Measuring the Carbon Footprint of Freight and Logistics Activity along Supply Chains

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Introduction

Targets have been set by industrialized countries and regions to reduce their total annual Green House Gas (GHG) emissions, so as to keep impacts of climate change at a manageable level. With reference to freight transport and logistics activities, emissions must be estimated and controlled at the policy side as well as by the shippers, logistics and transport service providers and consumers. Governments need information on carbon emissions for the whole transport sector to stimulate the use of new energy efficient technologies, improve mode choice behaviour in favour of more energy efficient modes and include energy considerations in devising their transportation plans. Businesses need to control processes not only by economic but also by environmental parameters to support their corporate environmental responsibility strategies. Transport and logistics service providers use carbon emissions information for internal performance monitoring, environmental awareness and company reporting purposes, and to increase their energy efficiency. Consumers have an increasing demand for eco-friendly, carbon neutral products. To meet the freight transport and logistics sector stakeholder needs, various measurement tools have been developed and used to measure carbon emissions within various elements of the supply chain. Several such tools reliably estimate transport emissions at a national level in the economic and private sectors. Any company that organizes transport itself, for example, can measure its carbon emissions on the basis of the amount of fuel used by its vehicle fleet. However, the majority of companies and supply chains operate in a mixed setting, where at least some transport processes are outsourced, and others are not under control of a single company. For such complex supply chains, which may involve different transport modalities and supply chain configurations, emissions are difficult to estimate. The available tools provide an extremely valuable starting point. However, there are many inconsistencies related to which greenhouse gases and supply chain elements are taken into account and which modes are considered. A global standard for the calculation of CO2 and CO2-equivalents (CO2e) aligning the best practice elements in a neutral approach and being applicable for all forms of supply chains and modes of transport is required. Such a global standard will enable establishment of actual emissions levels and provide a basis for comparison between various supply chains, and over time. COFRET, a collaborative research and demonstration project co-funded by the European Commission, aims to address this need. The objective of the COFRET project is to develop and test a harmonised methodology and give a framework for the accurate calculation of the carbon footprint of transport and logistics along the full supply chain (Johansen et al., 2012). Based on the findings of a thorough user-needs assessment and the review of existing methodologies, tools and databases, the key elements and most important items for a streamlined, harmonized methodology have been identified and are presented in the following in order to derive a contribution to the development of a framework for standardized CO2 and CO2e calculation and reporting schemes

State of the Art of CO2 emission calculation – an Analysis of existing tools, methods and databases

In order to provide a foundation for building a complete GHG emission calculation methodology for complex supply chains based on available calculation tools for CO2 emissions, a total of 102 currently existing items have been identified and reviewed within the context of the COFRET project. A comprehensive review and comparative assessment of these items has been performed using a structured approach. The items reviewed are classified as (a) carbon footprint methodologies, (b) carbon footprint calculation tools, (c) emission factor databases, or (d) other activities and initiatives. The criteria used in their assessment include the transport modes, vehicles and equipment covered, supply chain elements and logistics operations

considered, emission compounds and life cycle phases covered, and geographical and methodological approaches and data sources used. This categorisation of the items was defined as follows:

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. In the course of the review process around twenty items classified as carbon footprint methodologies were identified and examined. These methodologies were divided into three groups. The first, and most important group, consists of standards and standard-like guidelines that are widely accepted and in use. The second group comprises guidelines that focus especially on transport or logistics and the third group covers industry-led schemes and programmes.

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. The number of carbon footprint calculation tools of various types was significant, and almost forty of them were selected for the review process. The level of detail, coverage and scope, not to mention quality in terms of transparency, credibility and reliability, varied significantly among these tools. Prioritisation was exercised in order to limit and focus the review on tools relevant to the COFRET objectives. From this point of view, the tools reviewed were divided into three categories:

1. publicly accessible, best available tools covering all modes,
2. company-internal and commercial tools, and
3. miscellaneous tools. This last category consists of tools that are considered relevant but are somehow lacking in terms of, for example, coverage, scope or objectives.

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. Emission factor databases were considered in two rough groups: databases providing basic data on vehicle and fuel technologies, and databases providing further refined data on transport performance. The number of databases offering carbon footprint related information regarding transport and logistics is large, but the number of original data sources which are often referenced and/or further processed by others is much smaller. These original sources (around a dozen) were considered to be most relevant and hence thoroughly examined during the review process, with the selection based on their originality, scope and number of references made in other items.

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.

Strength and Open Issues of Existing CO2 Emission Calculation Approaches

The reviewed methodologies were commonly based on a life cycle approach. However, the level of precision and detail varies, and there are significant methodological gaps regarding the inclusion of all transports and logistics along the entire supply chain. Furthermore, loose guidance that allows the user to choose from and use a range of numerous alternatives, for example rules regarding allocation of emissions to different shipments on the same vehicle, is common and leads to confusion and lack of comparability. In contrast, the number of carbon footprint calculation tools and data sources is significant, as is the variation in quality in terms of coverage and originality. The use of these tools and data, all of which seem to interpret seemingly uniform carbon footprint methodology in different ways, 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).

The coverage and assessment of reviewed items against the COFRET evaluation criteria is summarized in the following table.

TABLE 1: Evaluation Criteria and Coverage within the COFRET evaluation

Evaluation criteria	Coverage / assessment
Transport modes, vehicles and equipment	The four basic transport modes and relevant vehicles are all well covered by methodologies, tools and data respectively, whereas comparability is a problem. Most detailed and advanced applications are available for road transport. Working machines (e.g. industrial vehicles and mobile machinery) are covered in lesser detail.
Logistics operations and supply chain elements	Methods, tools and data largely focus on the transport phase. Other logistics operations (e.g. loading and unloading, transshipment, storage and terminals) are rarely included, even though the need to allocate impacts of these operations to the product or transport service is acknowledged.
Phases of the life cycle (of a transport service)	Tools and data typically address the transport phase only. However, the methodological side is likely to direct them towards inclusion of upstream energy processes. Instead, life cycle phases taking e.g. transport infrastructures or vehicle manufacturing into account are not seen relevant under this scope. WTW and TTW approaches are supported.
Emission compounds	Typically the three focal greenhouse gases (CO_2, CH_4 and N_2O) are addressed. Some carbon footprint applications, however, still limit calculation to CO_2 only, based on it being the main contributor. Other greenhouse gases are rarely included. On the other hand, certain other air emissions are often provided, as environmental impacts other than climate change are often being addressed simultaneously (e.g. HC, NOx and PM emissions, relevant in air quality issues).
Methodological ambition	In general, tools (and data) refer and resort to established, widely accepted methods (programs, initiatives and standards) and use them together even though comparability remains questionable (e.g. due to variability and freedom of choice in many methodological aspects such as allocation). Methodological shortcuts and lack of transparency are significant problems.
Referenced methods and data	The methods and data referenced by other items seem to converge to a reasonable number of established, widely accepted standards, guidelines and databases.
Relevant calculation context	Methods, tools and data are available through the spectrum of the scope (e.g. shipment, company, vehicle and policy-oriented) and level of detail. Scope and level of detail relevant to the supply chain approach are available.
Geographical context	Limitation in applicability beyond national context is one of the most common weaknesses. Collaboration towards comparable systems with neighbouring countries, the whole of Europe and worldwide are needed.
Publicity and availability	Methods, tools and data are widely available free-of-charge and the commercial solutions are reasonably priced. Instead of financial and publicity aspects, language limitations are a bigger barrier in terms of accessibility and availability.

From the point of view of the COFRET objectives, the main gaps identified in the review of carbon footprint methodologies, tools and databases include the following:

- In spite of the importance of extending calculations over all transport and logistics along the supply chain, most items only concentrated on the transport operation as performed by a specific actor (for example a logistics service provider). Other parts of logistics (transport performed by other actors and non-transport logistics operations) were usually neglected or completely excluded.
- Whereas the methodological side requires the inclusion of upstream energy processes, this has not yet reached the tools and databases, where the WTT part is often missing.

It is, however, acknowledged that full WTW analysis is required to enable comparability, especially when non-fossil energy sources are used (for example road transport biofuels or railway electric traction).

- Only a few items were able to include all transport modes, and even if they were, differences often showed between modes regarding the level of precision.
- In general, road transport was both the best covered mode and the mode with most detailed methods, tools and databases. Also, road transport is where most commercial applications and business solutions for carbon footprinting are available.
- Most databases and tools were geographically limited, focusing typically on the national context. Even among the internationally initiated items only the most advanced few were applicable to the whole of Europe or globally. Furthermore, ambitions in the national context varied a lot and little co-operation between countries, for example to set up comparable databases, could be identified.
- The opportunities to adjust data and the data items used in tools to reflect the actual transport conditions (for example actual load factors, specific vehicle characteristics, location-based characteristics and empty trips) were few.

How Close Are We to a Common Approach?

Initial attempts to address the problem of incomparability have been taken through standardisation initiatives such as CEN/TC 320/WG 10, which has produced a draft European norm (EN 16258) for calculation of the carbon footprint of transport services, and the ISO 14064-1:2006 which considers transport and logistics operations. EN 16258:2012 will be the first standard for the transport sector and will be announced at the end of 2012. EN 16258 is expected to have a major impact towards harmonisation, and our analysis showed many tools and methods already consider EN 16258 as of utmost importance, particularly as it could be proposed for development as an international ISO standard.

From a supply chain perspective these emerging standards are a first step and still allow for alternative ways of allocating and calculating emissions, within certain boundaries, and the use of different sources of default data. Additionally they do not consider either the full logistics operations or all transport elements of a supply chain. The lack of one Europe-wide or, more significantly, a globally applicable standard therefore remains.

To supplement the general review of the state of the market, 40 interviews conducted with a range of transport companies and shippers showed that, in practice, in-house tools are often developed and used, so that a wide variety of different calculation methods and data sources is used for the emissions calculations by different companies. Due to the variety of these methods and data sources, and considering that most companies prefer an internally developed tool that meets their own specific requirements, a lot of effort needs to be put into creating a common framework for calculations to coincide as much as possible with current practices (Auvinen et al., 2012). Nevertheless, it can be argued that among the existing methods, tools and databases suitable elements for calculation of carbon footprint of transport and logistics along supply chains already exist, even though a harmonised framework is currently missing (Auvinen et al., 2012).

The results of the surveys and workshops provided some key pointers for the development of the COFRET methodology, which can be summarised as follows:

- The need for an approach to carbon footprint calculations that can be applied consistently across all modes
- A methodology that will allow transparent comparison between different transport providers and supply chain options
- Data requirements which draw as much as possible on simple data from existing systems
- Additional guidance to improve the credibility of results, even within existing standards
- Consistency between emerging European standards and future global standards

Four reasons were identified for why users calculate their emissions:

(1) to increase energy efficiency,
(2) for internal controlling, (e.g. managing detailed information from subcontractors)
(3) for their customers on different levels (e.g. product level) and

(4) to see the effect of different company initiatives on the carbon footprint (e.g. modal choice comparisons for the same shipment).

The most important weaknesses with current practices were summarized as:

(1) differences in calculation methods lead to incomparable results,
(2) data gathering, including lack of primary data,
(3) missing interfaces to tools used (a) by subcontractors, (b) in other companies and (c) in other countries,
(4) developed or used tools focus only on one transport mode e.g. road, now there is need to improve the current tools to include other transportation modes,
(5) allocation of emissions to different supply elements and partners in the supply chain, such as different shipments in the same vehicle,
(6) intermodal routing,
(7) the need for increasing transparency, and
(8) the limitation to transport processes (not covering warehousing, terminals).

Summarising, a further standardisation of CO2 emission calculations on a global level is urgently needed.

Next Steps and Outlook

The majority of the reviewed methodologies, calculation tools and databases provide estimations at vehicle or regional level. Vehicle level implies a way to estimate emissions related to a vehicle movement between a certain origin and destination pair, which are normally characterized by the distance between them. For regional emissions, traffic throughout the infrastructure network and the sum of emissions over all vehicles form the basis for the emission calculation. COFRET, however, aspires to calculate shipment emissions, which requires the allocation of emissions of a single vehicle to individual shipments on the basis of weight, volume or other capacity constraints.

In order to achieve this, two essential challenges need to be overcome:

- firstly, basic flow imbalances for example between European countries and the countries of East Asia, resulting in flows of empty containers or partly loaded vehicles in eastbound directions.
- secondly, the allocation of vehicle emissions to individual shipments causes a challenge, especially regarding pickup and distribution tours. These are characterized by a relatively large number of stops, where goods are offloaded and picked up as shipments have different origins, destinations or both.

The COFRET project has a two-fold objective: on the one hand to develop a methodology to calculate the carbon footprint of global supply chains (which is the main focus of this paper) and on the other hand to strive for maximum recognition of the COFRET methodology in the logistics industry as the harmonised approach that it craves. This paper therefore finishes with an outlook in how far the method of the COFRET-project provides for a viable approach to contribute to a new global standard for the calculation of emissions along supply chains.

The research conducted with transport providers and shippers emphasizes the need for simplicity and practicality within potentially complex supply chains. Future use of the resulting methodology will depend on awareness and acceptance of the methodology and its applicability in real-life situations. With this in mind COFRET has prioritized communication and partnering as a key component of its activities through four main avenues:

- Ensuring representation of key industry partners on the COFRET Advisory Board and within the project case studies.
- *Establishing dialogue and partnership* with existing initiatives and taking an inclusive approach to harmonizing the future methodology development.
- Taking steps to present and publicize COFRET to as wide a range of organizations as possible.
- Identifying international channels for the dissemination and exploitation so that the global potential is maximised.

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