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Methodologies for emission calculations - Best practices, implications and future needs

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Classification and Approval

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PU = Public
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Executive Summary

Introduction

The main objective of the COFRET (Carbon Footprint of Freight Transport) project is to develop and test a harmonised methodology for the accurate calculation of carbon footprint of transport and logistics along supply chain configurations. The proposed COFRET methodology will build on already existing tools and methodologies, combining state-of-the-art elements and filling in gaps. WP 2 User needs and existing methods and tools for calculation of carbon footprint (June 2011 - March 2012) consisted of four tasks that studied the user needs, existing means of calculation and new enabling technologies in the context of carbon footprint of transport and logistics. This work supports the further steps in the COFRET project by giving a thorough presentation of the state-of-the-art and gaps to be addressed within the COFRET methodology development.

Existing carbon footprint methods, tools and data

Under **Task 2.1** *Analysis of existing carbon footprint calculation methods, tools and data* existing methods, tools and databases (items) for calculation of carbon footprint of transport and logistics were reviewed and assessed. As the main result, an up-to-date knowledge base of existing methods, tools and data was established, and tentative selections and inquiries on possible co-operation and alignment with the best available initiatives were made. Findings on the shortcomings of the current resources when trying to apply carbon footprint calculations to the entire supply chain were addressed and set as challenges to be pursued in the later COFRET methodology development phase. The background work to support methodology development included also clarification of terminology and scope of the project.

To build up a comprehensive list of existing resources relevant to the COFRET methodology, the items analysed were categorised into four groups: (1) methodologies, such as standards and guidebooks, (2) calculation tools, (3) emission factor databases and (4) other activities and initiatives, such as research projects, forums and communication channels. A total of 102 methods, tools and databases were identified as relevant for the COFRET project.

In general, the carbon footprint methodologies reviewed support a consistent, mutual approach based on life cycle thinking. However, the level of precision and detail varies, and there are significant methodological gaps regarding the inclusion of all logistics operations. Furthermore, loose guidance with numerous alternatives to choose from, for example regarding allocation, leads currently to confusion and lack of comparability. Especially in the context of complex supply chain configurations, combining various methods in order to cover the entire chain inevitably leads to incomparability, even if each of the methods were compliant with a given standard individually.

The number of carbon footprint calculation tools and data sources was observed significant with great variation in quality, coverage and originality. The actual use of these tools and data, all of which interpret seemingly uniform carbon footprint methodology, is the step where a common, sufficiently well-structured methodology is needed to avoid divergence, i.e. to avoid incomparable, non-transparent carbon footprint results. In addition, calculation tools present themselves typically as “black boxes” and to track down which methodologies and data are used is difficult.

To sum up the task results, it can be argued that among the existing methods, tools and databases there are already suitable elements for calculation of carbon footprint of transport and logistics along supply chains even though a harmonised framework is currently missing. Because of the current lack of universally established standards, various stakeholders have independently developed incomparable methods, tools and data for various solutions for various users and with differing scope. Besides national and sector-specific standards, the draft-phase standards for greenhouse gas emission declaration for transport services (a European standard to be published around 2012) and for carbon footprint of products (an international standard to be published around 2012) are expected to have a major impact towards harmonisation.

Understanding user needs and experiences

Task 2.3 *User needs, practices and experiences in the context of carbon footprint calculations in supply chain configurations* aimed to identify the core users and their needs for calculation of carbon footprint. Having clarified the user needs, the justification of the COFRET objectives and scope was once more recognised and ensured, and assessment criteria for successful delivery of the project could be specified. The first part of this task was dedicated to in-depth interviews with main stakeholders. This was carried out using a semi-structured questionnaire designed for open-ended replies, with qualitative analysis in mind. Second part was dedicated to an online survey addressing the same main issues as the in-depth interviews, but was designed in a check box format. Commitment and interest of the stakeholders to the progress in COFRET was further strengthened in **Task 2.2** *Organisation of stakeholder workshop.* The event took the analysis of user needs another step forward by inviting a selection of users of carbon footprint calculation tools to a meeting in Berlin. The results from the preceding Task 2.3 in-depth interviews and online survey could then be further discussed and validated. The outcome of the two interlinked tasks consists of user needs clarifications that will be input for development and validation of a user-friendly methodology for carbon footprint calculations.

The tasks accomplished have given a series of user needs and requirements, categorized in three types of needs and requirements: methodology, data and interface (the implementation of the methodology for users). A compilation of the most important points follows:

Methodology:

- Output: The output from the methodology should be CO_2e and energy.
- Transport modes: All modes of transport should be included.
- Allocation: The calculations apply clear allocation principles, especially between weight and volume. Special questions of empty trips and last mile delivery need to be answered.
- The CEN standard: The methodology should be based on the forthcoming CEN standard.
- Terminal handling and warehousing: Separate methodologies for terminal handling and warehousing should be included.

Data:

- Input data accuracy: Defining different layers of calculation accuracy based on the input data was suggested. No consensus on default data provision was reached.
- Level of detail: A calculation tool should notify the level of detail of input data by: (1) reporting uncertainty, (2) reporting the input data used and/or (3) have some sort of punishing mechanism for poor data.
- Subcontractors: The methodology must enable inclusion of subcontractor's data.
- Shipment level: To give the most detailed (disaggregated) results, calculations should be based on input data on shipment level. Other levels can then be derived by aggregation.

Interface:

- Guidelines: The COFRET methodology should give more guidelines than CEN to explain why the different indicators are used, for comparability and transparency.
- Corporate IT systems: The COFRET methodology should promote and support automatic calculations by making use of corporate IT systems.
- Global supply chains: The methodology should allow the calculation of emissions from supply chains on a global scale.
- Flexibility: Since most companies today prefer internal emission calculation solutions, the methodology must be applicable to company specific tools fulfilling specific needs.

Potential with enabling technology systems

Task 2.4 *Future technologies and innovations relating to freight transport which are relevant for carbon footprint calculation* analysed new technologies and innovations in freight transport and logistics regarding their potential to improve the measurement and the calculation of carbon footprint of transport and logistics along the supply chain. By firstly identifying, secondly assessing potential contribution to carbon footprinting and finally exploring the integration possibilities of these technologies and systems, ways to facilitate smooth, accurate and automated calculation procedures were mapped. Task findings will help the COFRET project to accommodate environmental reporting in the form of carbon footprint of transport and logistics along the supply chain into other company processes.

The investigated technologies and systems can contribute to the measurement or calculation of the carbon footprint of freight transport and logistics chains. The main contribution is the data and information collection and the measurement of key figures for the calculation process. Main conclusions by type of technology system:

- Supply chain and transport planning systems have a medium to high potential to improve the carbon footprint calculation, especially because they typically cover the whole transport and logistics chain.
- Information and communication systems have a mostly high potential to improve the carbon footprint calculation, most importantly by providing input data such as real measured values.
- Business applications have a medium to high potential to improve the carbon footprint calculation, and they can cover the whole supply chain or focus only on transport or nodes (warehouses, terminals).

Main benefits of the investigated technologies and innovations include improving the measurement, data collection, data quality and efficiency regarding carbon footprint measurement and calculation. This will enhance the comparability, transparency and credibility of carbon footprint calculations. There are still various barriers which hinder the implementation of new technologies and innovations in the industry. Because of the variety of systems within the freight industry it is a challenge to link supply chain and transport planning systems, information and communication systems and business applications with carbon footprint calculation tools.

Based on the task specific findings, the following recommendations can be made:

- Within the COFRET work, requirements of new technologies and innovations should be thoroughly considered and interfaces of calculation tools to planning systems, ICT and business applications provided.
- The European Commission should provide incentives for the implementation of promising new technologies and systems, support research and further standardisation and seek for ways to reduce the identified barriers.
- Logistics and transport service providers and shippers should adopt an active and cooperative role in embedding carbon footprint calculation functionalities and requirements in the enterprises IT environment.

Next Steps

For the next steps of the COFRET project, these results of the WP2 tasks provide not only methodological backbone derived from existing resources but also understanding of user needs and views of potential of the developing technology systems in making calculations more efficient. On the other hand, this preparatory work has shown specific areas where efforts along the project need to be targeted when trying to ensure successful delivery of a comprehensive methodology. Balance between methodological finesse and ease-of-use needs to be found without compromising either calculation accuracy or user friendliness. Also, the application areas, use cases and limitations of the methodology need to be clearly stated, and comprehensive step-by-step guidance on inputs and outputs to the calculation framework needs to be made available. These, as well as interfaces to technological solutions and compliance to forthcoming schemes, standards and reporting obligations, will be addressed in the following phases of the project by means of methodology development, test cases with the industry and feedback loops through evaluation and validation processes.

Along the WP2 efforts it has been proven that the timing of the COFRET approach aiming to cover all transport and logistics along the entire supply chain is spot on. Urgency to address greenhouse gas emissions in the transport sector has led to disconnected initiatives in different modes and industries, but a joint approach has been missing, a situation where the potential users are left confused. Interest in the international setting has been shown in the COFRET project that could well play a major part in the global, comprehensive alignment of efforts. On the other hand the methodological complexity is about to be slightly reduced as the forthcoming European standard on transport service GHG emission calculation will be published, and the COFRET approach will facilitate the uptake of the standard by an extended practical guidance on the supply chain level, with compliance to the standard.

1 Introduction

This chapter gives a brief introduction to the COFRET project objectives, with emphasis on its second work package.

To support the realisation of the European Union (EU) greenhouse gas (GHG) emission policies and targets, the main objective of the COFRET project is to develop and test a harmonised methodology for the accurate calculation of carbon footprint of transport and logistics along supply chain configurations. The end result will be a framework for how to calculate and report carbon footprint, i.e. GHG emissions expressed as carbon dioxide equivalents, at product or shipment level. The proposed COFRET methodology will build on already existing tools and methodologies, combining state-of-the-art elements and filling in gaps. It will consider all types of shipments, all transport and logistics operations (e.g. loading and unloading, transport by any mode, empty driving, transhipment, handling, and warehousing), and it will apply to the European as well as to the global context. Furthermore the COFRET approach will be demonstrated and validated through test cases together with the logistics sector stakeholders. The work package (WP) structure of the COFRET project is illustrated in Figure 1.

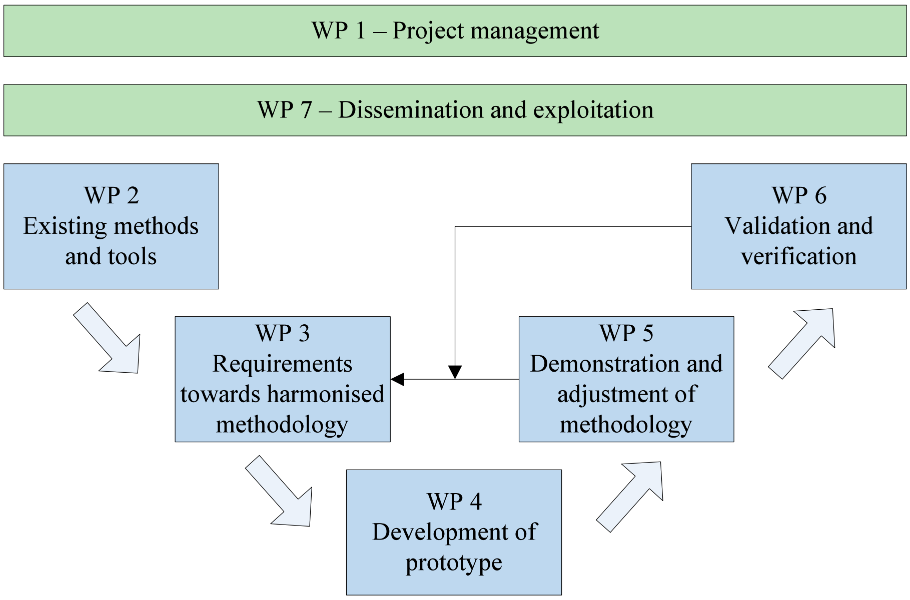

Figure 1. COFRET work package structure.

WP 2 *User needs and existing methods and tools for calculation of carbon footprint* consists of four tasks that study the user needs, existing means of calculation and new enabling technologies in the context of carbon footprint of transport and logistics. Next, the four tasks and related deliverables are briefly introduced. In addition, a list of WP 2 tasks and deliverables is shown in Table 1.

Table 1. Work package 2 tasks and deliverables.

<table>
<tr><th>Task</th><th>Deliverable</th></tr>
<tr><td>Task 2.1
Analysis of existing carbon footprint calculation methods, tools and data
(June 2011 - December 2011)</td><td>Deliverable 2.1
Existing methods and tools for calculation of carbon footprint of transport and logistics [2]
(December 2011)</td></tr>
<tr><td>Task 2.2
Organisation of stakeholder workshop
(Berlin, January 19, 2012)</td><td rowspan="2">Deliverable 2.2
User needs, practices and experiences in the context of carbon footprint calculations in supply chain configurations [12]
(March 2012)</td></tr>
<tr><td>Task 2.3
User needs, practices and experiences in the context of carbon footprint calculations in supply chain configurations
(June 2011 - March 2012)</td></tr>
<tr><td>Task 2.4
Future technologies and innovations relating to freight transport which are relevant for carbon footprint calculation
(June 2011 - February 2012)</td><td>Deliverable 2.3
Future technologies and innovations relating to freight transport which are relevant for carbon footprint calculation [22]
(February 2012)</td></tr>
<tr><td>WP 2, all tasks</td><td>Deliverable 2.4
Methodologies for emission calculations - Best practices, implications and future needs
(March 2012)</td></tr>
</table>

The main objective of **Task 2.1** *Analysis of existing carbon footprint calculation methods, tools and data* (June 2011 - December 2011) was to review and assess existing methods, tools and databases (referred to collectively as items) for calculation of carbon footprint of transport and logistics. This state-of-the-art survey includes an analysis of coverage as well as strengths and weaknesses of the selected items against the COFRET objectives. Based on WP 2 results and recommendations, a more detailed analysis and comparison of the most relevant items, and their possible input to the COFRET methodology development, will follow under WP 3 *Requirements towards harmonised methodology*. Deliverable 2.1 [2] summarises the work carried out under Task 2.1 and to be continued under Task 3.1 *Analysis, assessment and development of typology of existing CO2 calculation tools*.

The target with **Task 2.3** *User needs, practices and experiences in the context of carbon footprint calculations in supply chain configurations* (June 2011 - March 2012) was to identify the core users and their needs for calculation of carbon footprint. Potential user groups under study included transport operators, logistics service providers, researchers and policy makers, as well as manufacturers, wholesalers, retailers and consumers. The research was designed to ensure a thorough understanding of user needs, existing practices and lessons learned, and it was structured in two parts: in-depth interviews with stakeholders selected by the COFRET project partners and an online survey on the COFRET website, open for all interested parties to respond to. Invitations to take part in the online survey were sent out to over 400 potential respondents, and an open invitation was published on the project website. Supported with progress in Task 2.3, the interconnected **Task 2.2** *Organisation of stakeholder workshop* took the analysis of user needs further, by inviting a selection of users of carbon footprint calculation tools to Berlin in January 2012. Deliverable 2.2 [12] summarises the work done in Task 2.2 and Task 2.3, the results of which provide input to most importantly WP 3.

Task 2.4 *Future technologies and innovations relating to freight transport which are relevant for carbon footprint calculation* (June 2011 - February 2012) analysed new technologies and innovations in freight transport and logistics regarding their potential to improve the measurement and the calculation of carbon footprint of transport and logistics along the supply chain. This included an inventory of relevant technologies or technology areas, such as supply chain and transport planning systems, information and communication systems and business applications, and an assessment of their potential to improve carbon footprint measurement and calculation. Deliverable 2.3 [22] summarises the work under Task 2.4 that is to be continued in WP 3 and WP 4.

This Deliverable 2.4 sums up the results of WP 2. Main findings and highlights from each task are presented, and implications and contribution to the COFRET methodology development continued in other work packages are discussed. The report is structured as follows. Chapter 2 presents, by task, the main results and findings achieved in WP 2. Chapter 3 captures the main contribution areas of WP 2 to the COFRET project. Accomplishments are explained, and open issues to be addressed in the next steps of the project are raised.

2 Summary of task results

This chapter sums up, by task (see Table 1 on page 2), the results and findings achieved in WP 2.

2.1 Existing methods and tools

2.1.1 Overview

Under **Task 2.1** *Analysis of existing carbon footprint calculation methods, tools and data* (June 2011 - December 2011) existing methods, tools and databases (items) for calculation of carbon footprint of transport and logistics were reviewed and assessed. To build up a comprehensive list of methods, tools and databases relevant to the COFRET methodology development was a shared task of the entire, extended COFRET consortium, involving all project partners, members of the Advisory Board and companies taking part in the test cases. Furthermore, the list of items was circulated among stakeholders in the industry and academia, as well as displayed on the COFRET project website, open for further discussion. The actual review work was divided between project partners based on their areas of expertise. The main research method applied was literature survey, using explanatory methodology reports, guidebooks, manuals, project deliverables, scientific literature, conference papers, promotional brochures, online material, etc. as source material. Concerning information gaps and lacking publicly available documentation, personal contacts were established and interviews were used as a complimentary approach.

The items analysed were categorised into the following four groups that are further explained in Table 2:

- carbon footprint **methodologies**
- carbon footprint **calculation tools**
- emission factor **databases**
- **other** activities and initiatives.

Table 2. Explanation of the four categories for items reviewed.

Carbon footprint methodologies cover actual standards, standard-like guidelines, guidebooks and schemes that provide the framework for how to calculate and report carbon footprint of transport and logistics along the supply chain or some part of it.
Carbon footprint calculation tools encompass all tools, instruments, software, algorithms and other applications, whether public, commercial or company specific, that are used to carry out and facilitate the calculations of carbon footprint of transport and logistics along the supply chain or some part of it.
Emission factor databases are considered as collections of greenhouse gas emission data, either public or commercial, that are needed in order to calculate carbon footprint of transport and logistics along the supply chain or some part of it. Examples of emission factors in such databases are vehicle emissions, emissions from fuel production and emissions per transport unit.
Other activities cover all items other than methodologies, calculation tools and databases that contribute to the topic of carbon footprint of transport and logistics along the supply chain. Examples of such activities include research projects, awareness raising initiatives and different types of communication forums and channels.

In the course of the review and assessment process, a total of 102 methods, tools and databases were identified as relevant for the COFRET project. Figure 2 illustrates the number of items by category. Of these items, twenty were ranked as *very important* (the top priority category, as valued by project partners in the review process). These state-of-the-art items are summarized in Table 3. As opposed to Figure 2 categorisation, where each item was identified and allocated to one category only, some items fulfil the characteristics of several categories. And some items, even though listed separately, may bear very close connections to other items either within or beyond that category. In Table 3, items are appointed to each and all relevant categories. The importance of the items was assessed according to their relevance for the scope and objectives of the COFRET project, not according to their quality or overall importance in itself. The selected twenty items mean to cover all transport modes and energy production in terms of methodologies, tools and data sources. At the same time aspects such as scientific advancement, impact through user volumes and acceptance as well as coverage of different industries are emphasized.

Based on the review and assessment, first suggestions on most relevant items and their possible input to the COFRET methodology development to be continued in WP 3 were given. A comprehensive list of items (by category) reviewed, together with short introductions to selected ones and recommendations how to integrate state-of-the-art to the COFRET methodology development is provided in task deliverable D 2.1 [2] (see Table 1 on page 2).

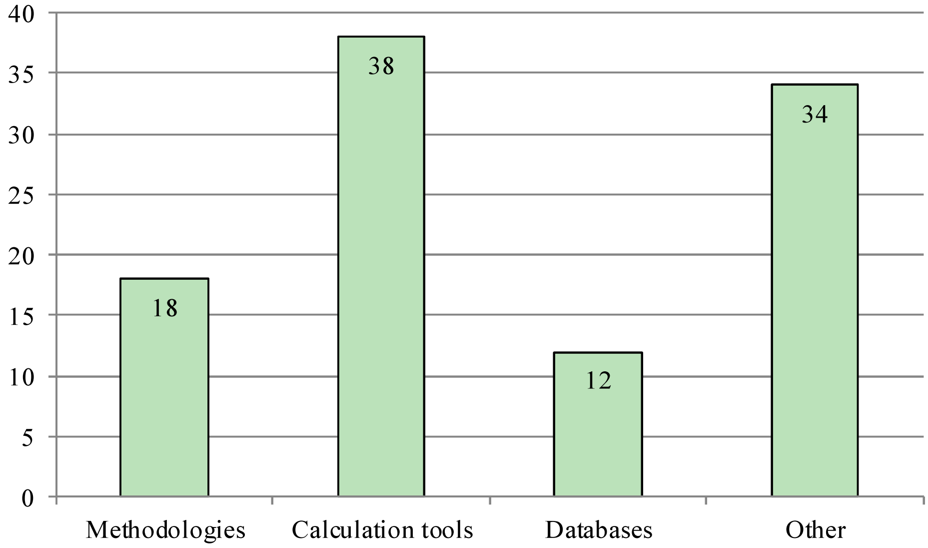

Figure 2. Number of items by category (102 in total) in December 2011. Division to categories is done based on initial classification of items by partners so that each item was fixed to one category only to avoid double counting.

Table 3. Summary of the most important identified items (as ranked by the project partners regarding the COFRET project objectives) by relevant category or categories.

Name	Method	Tool	Database	Other
Bilan Carbone [1]	X	X	(X)	
CENEX [3]		X		
DEFRA guidance [5] [6]	X	(X)		
DSLV guideline [23]	X			
EcoTransIT World [8]		X		
EN 16258 [7]	X			
GHG Protocol [28] [27]	X	X		
Grønn godstransport (Green Freight Transport (GFT)) [21]	X	X		
HBEFA [15]			X	
IPCC [11] [10]	X		(X)	
JEC [13] [14]			X	
L4LIFE [20]				X
LIPASTO [18]			X	
NTM [19]	X	(X)	X	
SmartWay [25]		X		
SmartWay Europe [24]				X
TREMOD [16]			X	
Versit+ [17]			X	
Vestlandsforskning [26]			X	
ZichtopCO2 [4]	X	X	(X)	

2.1.2 Main findings

In general, the number of relevant carbon footprint **methodologies** reviewed remained manageable, and in terms of content these methodologies support a consistent, mutual approach based on life cycle thinking. Methodological angle of approach varied from systematic processing by transport mode to industry oriented schemes covering given industries or commodity groups. However, the level of precision and detail varies, and there are significant methodological gaps regarding the inclusion of all logistics operations. Furthermore, loose guidance with numerous alternatives to choose from, for example regarding allocation, leads currently to confusion and lack of comparability. Especially in the context of complex supply chain configurations, combining various methods in order to cover the entire chain inevitably leads to incomparability, even if each of the methods were compliant with a given standard individually.

The number of carbon footprint **calculation tools** and **data** sources was observed to be significant with great variation in quality, coverage and originality. The actual use of these tools and data, all of which interpret seemingly uniform carbon footprint methodology, is the step where a common, sufficiently well-structured methodology is needed to avoid divergence, i.e. to avoid incomparable, non-transparent carbon footprint results. In addition, calculation tools present themselves typically as "black boxes" and to track down which methodologies and data are used is difficult.

To sum up the results of Task 2.1, it can be argued that among the existing methods, tools and databases there are already suitable elements for calculation of carbon footprint of transport and logistics along supply chains even though a harmonised framework is currently missing. Thus the objectives of the COFRET project with the aim to fill this gap are justified. It should be acknowledged that the majority of the awareness raising and activity around carbon footprinting has occurred as late as the past decade. And because of the current lack of universally established standards, various stakeholders have independently developed incomparable methods, tools and data for various solutions for various users and with differing scope. Besides national and sector-specific standards, the draft-phase standards for greenhouse gas emission declaration for transport services (CEN, to be published around 2012) [7] and for carbon footprint of products (ISO, to be published around 2012) [9] are expected to have a major impact towards harmonisation.

2.2 User needs and practices

2.2.1 Overview

Task 2.3 *User needs, practices and experiences in the context of carbon footprint calculations in supply chain configurations* (June 2011 - March 2012) aimed to identify the core users and their needs for calculation of carbon footprint. Relevant user groups under study included transport operators, logistics service providers, researchers and policy makers, as well as manufacturers, wholesalers, retailers and consumers. The research work was structured in two parts: in-depth interviews with stakeholders selected by the COFRET project partners and an online survey on the COFRET website, open for all interested parties to respond to.

The first part, **in-depth interviews** with main stakeholders, was carried out using a semi-structured questionnaire that was created to be used as a guideline when conducting the in-depth interviews. The questionnaire consisted of 21 questions designed for open-ended replies, with qualitative analysis in mind. The in-depth interviews were conducted by COFRET project partners, and reported to take between 25 and 40 minutes per interview. In total, 29 interviews were conducted. Two thirds of the interviewees were either logistics service providers or transport operators, and one third represented the manufacturing industry, wholesale and retail.

For the second part, the **online survey**, a shorter questionnaire was created consisting of 12 questions. It addressed the same main issues as the in-depth interview questionnaire, but was designed to be easily understandable and more of a check box-format so it could be answered quickly. These simplifications were made to ensure an answering rate as high as possible. None of the questions were mandatory to answer. In that way, participants could answer the questions they knew the answer to and skip the rest, so that as much information as possible could be extracted from the results. A link to the online survey was sent to relevant stakeholders, chosen by the entire COFRET project consortium to ensure the quality of the results as well as the coverage of different stakeholder groups. In total 419 e-mail addresses were compiled into a mailing list of online survey invitees. Within the answering period of 10 weeks, 62 answers were registered. This constitutes a response rate of 14.8%. Represented were the logistics service providers and transport operators (13 answers from each), researchers and consultants (15 answers) and manufacturers, wholesalers and and retailers (11 answers). Other user groups identified were terminal operators and governmental authorities. The survey was also available on the COFRET website, with an open invitation for any interested party to take part in. However no answers were received through this channel, only answers from the e-mail sample were used for the analysis.

Both the in-depth interview questionnaire and the online survey questionnaire were structured of three sections, with questions trying to answer respectively:

- who the main users of emission data are
- why stakeholders may feel that there is a need for an emission calculation tool
- what the technical specifications and accuracy requirements in a desired tool should be.

Besides mapping the status quo and future aspirations, an objective of Task 2.3 was to identify what the users of emission calculation tools consider to be the most important gaps in the current tools and methodologies used, based on their experience.

Results from Task 2.3 are reported in deliverable D 2.2 [12] (see Table 1 on page 2).

2.2.2 Main findings

Here the main results derived from the in-depth interviews and online survey are summarized by topic.

User motivations: The interviews and the survey indicate that there is a wide variety of interest in *green logistics* (environmentally sustainable logistics) among stakeholders. Some stakeholders will only take the measures forced upon them, while others are either concerned about the sustainability of the logistics sector or ready to exploit the marketing potential green logistics involves. However, most of the respondents expressed a real need for a common methodology, standardized emission factors and transparent calculations.

Important reported motivations for an emission calculation tool from the interviews were (a) internal performance monitoring, (b) to increase energy efficiency, (c) environmental awareness, (d) annual company reporting and (d) requests from customers. The most explicit motivations from the survey were (a) to increase energy efficiency, (b) marketing purposes, (c) environmental awareness and (d) internal performance monitoring.

Use of emission calculation tools: For the interviews, 24 participants corresponding to 83% of the sample replied to be using an emission calculation tool. For the online survey, 46 participants, corresponding to 74%, reported to use a tool for emission calculations. 87% of these interviewed stakeholders stated that the tool they are using is internally developed. That means that a methodology is necessary to refer to a common approach. Otherwise it could become a problem that stakeholder solutions to calculate the carbon footprint are not comparable and different service providers report different sized carbon footprints for identical logistics services. In addition, a wide range of different data sources are used in the emissions calculations by different companies. Because of the extent of these data sources and the fact that most companies want an internally developed, more specialized tool, a considerable amount of effort needs to be put into creating a common framework for calculations to coincide as much as possible with current practices. For the online survey, 70% of participants with a calculation tool have an internally developed tool, while 30% only use tools that are externally created.

The survey indicates that stakeholders requesting emission data prefer to consult researchers instead of transport operators, logistics service providers or other firms directly involved with the supply chain. This may indicate lack of trust in the emission figures from companies with financial interests in the supply chain operations and therefore a demand for a common emission calculation standard.

When to calculate emissions: For the online survey, calculating emissions *after the transport* is most important (80%), and calculations *before the transport* are desired by 60%. A smaller but still significant fraction of the respondents desires a tool that can calculate emissions *during the transport* (28%).

Technical specifications: The interviews indicated that the gap between desired requirements and currently implemented technical specifications is significant for almost all of the areas covered in the questionnaire. The online survey did not ask for current implementations; however desired requirements were reported. Emerging issues around the following topics are addressed in detail in the task deliverable:

- emission output
- supply chain elements
- level of calculation
- loading units
- mode of transport.
- vehicles and equipment types covered
- accuracy requirements.

2.3 Stakeholder workshop

2.3.1 Overview

Task 2.2 *Organisation of stakeholder workshop* took the analysis of user needs (Task 2.3) further, by inviting a selection of users of carbon footprint calculation tools to Berlin in January 2012. The workshop participant line-up of 17 external stakeholders consisted of e.g. shippers, logistics providers, international shipping lines and representatives from not-for profit organisations. The workshop was organized after receiving the majority of answers for the in-depth interviews and the online survey in order to enable deeper discussions into the issues, concerns and problems identified.

This first COFRET workshop was titled to address *the user needs for a globally harmonized carbon footprint calculation methodology for freight transport*. The event started with motivational presentations from two stakeholders. The actual workshop was arranged in parallel sessions, by dividing the participants in two groups. In the first group the discussion followed a semi-structured template with questions concerning the different elements of a calculation methodology. In the second group the discussion had a more open format. Results from Task 2.2 are reported in deliverable D 2.2 [12] (see Table 1 on page 2).

2.3.2 Main findings

In this section the main results derived from the workshop are summarized by topic.

Current practices and user needs: Four reasons were identified for why users calculate their emissions as a part of implementation of their sustainable strategies: (1) to increase energy efficiency, (2) for internal controlling, (3) for their customers on different levels (e.g. product level reporting and marketing uses) and (4) to see the effect of different company initiatives on the carbon footprint. The eight most important weaknesses with current practices in calculating emissions from supply chains can be summarized to (1) the fact that differences in calculation methods leads to incomparable results, (2) problems with data gathering, which is implying lack of primary data, (3) missing interfaces to tools used by (a) subcontractors, (b) other companies and (c) stakeholders in other countries, (4) developed or used tools focus only on one transport mode, e.g. road; now there is a need to improve the current tools to include other modes, (5) inconsistencies in the allocation of emissions to different elements and partners in the supply chain, (6) intermodal routing is inadequately covered by existing practices, (7) low transparency in existing practices and (8) that logistics processes currently included are often limited to transport processes only.

The CEN standard [7]**:** All participants agreed that a methodology for calculating emissions should be based on the forthcoming CEN standard. The importance of the European CEN standard is stressed by the fact that it could be established as an international ISO standard later on. In cases where the CEN standard gives two allocation options, the COFRET methodology should recommend the most preferable one to be more user friendly and give more comparable results.

Terminals and warehouses: In general there was an agreement that non-transport logistics operations need to be included in the calculation methodology. Assuming these operations are to be included, transport, warehouses and handling need to be defined as three separate elements, and three different methodologies needs to be worked out. Cooling should also be included in the transport methodology by clear allocation rules if the cooling device is provided with energy from the engine of a transport vehicle or vessel.

Level of calculation: Examples of three reported desired output levels are (1) company level, (2) network level (e.g. road, sea) and (3) a level where comparing high and low numbers is the same as comparing efficiency. This could for instance be emission per tonne km, or emissions per shipment or pallet for a particular route. However, it was recommended to report on the most disaggregated level, so that all other levels could be calculated accurately by means of aggregation. It was agreed that shipment level is the most disaggregated unit for the purpose of COFRET. Therefore, the most desired input in a calculation methodology should be shipment level.

Accuracy and input requirements: The COFRET methodology should be based on primary data sources, and default values should be avoided as much as possible. A calculation tool based on this methodology should also be able to notify about the level of detail of the input data. There are three main ways of doing this: (1) report uncertainty, (2) report the input data used or (3) have a punishing mechanism for bad data.

Other topics covered and further analysed in task deliverable included e.g.:
- geographical coverage
- subcontractors
- emission output
- various allocation issues
- last mile delivery (shopping trips and home delivery)
- loading units.

2.4 Potential future technologies

2.4.1 Overview

Task 2.4 *Future technologies and innovations relating to freight transport which are relevant for carbon footprint calculation* (June 2011 - February 2012) analysed new technologies and innovations in freight transport and logistics regarding their potential to improve the measurement and the calculation of carbon footprint of transport and logistics along the supply chain. The research method used was literature survey, based mainly on internet resources, and in some cases extended with interviews. A list of technologies and systems was prepared and circulated between the contributing COFRET partners, and an inventory was made of relevant technologies or technology areas and an assessment of their potential to improve carbon footprint measurement and calculation. The information and material collection was done by the task participants based on a structured review format. Results of the task, together with recommendations how to make use of them in the COFRET methodology development are reported in task deliverable D 2.3 [22] (see Table 1 on page 2). Also, barriers and important framework conditions to incorporate reviewed technologies are analysed.

Table 4 gives an overview of the analysed technologies and systems clustered in three main areas: **supply chain and transport planning systems**, **information and communication**

systems and **business applications**. The systems and technologies are classed with the components *plan, do and check* of the 4-step-management process plan-do-check-act (PDCA cycle) in freight and logistics processes. PLAN covers the planning phase in supply chain management and transport (ex ante). DO covers the operation phase and CHECK covers the controlling phase (ex post). Carbon footprinting can also take place, depending on the objective, within any of these three phases.

Table 4: Summary of technologies and systems in three clusters and their applicability in plan, do and check phases in the management process.

Technologies and Systems	**Management Process**		
	PLAN	DO	CHECK
Supply Chain and Transport Planning Systems			
Supply Chain Planning Systems	X		
Multimodal Transport Planning Systems	X		
Multimodal Tour Planning and Routing Systems	X	X	
Ordering / Dispatching	X	X	
Information and Communication Systems			
Positioning		X	X
Identification / Scanning (Tracking and Tracing)		X	X
Electronic Information Exchange	X	X	X
Internal Vehicle Systems		X	X
Business Applications			
ERP Systems (Enterprise Resource Planning)	X	X	X
Fleet Management Systems / Operations Management	X	X	X
Terminal Management Systems		X	X
Warehouse Management Systems	X	X	X

The investigated technologies and systems can contribute to the measurement or calculation of the carbon footprint of freight transport and logistics along the supply chain. The main contribution is the data and information collection and the measurement of key figures for the calculation process as shown in Figure 3.

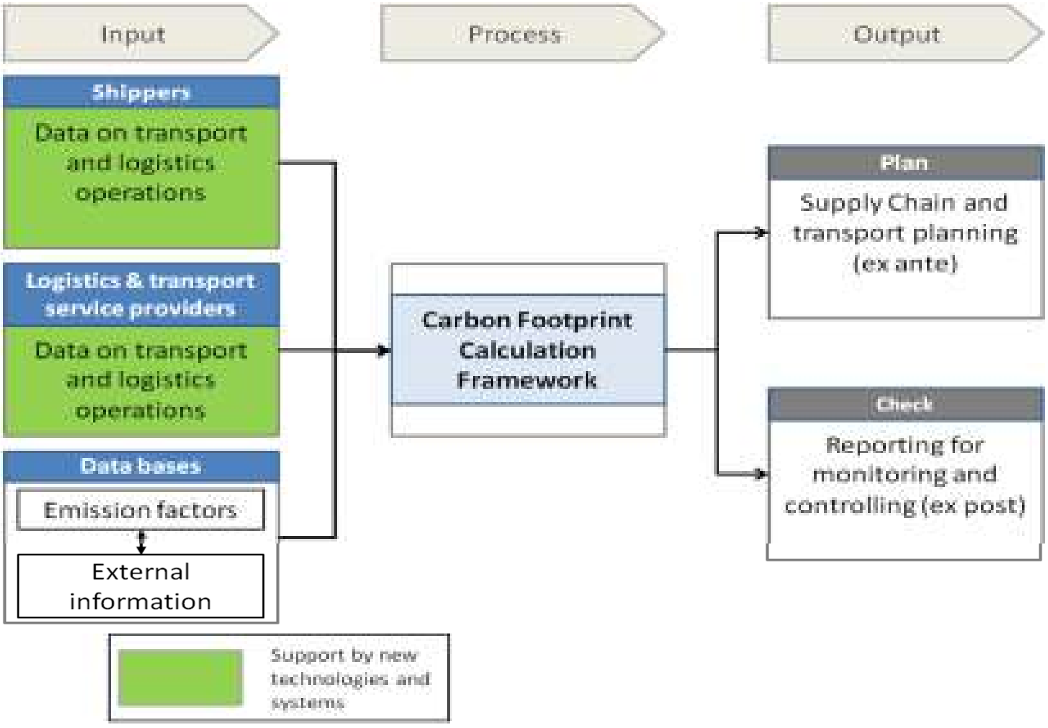

Figure 3. Contribution of new technologies and systems in the carbon footprint calculation process.

Table 5 shows the possible current contribution of each reviewed technology and system to carbon footprint measurement and calculation.

Table 5: Possible current contribution of new technologies and systems to carbon footprint measurement and calculation (M=values can be measured, C=values can be calculated).

Technologies and Systems	Distance / Route choice	Energy use	Amount/ weight of freight	Carbon footprint
Supply Chain and Transport Planning Systems				
Supply Chain Planning Systems			C	C
Multimodal Transport Planning Systems	C	C	C	C
Multimodal Tour Planning and Routing Systems	C	C		
Ordering / Dispatching	C	C	C	C
Information and Communication Systems				
Positioning	M/C			
Identification / Scanning (Tracking and Tracing)	C		C	
Electronic Information Exchange	C		C	(C*)
Internal Vehicle Systems	M	M		C
Business Applications				
ERP Systems (Enterprise Resource Planning)				C
Fleet Management Systems / Operations Management	C	C	C	C
Terminal Management Systems			M/C	
Warehouse Management Systems		C		

(*) only support for calculation due to standardisation of data

Table 6 summarises the parts of the supply chain that are covered by each technology and system. In addition, technologies expected to have the highest potential in the COFRET context are shown in italics.

Table 6: Parts of the supply chain covered by technologies and systems. In italics are the technologies expected to have the highest potential.

Technologies and Systems	**Whole supply chain**	**Trans-port processes**	**Trans-shipment / Ware-housing (nodes)**
Supply Chain and Transport Planning Systems			
Supply Chain Planning Systems	X		
Multimodal Transport Planning Systems		X	(X)
Multimodal Tour Planning and Routing Systems		X	
Ordering / Dispatching		X	
Information and Communication Systems			
Positioning	X		
Identification / Scanning (Tracking and Tracing)	X		
Electronic Information Exchange	X		
Internal Vehicle Systems		X	
Business Applications			
ERP Systems (Enterprise Resource Planning)	X		
Fleet Management Systems / Operations Management		X	
Terminal Management Systems			X
Warehouse Management Systems			X

2.4.2 Main findings

The provision of accurate and reliable data is a critical step of carbon footprint calculation. From the review of new technologies and systems regarding the measurement and calculation of the carbon footprint of supply chains following conclusions were made:

- The investigated technologies and systems can contribute to the measurement and calculation of the carbon footprint of freight transport and logistics. The main contribution is the data and information collection and the measurement of key figures for the calculation process.

- Supply chain and transport planning systems have a medium to high potential to improve the carbon footprint calculation. Especially supply chain planning systems are valuable tools because they cover the whole transport and logistics chain. The other systems cover mostly only transport processes and sometimes processes at warehouses and terminals.

- Information and communication systems have a mostly high potential to improve the carbon footprint calculation. Positioning and Tracking and Tracing deliver important input data. Electronic information and data exchange is vital for data provision. Internal vehicle systems can contribute substantially to the measurement of the carbon footprint (e.g. digital tachograph). ICT provide the essential data on an IT platform to monitor carbon footprinting. Based on this high quality data credible calculations of supply chains could be realized.

- Business applications have a medium to high potential to improve the carbon footprint calculation. Especially ERP systems could be very valuable supporting the carbon footprint calculation process. They can cover the whole supply chain whereas other business applications focus only on transport or nodes (warehouses, terminals).

- Main benefits of the investigated technologies and innovations include improving the measurement, data collection, data quality and efficiency regarding carbon footprint measurement and calculation. This will enhance the comparability, transparency and credibility of carbon footprint calculations.

- There are still various barriers which hinder the implementation of new technologies and innovations in the industry. Because of the variety of systems within the freight industry (small companies with simple systems and big companies with complex systems) it is a challenge to link supply chain and transport planning systems, information and communication systems and business applications with carbon footprint calculation tools.

3 Discussion

This chapter captures the main contribution areas of WP 2 to the COFRET project. Firstly, the accomplishments are explained, with reference to contributing WP 2 tasks (see Table 1 on page 2). Secondly, open issues to be addressed in the next steps of the project are brought up with reference to the work packages in which they will be addressed.

3.1 Accomplishments

The following accomplishments crystallise the main contribution of WP 2 tasks:

- Terminology and scope when discussing carbon footprint of transport and logistics along the supply chain were clarified (Task 2.1).
- An up-to-date knowledge base of existing methods, tools and data was established (Task 2.1, Task 2.3).
- State-of-the-art and best available methods, tools and databases were identified (Task 2.1). These imply potential co-operation opportunities regarding further COFRET methodology development.
- User needs were clarified (Task 2.3).
- Confirmation with minor adjustments to the COFRET objectives and scope was achieved based on user needs analysis (e.g. inclusion of non-transport logistics operations in the calculation methodology) (Task 2.2, Task 2.3). This implies justification to the COFRET approach in general.
- Connections to the users were established and co-operation will continue along the COFRET methodology development phase (Task 2.2).
- Technologies and systems to calculate and measure carbon footprint were identified, as well as their contribution to carbon footprinting and related integration possibilities (Task 2.4).

All research conducted and results achieved in WP 2 are reported in detail in the task-specific COFRET project deliverables [2] [12] [22]. A list of WP 2 tasks and deliverables is shown in Table 1 on page 2. Together with this summarising deliverable, the three task-specific deliverables provide the necessary overview and knowledgebase on the current situation and on-going development in the topic of carbon footprint of transport and logistics.

3.2 Further issues

Concerning further work in the COFRET project, numerous issues to be addressed were identified along WP 2 tasks. These issues, detailed information on which can be found in task deliverables (see Table 1 on page 2), include the following (relation to other work packages is indicated in parentheses):

- Terminology and scope in the context of the COFRET methodology need to be further clarified and adjusted, if required (WP 3).
- Detailed definition and limitations need to be outlined in terms of e.g. application areas and use of the COFRET methodology, descriptions of methodology inputs and outputs and validation of input and output data in reporting (WP 3).

- It should be ensured that methodology development answers the identified user needs of the various stakeholder groups and addresses the most detailed and disaggregated level possible (e.g. shipment level) (WP 3).
- Opportunities and possible benefits of integration between best available methods, tools and databases (top twenty) and the COFRET methodology development should be examined further; it needs to be investigated how the various logistics operations along the supply chain can be linked by the means of available methods, tools and databases (WP 3, WP 4, WP 5).
- A balance needs to be found concerning the user requirement for high flexibility of the methodology e.g. regarding the variety and accuracy of input data (WP 3). However, practical challenges in data gathering in the current setting should not compromise the primary objectives of the COFRET methodology. Issues such as lacking primary data need to be acknowledged and addressed even though they are not the dominant element in the COFRET methodology development.
- Opportunities and possible benefits of integration between technology systems and innovations and the COFRET methodology development should be examined, including interfaces between the calculation tools and systems (WP 3, WP 4, WP 5). In addition to the current state, expected future technological developments should be considered together with future upgrades of the COFRET methodology after the project.
- It should be ensured that the COFRET methodology will be compliant with e.g. the forthcoming CEN standard [7] and GHG Protocol [27], but at the same time open issues in these schemes should be eliminated in the COFRET approach (WP 3, WP 6). This will be achieved by continuous updates and close cooperation with the CEN standard working group. Compliance will promote harmonisation and acceptance.
- Active participation in the evolving environment needs to continue e.g. in form of follow-up on progress in the area and continued communication with stakeholders, most importantly tool users and tool and methodology developers (WP 3, WP 7). Timing of the on-going COFRET methodology development and future COFRET methodology upgrades need to be contemplated in the context of other initiatives and activities.
- Decisions need to be made concerning such technical details in methodology development as (WP 3, WP 4):
    - calculation output of both absolute and relative emissions
    - allocation of emissions to the transported goods (relative emissions)
    - allocation of emissions to different logistics operations along the supply chain and to different partners in the supply chain
    - applicability of calculation methodology for different uses (e.g. ex-ante vs. ex-post, procurement vs. customer or internal reporting); two or more separate approaches within the COFRET methodology may be required to meet the needs for both planning-phase and reporting- or monitoring-phase calculations
    - time averaging decisions
    - comparable inclusion of non-transport processes
    - system boundaries (e.g. last mile delivery)
    - VAT (value added tax) analogy in carbon footprint reporting
    - interfaces to information systems
    - interfaces to tools used (a) by subcontractors, (b) in other companies and (c) in other countries

    - uncertainty and sensitivity of calculation input and output.
- To support the COFRET methodology under development, suggestions for deployment strategies and models to involve relevant actors along the supply chain need to be outlined (e.g. how to involve subcontractors and how to take into account matters of confidentiality) (WP 3, WP 5). This includes up-keep of the discussion around the benefits of the proposed COFRET methodology, and how it enables harmonisation and transparency in methodological aspects as well as promotes interoperability between different user groups and their tools. Importance of dissemination activities to ensure acceptance and deployment need to be stressed.
- Technical systems which improve data availability and accuracy and the integration of carbon footprint functions in the enterprises IT-environment should be further examined, put to use (WP4, WP5, WP6) and disseminated (WP7).
- The findings on user needs should be used when evaluating the COFRET methodology in order to prove that the methodology meets the user requirements. Also, it needs to be shown which contradictory or otherwise problematic views could not be incorporated in the methodology (WP 6).

References

[1] ADEME 2010. Bilan Carbone. Companies – Local Authorities – Regions. Methodology guide (version 6.1), Paris.

[2] Auvinen, H., Mäkelä, K., Lischke, A., Burmeister, A., de Ree, D. & Ton, J. 2011. Existing methods and tools for calculation of carbon footprint of transport and logistics. Deliverable 2.1, the COFRET project (Carbon Footprint of Freight Transport).

[3] Cenex 2010. Fleet carbon reduction guidance.

[4] Connekt 2010. Zicht op CO2. Handreiking berekenen CO2 en andere emissies in logistiek.

[5] DEFRA (The Department for Environment, Food and Rural Affairs) 2011. DEFRA greenhouse gas conversion factors [Online]. Accessible at: http://www.defra.gov.uk/environment/economy/business-efficiency/reporting/

[6] DEFRA (The Department for Environment, Food and Rural Affairs) 2010. Guidance on Measuring and Reporting Greenhouse Gas (GHG) Emissions from Freight Transport Operations.

[7] European Committee for Standardization (CEN) 2011. prEN 16258:2011 *Methodology for calculation and declaration on energy consumptions and GHG emissions in transport services (good and passengers transport)*. Working Draft. Brussels.

[8] IFEU Heidelberg, Öko-Institut, IVE & RMCON 2010. EcoTransIT World. Ecological Transport Information Tool for Worldwide Transports. Methodology and Data. Commissioned by DB Schenker Germany & UIC (International Union of Railways).

[9] International Organisation for Standardisation (ISO), 2011. ISO/CD 14067.3 *Carbon footprint of products. Requirements and guidelines for quantification and communication*. Working Draft.

[10] IPPC (The Intergovernmental Panel on Climate Change), 1996. Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

[11] IPPC (The Intergovernmental Panel on Climate Change), 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

[12] Johansen B. G., Eidhammer O. & Platz T. 2012. User needs, practices and experiences in the context of carbon footprint calculations in supply chain configurations. Deliverable 2.2, the COFRET project (Carbon Footprint of Freight Transport).

[13] Joint Research Centre, Eucar & Concawe. 2007. Well-to-wheels analysis of future automotive fuels and powertrains in the European context. Well-to-wheels report. Version 2c, March 2007.

[14] Joint Research Centre, Eucar & Concawe. 2008. Well-to-wheels analysis of future automotive fuels and powertrains in the European context. Tank-to-wheels report. Version 3, October 2008.

[15] Keller, M., de Haan P., 2004. Handbuch Emissionsfaktoren des Straßenverkehrs 2.1, Dokumentation. Bern, Heidelberg, Graz, Essen, 30 July 2004.

[16] Knörr, W. et.al. 2010. Fortschreibung und Erweiterung “Daten- und Rechenmodell: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland

1960-2030“. TREMOD, Version 5, Endbericht. Heidelberg 2010. [Online] Available: http://www.ifeu.de/verkehrundumwelt/pdf/IFEU(2010)_TREMOD_%20Endbericht_FKZ%203707%20100326.pdf

[17] Ligterink, N. et al. (2009). Refined vehicle and driving-behaviour dependencies in the Versit + emission model. ETAP 2009.

[18] Mäkelä, K. & Auvinen, H. (2010). LIPASTO website - a calculation system for traffic exhaust emissions and energy consumption in Finland. [Online] Accessible at: http://lipasto.vtt.fi

[19] Network for Transport and Environment, NTM (2010). NTM Calc website. [Online] Accessible at: http://www.ntmcalc.se/index.html

[20] Paganelli, Paolo, 2011. Roadmap on ICT for Sustainable Freight Transport and Logistics. Draft, version 0.3, August 2011.

[21] Roar Norvik et al, 2011. Grønn godstransport. SINTEF.

[22] Ruesch M., Schmid T., Bohne S., Auvinen H., Platz T., & Lischke A. 2012. Future technologies and innovations relating to freight transport which are relevant for carbon footprint calculation. Deliverable 2.3, the COFRET project (Carbon Footprint of Freight Transport).

[23] Schmied, M. & Knörr, W 2011. Berechnung von Treibhausgasemissionen in Spedition und Logistik. Publisher DSLV Deutcher Speditions- und Logistikverband e.V.

[24] SmartWay Europe Initiative 2011. Towards a multi-industry voluntary programme for monitoring and reporting of carbon emissions in road transport. Green Freight Seminar, Beijing / China 24 May 2011. [Online] Accessible at: http://cleanairinitiative.org/portal/sites/default/files/presentations/Bjoern_Hannappel_-_DPDHL_-_SmartWay_Europe_Initiative_-_May2011.pdf

[25] SmartWay Transport Partnership 2011. SmartWay Transport Overview. USEPA 2011. [Online] Accessible at: http://www.epa.gov/smartway/

[26] Vestlandsforskning, 2010. Transport, energy og miljø, transport emission database. [Online] Accessible at: http://transport.vestforsk.no/

[27] World Resources Institute & World Business Council for Sustainable Development, 2011. Product Life Cycle Accounting and Reporting Standard. Greenhouse Gas Protocol.

[28] World Resources Institute 2008. GHG Protocol tool for mobile combustion. Version 2.2.