.

EC (2012). "Road transport: Reducing CO2 emissions from vehicles." Retrieved 12 May 2013, from http://ec.europa.eu/clima/policies/transport/vehicles/index_en.htm.

Eckerson, W. W. (2011). Performance Dashboards: Measuring, Monitoring, and Managing Your Business, John Wiley & Sons

GRI (2006). "Logistics and Transportation Pilot Sector Supplement ".

Hassini, E., C. Surti and C. Searcy (2012). "A literature review and a case study of sustainable supply chains with a focus on metrics." International Journal Production Economics **140**(1): 69.

Hervani, A. A., M. M. Helms and J. Sarkis (2005). "Performance measurement for green supply chain management." Benchmarking An international journal **12**(4): 330-353.

Hultkrantz, O. (2011). Lecture: Performance measurements, Chalmers University of Technology.

Kovács, G. and K. Spens (2005). "Abductive reasoning in logistics research." International Journal of Physical Distribution and Logistics Management **35**(2): 132-144.

Li, T. T., J. Regnander Bergh, P. Simonsson, D. Sunquist and J. Ainson (2011). Mölnlycke Health Care Host Company Case. Department of Technology Management and Economics. Göteborg Chalmers University. **Master of Science**.

Lumsden, K. (2006). Fundamentals of logistics, Compendium. Chalmers, Division of transportation and logistics

Maersk (2012). "Constant care for the environment." Retrieved 5 June 2013, from http://www.maerskline.com/globalfile/?path=/pdf/environmental_brochure.

McKinnon, A. and CEFIC ECTA (2011). "Guidelines for measuring and managing CO2 emission from freight transport operations." from http://www.cefic.org/Documents/IndustrySupport/Transport-and-Logistics/Best%20Practice%20Guidelines%20-%20General%20Guidelines/Cefic-ECTA%20Guidelines%20for%20measuring%20and%20managing%20CO2%20emissions%20from%20transport%20operations%20Final%2030.03.2011.pdf.

McKinnon, A. and M. Piecyk (2011). "Measuring and Managing CO2 emissions of European Chemical Transport." from http://www.cefic.org/Documents/IndustrySupport/Transport-and-Logistics/Sustainable%20Logistics/McKinnon%20Report%20Transport%20GHG%20emissions%2024.01.11.pdf.

Mölnlycke Health Care (2012). "360 Sustainability Magazine." Retrieved 15 January 2013, from http://www.molnlycke.com/com/About/CSR/360-Sustainability-Magazine-2011-/.

NTM (2008). "Environmental data for international cargo transport, Road transport." Retrieved 15 January 2013, from http://www.ntmcalc.org/Magellan/render/library/reports/goodslogistics.

NTM (2008). "Environmental data for international sea cargo transport, Sea transport." 15 January 2013, from http://www.ntmcalc.org/Magellan/render/library/reports/goodslogistics.

Riff, S. (2011). Cours Diagnostic, EPF Graduate School of Engineering.

Riff, S. (2011). Les indicateurs du pilotage operationnel: Démarche et exemple, EPF Graduate School of Engineering

Sarkis, J. (2009). "Convincing Industry that there is value in environmentally supply chains." Problems of Sustainable Development **4**(1): 61-64.

Sarkis, J. (2012). "A boundaries and flows perspective of green supply chain management." Supply Chain Management: An International Journal **17**(2): 202-216.

Sarkis, J., Q. Zhu and K.-h. Lai (2011). "An organizational theoretic review of green supply chain management literature." International Journal Production Economics **130**(1): 1-15.

Saunders, M., P. Lewis and A. Thornhill (2007). Research Methods for Business Students Harlow, Person Education Ltd.

Sharan B., M. (1994). Fallstudien som forskningsmetod Lund, Studentlitteratur.

Shaw, S., D. B. Grant and J. Mangan (2010). "Developing environmental supply chain performance measures." Benchmarking: An International Journal **17**(3): 320-339.

Winter, M. and A. M. Knemeyer (2012). "Exploring the integration of sustainability and supply chain management: Current state and opportunities for future inquiry." International Journal of Physical Distribution & Logistics Management **43**(1): 18-38.

Wu, H.-J. and S. C. Dunn (1995). "Environmentally responsible logistics systems." International Journal of Physical Distribution and Logistics Management **25**(2): 20-38.

Wu, J., S. Dunn and H. Forman (2012). "A study on green supply chain management practices among large global corporations." Journal of Supply Chain and Operations Management **10**(1): 182-194.

Xu, A., X. Hu and S. Gao (2013). "Review of green supply chain management " Int. J. Networking and Virtual Organisations **12**(1): 27-39(13).

Yin, R. K. (2004). Case study research : design and methods. London, SAGE.

Appendices

1. Questionnaire MHC

MHC EHS manager was interviewed on February 4th at MHC HQ.

- Since 2008 the Corporate Quality Affairs department manages environmental issues globally. Each site reports results to the EHS manager who summarises environmental progress. Could you explain in more detail? Could you describe your tasks?
- Do you see your company either as ‘Good citizens’ who ‘do the things the same’ and comply with SER rules and norms, or ‘Movers and shakers’ who ‘do things better’ and go beyond existing regulations’, or ‘Trailblazers’ who ‘do things differently’ and introduce new processes, technologies or products?
- How much influence does the EHS manager have over top management?
- All your production facilities are ISO 14001. Could you explain in more detail?
- Your corporate environmental focus areas are: reduction of waste, consumption of energy, emission of carbon dioxide from transport, removal and replacement of chemicals that are classified as hazardous to the environment. Could you explain in more detail?
- Your measure the amount of carbon dioxide emitted from the transport of raw materials to the factories, the transport of goods between factories, and the transport of finished goods from the factories to the warehouses. This is done in collaboration with the freight companies. Could you explain in more detail? Could you show me the tool/Excel file and raw data you use to measure and report environmental performance?

2. Questionnaire DSV

The interview of DSV Account Manager was held on February 21st at MHC HQ. The questionnaire was sent to the CSR Manager at DSV on March 15th.

DSV’s environmental commitment

- Do you see DSV either as ‘good citizens’ who do the things the same and comply with environmental rules and norms, or ‘movers and shakers’ who do things better and go beyond existing regulations, or ‘trailblazers’ who do things differently and introduce new processes, technologies, or products?
- As stated in DSV’s CSR report, DSV is not directly responsible for transport activities carried out by the subcontractors (hauliers, shipping companies, and airlines). Could you explain in more detail?
- How much influence does DSV’s CSR manager have over top management? How much does environment weigh against the drivers cost and lead time? Before the crisis? Over the next few years?

- To what extent does DSV perceive demand for sustainable transport and logistics solutions from customers? Before the crisis? Over the next few years?

DSV's environmental policies

- As stated in DSV's CSR report, DSV aims at reducing its environmental impact by optimizing the cargo volumes carried between the different destinations. Could you explain in more detail?
- By optimizing utilisation of the available capacity. Could you explain in more detail? How does DSV calculate truck fill rate?
- By optimizing route planning. Could you explain in more detail? Does DSV try to reduce empty trucks on return? Does DSV take into account last-mile?
- Does DSV plan to use rail transportation in the future?

DSV's environmental performance measurement and reporting

- As stated in DSV's 2011 CSR report, every year DSV calculates its carbon footprint. Could you explain in more detail?
- How does DSV measure environmental performance from transport (assumptions, input data, formulas, output data, sensitivity analysis etc.)? Does it include all transport modes? Does it include others gases than CO_2 such as Methane or Nitrous Oxide? Does it include all activities from subcontractors? How this is linked to the FTC tool?
- How does DSV report environmental performance from transport (metrics definition, metrics updating process and frequency etc.)? As stated in DSV's 2011 and 2012 CSR report and website, GRI, UN Global, and Carbon Disclosure Project parameters are used. Could you explain in more detail? How this is linked to the FTC Tool?

Environmental requirements from MHC

- As stated in MHC's Sustainability magazine, MHC's environmental expectations have to be met by freight companies. Could you explain in more detail? How do you set targets with MHC? How often? How this is linked to the FTC tool?

Environmental requirements for DSV's subcontractors

- As stated in DSV's CSR report, DSV's environmental impact is mainly caused by the transport activities carried out by subcontractors. Thereby a reduction of the environmental impact is mainly achieved through DSV's dialogue with and requirements from DSV's subcontractors. DSV's suppliers are selected on the basis of professional business parameters including assessment of their environmental policies. DSV receives annual reports on emission data from its suppliers of sea, air, and road transport services. Could you explain in more detail? Does DSV have a list of carriers prioritised by certifications, ISO 14001 for instance? Does DSV carry audit of subcontractors?

3. Questionnaire SGL

The interview of SGL Account Manager was held on April 9th at MHC HQ. The questionnaire was sent to the Quality and Environmental Manager at SGL on April 16th.

SGL's environmental commitment

- Do you see SGL either as 'good citizens' who do the things the same and comply with environmental rules and norms, or 'movers and shakers' who do things better and go beyond existing regulations, or 'trailblazers' who do things differently and introduce new processes, technologies, or products?
- To what extent does SGL take responsibility for transport activities carried out by the subcontractors i.e. hauliers, shipping companies, and airlines?
- As stated in SGL's environmental policy, the scope includes core services within Aid & Development, Projects, warehousing, logistics, and road, rail, sea, and air freight. Could you explain in more detail each of these areas?
- How much influence does SGL's CSR manager have over top management?
- To what extent does SGL perceive demand for sustainable transport and logistics solutions from customers?

SGL's environmental policies

- As stated in SGL's CSR report, SGL has established an environmental management system. Could you explain in more detail? The SGL's environmental management system ensures that the environmental impact from activities and services is constantly reduced. Could you explain in more detail?
- As stated in SGL's environmental policy statement, environmental targets are set for electricity consumption, combustible waste, consumption of copy paper, cardboard waste, and heat consumption. Does SGL plan to set environmental targets for transport?
- Does SGL plan to set targets for reduction of emissions?

SGL's environmental performance measurement and reporting

- How does SGL measure environmental performance? Does it include all transport modes? Does it include others gases than CO2 such as Methane or Nitrous Oxide?
- How does SGL report environmental performance? i.e. Global Reporting Initiative (GRI), Carbon Disclosure Project (CDP), United Nations Global Compact (UN Global Compact)

Environmental requirements from Mölnlycke Health Care

- As stated in Mölnlycke Sustainability magazine, Mölnlycke environmental expectations have to be met by freight companies. Could you explain in more detail in the case of SGL?

4. Questionnaire DHL

The telephone interview of DHL Key Account Manager and Quality Manager was held on April 15th.

DHL's environmental commitment

- Do you see DHL either as 'good citizens' who do the things the same and comply with environmental rules and norms, or 'movers and shakers' who do things better and go beyond existing regulations, or 'trailblazers' who do things differently and introduce new processes, technologies, or products?
- To what extent does DHL take responsibility for transport activities carried out by the subcontractors i.e. hauliers, shipping companies, and airlines?
- How much influence does DHL's CSR manager have over top management?
- To what extent does DHL perceive demand for sustainable transport and logistics solutions from customers?

DHL's environmental policies

- DHL has implemented "Go Green" in Sweden and has to set targets for reduction of emissions. Could you explain in more detail?
- DHL is implementing several actions to decrease environmental impact, including increasing load factors, implementing alternative technologies, using alternative fuels, streamlining and optimizing processes, ISO 14001 and continuous improvements, etc. Could you explain in more detail?

DHL's environmental performance measurement and reporting

- How does DHL measure environmental performance? Does it include all transport modes? Does it include others gases than CO2 such as Methane or Nitrous Oxide?
- As stated in DHL's website, reporting on environmental performance is done transparently to all stakeholders. Could you explain in more detail? How does DHL report environmental performance? As stated in DHL's website report, DHL works with the UN Global Compact. Could you explain in more detail?

Environmental requirements from Mölnlycke Health Care

- As stated in MHC's Sustainability magazine, MHC's environmental expectations have to be met by freight companies. Could you explain in more detail in the case of DHL?