Guidelines for Measuring and Managing CO_2 Emission from Freight Transport Operations

ISSUE 1 / MARCH 2011

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TABLE OF CONTENTS

1. INTRODUCTION …… ………………………………………………………………….. 2

2. OBJECTIVES AND SCOPE ………………………………………………………………. 2

3. GENERAL FRAMEWORK FOR MEASURING AND MANAGING OF TRANSPORT EMISSIONS ………………………………………………………….…. 3

4. MEASURING OF TRANSPORT EMISSIONS ……………………………………………. 3

4.1. CALCULATION METHOD ………..…………………………………………………. 3

4.2. AVERAGE EMISSION FACTORS FOR THE DIFFERENT TRANSPORT MODES AND ASSOCIATED ASSUMPTIONS ………………………………….. 5

4.3. CALCULATION TEMPLATE ……………………………………………………12

5. MANAGEMENT OF TRANSPORT EMISSIONS: OPPORTUNITIES TO REDUCE CO_2 EMISSIONS…………..……………………… 13

Disclaimer

This document is intended for information only and sets out guidelines for measuring and managing transport CO_2 emissions. The information contained in these guidelines is provided in good faith and, while it is accurate as far as the authors are aware, no representations or warranties are made about its completeness. It is not intended to be a comprehensive guide to all detailed aspects of transport CO_2 emissions. No responsibility will be assumed by the participating associations, Cefic and ECTA, in relation to the information contained in these guidelines.

1. INTRODUCTION

Transport (freight and passenger transport) accounts for 20% of all EU GHG emissions. The share of transport emissions is continuously increasing and could reach more than 30% of total EU emissions by 2020 if no action is taken. Emissions from freight transport account for approximately one third of total transport GHG emissions. 93-95% of GHG emissions from transport operations is accounted for by CO_2 emissions.
Significant efforts have already been made by industry to improve the energy efficiency of freight transport. These gains in energy efficiency have however not been sufficient to outweigh the growth in emissions caused by larger transport freight volumes, due to a strong increase in global trade and the further integration of the enlarged EU.

To meet the ambitious EU carbon reduction targets for 2020 and beyond, the reduction of CO_2 emissions from transport is already receiving a lot of attention and can be expected to receive even more attention in the coming years. Consequently, in order to contribute to the required GHG emission reduction targets, industry sectors will need to develop decarbonisation strategies for their logistics operations over the next few years. The chemical industry, representing less than 10% of total freight emissions, has adopted a pro-active approach in reducing the environmental impact of its logistics activities, in close cooperation with its logistics service providers.

Efforts have been made internationally to standardize the measurement and reporting of these emissions in order to ensure consistency, but up to now there is no single internationally agreed calculation method. CEN is developing a European standard for measuring emissions from transport services. This standard is expected to become available in 2012.

Numerous studies have been undertaken over the past 20 years to develop emission factors for the different modes of transport. None of these reports provide a comprehensive set of emission factors which can be used by the chemical industry. They vary in their coverage of the different freight transport modes, the extent to which they differentiate by vehicle type and power source and in the assumptions they make about vehicle loading. It is therefore necessary to ‘cherry-pick’ in compiling an appropriate set of emission factors for chemical transport operations.

In order to allow chemical companies and transport companies to identify further opportunities for improving the performance of their freight transport operations, an understanding of their current transport carbon footprint is needed. By developing a common calculation methodology, individual companies will be able to carry out a self-assessment of their emissions in a uniform way that is comparable across the industry.

These guidelines have been prepared by an issue team composed of Cefic and ECTA member companies.
Section 2 outlines the scope and objectives of the issue team. Section 3 provides a generic 5-step approach to set into motion and pursue a green logistics action program. Section 4 then provides a simple yet sufficiently accurate method for the calculation of CO_2 emissions from freight transport operations, which can be used as a basis for internal and external reporting. It will allow companies to establish the baseline, against which the effects of efforts to reduce CO_2 emissions from freight transport operations can be assessed. Section 5 provides a generic overview of opportunities and approaches for companies to reduce CO_2 emissions.

2. OBJECTIVES AND SCOPE

The objectives of these guidelines are twofold:

- Development of a common, simple, but sufficiently precise method for the calculation of CO_2 emissions from freight transport operations, allowing the chemical industry sector and individual chemical and transport companies to determine their transport carbon footprint (section 4);
- Assessment and promotion of industry best practices that offer opportunities to reduce transport emissions, primarily focusing on all modes of intra-European transport (section 5).

The scope of these calculation guidelines is limited to transport operations. Other logistics activities such as warehousing and handling are not covered.

3. GENERAL FRAMEWORK FOR MEASURING AND MANGING OF TRANSPORT CO_2 EMISSIONS

When developing a strategy and action plan to reduce transport carbon emissions, the following key steps should be considered by companies:

1. Establish the framework for your transport carbon reduction strategy defining the objectives, scope, time-frame etc.

2. Carry out a calculation of the baseline emissions (transport carbon footprint in the reference year).

3. Determine a realistic transport CO_2-emission reduction target and the timeframe during which it should be achieved (e.g. x % reduction in 2020 compared to the baseline). The reduction target can be absolute or relative:

    - absolute target: reduction by x % of the total transport carbon emissions

    - relative target: reduction by x % of the emissions per tonne of manufactured product (chemical companies) or reduction by x % of the emissions per tonne-km of transported product (logistics service providers).

4. Establish an action plan identifying concrete measures to reduce the transport carbon footprint to meet the reduction target.

5. Monitor progress and report year-on-year achievements.

4. MEASURING OF TRANSPORT EMISSIONS

These guidelines contain calculation methods for use by:

- chemical companies (activity-based approach)
- transport companies (energy-based approach in combination with an activity-based approach for sub-contracted activities).

4.1. CALCULATION METHOD

a. Activity-based approach (calculation method recommended for use by chemical companies)

Since the vast majority of freight transport operations of the European chemical industry are outsourced, most shippers have no direct access to energy or fuel consumption data. In the absence of such data, shippers can estimate CO_2 emissions of their transport operations by using an activity-based calculation method.

The activity-based method uses the following formula:

> 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]

It is important to select the most appropriate emission factor values for each mode of transport (see section 4.2).
To avoid double counting, only transport activities carried out under the control of the chemical company and for which the freight is paid for by the chemical company should be included in the calculation (e.g. customer self-collections are excluded).

b. Energy-based approach (calculation method recommended for use by transport companies)

The easiest and most accurate way for transport companies of calculating their transport emissions is to record energy and/or fuel use and employ standard emission conversion factors to convert energy or fuel values into CO_2 emissions. Carriers with direct access to fuel consumption data are therefore encouraged to collect all their fuel consumption data. Every liter of fuel consumed will result into a certain amount of CO_2 emissions.

The activity-based method uses the following formula:

> CO_2 emissions = fuel consumption x fuel emission conversion factor
>
> [Tonnes CO -emissions = liters x kg CO_2 per liter fuel / 1.000]

It is important for the carrier to use the correct emission conversion factor for the different types of fuel being used (see Table 1 below). Biofuels have lower emission factors than fossil fuels. In certain countries (e.g. Germany) it may be mandatory by law to use a percentage of biofuels within the fossil fuels. If the transport fuel is a blend of conventional fuel and biofuel, the value of the conversion factor shall be calculated by addition of the factor of each component weighted by the share of each component in the blend.

Table 1
Well-to-Wheel fuel emission conversion factors

Fuel type	kg CO_2/liter	kg CO_2/kg
Motor Gasoline	2.8	
Diesel Oil	2.9	
Gas Oil	2.9	
Liquefied Petroleum Gas (LPG)	1.9	
Compressed Natural Gas (CNG)		3.3
Jet Kerosene		3.5
Residual Fuel Oil		3.5
Biogasoline	1.8	
Biodiesel	1.9	

Source: CEN/TC 320/ WG 10 Methodology for calculation and declaration of energy consumptions and GHG emissions in transport services

Carriers with split operations (i.e. own fleet and subcontractors) should calculate their own fleet CO_2 emissions based on the energy based approach. If access to subcontractors' fuel consumption data is limited or incomplete, a calculation using the activity based approach may be recommended for the sub-contracted operations. For intermodal operations an activity-based approach is the best option.

4.2. AVERAGE EMISSION FACTORS FOR THE DIFFERENT TRANSPORT MODES AND ASSOCIATED ASSUMPTIONS

Chemical shippers will generally use an activity-based calculation method to estimate their transport carbon emissions. This calculation method is based on volumes, distances and emission factors for the different modes of transport. It is important to select the most appropriate emission factor values for each mode of transport. The shipper can use either a default average emission factor for each mode or emission factors specific for his operation.

The default average emission factors used in this guideline are based on the average emission factors recommended by professor Alan McKinnon, Heriot-Watt University, Edinburgh, UK in his report "Measuring and Managing CO_2 emissions" prepared for Cefic (see http://www.cefic.org/files/publications/McKinnon-Report-Final-230610.pdf).

Companies can use these recommended average emission factors as a default for the calculation of their transport emissions. It is however preferable for companies to use emission factors that are representative for the company's specific operations, reflecting the characteristics of their supply chains, transport vehicles, products and customer base.

The most important parameters determining the exact value of the emission factor for each mode of transport are:
- The load factor (payload) i.e. the degree of utilization of the maximum payload capacity of each transport unit;
- The share of empty running associated with positioning transport equipment to the next loading point;
- The energy efficiency of the vehicle, train or vessel. This is dependent on many factors such as engine design, characteristics of the vehicle, train or vessel, driving behavior, average speed, traffic conditions, road infrastructure, topography, etc.
- The carbon intensity of the energy source i.e. the amount of CO_2 emitted per unit of energy consumed, either directly by the vehicle's combustion engine or indirectly for

electrically-powered freight operations. For vehicles with combustion engines the carbon intensity will be dependent on the nature of the fuel (i.e conventional diesel, biofuels, LPG etc).

The following section identifies the assumptions made by McKinnon in determining the average CO_2-emission factor values for each mode of transport. By identifying the rationale behind these average values, individual companies do also have a basis to select the most appropriate values, if they want to make use of specific emission factors that better reflect their individual company situation or if they want to take into account the reduction effect as a result of specific company measures (e.g. increasing payload and/or reducing the portion of empty running).
For a more detailed outline of the underlying rationale determining the exact value of the recommended average CO_2-emission factors by mode of transport, please refer to the report of Alan McKinnon (http://www.cefic.org/files/publications/McKinnon-Report-Final-230610.pdf)

a. Road

The average CO_2-emission factor recommended by McKinnon for road transport operations is **62g CO_2/tonne-km**. This value is based on an average load factor of 80% of the maximum vehicle payload and 25% of empty running.
Individual companies can however use emission factors that better reflect the specific characteristics of their supply chains, products and customer base, by taking into account different payloads and levels of empty running (see table below).

Table 2
Carbon emission factors (gCO_2/tonne-km) for 40-44 tonne trucks with varying payloads and levels of empty running

Payload tonnes	% of truck-kms run empty										
	0%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
10	81.0	84.7	88.8	93.4	98.5	104.4	111.1	118.8	127.8	138.4	151.1
11	74.8	78.2	81.9	86.1	90.8	96.1	102.1	109.1	117.3	127.0	138.6
12	69.7	72.8	76.2	80.0	84.3	89.2	94.7	101.1	108.6	117.5	128.1
13	65.4	68.2	71.4	74.9	78.9	83.4	88.5	94.4	101.3	109.5	119.3
14	61.7	64.4	67.3	70.6	74.2	78.4	83.2	88.7	95.1	102.7	111.8
15	58.6	61.0	63.8	66.8	70.3	74.2	78.6	83.7	89.7	96.8	105.3
16	55.9	58.2	60.7	63.6	66.8	70.5	74.6	79.5	85.1	91.7	99.7
17	53.5	55.7	58.1	60.8	63.8	67.2	71.2	75.7	81.0	87.2	94.7
18	51.4	53.5	55.8	58.3	61.2	64.4	68.1	72.4	77.4	83.3	90.4
19	49.6	51.5	53.7	56.1	58.8	61.9	65.4	69.5	74.2	79.8	86.5
20	48.0	49.8	51.9	54.2	56.8	59.7	63.0	66.9	71.4	76.7	83.0
21	46.6	48.3	50.3	52.5	54.9	57.7	60.9	64.5	68.8	73.9	80.0
22	45.3	47.0	48.8	50.9	53.3	55.9	59.0	62.5	66.5	71.4	77.2
23	44.2	45.8	47.6	49.6	51.8	54.3	57.2	60.6	64.5	69.1	74.7
24	43.2	44.7	46.4	48.3	50.5	52.9	55.7	58.9	62.7	67.1	72.4
25	42.3	43.8	45.4	47.3	49.3	51.7	54.3	57.4	61.0	65.2	70.3
26	41.5	42.9	44.5	46.3	48.3	50.5	53.1	56.0	59.5	63.6	68.5
27	40.8	42.2	43.7	45.4	47.3	49.5	52.0	54.8	58.1	62.1	66.8
28	40.2	41.5	43.0	44.6	46.5	48.6	51.0	53.7	56.9	60.7	65.3
29	39.7	41.0	42.4	44.0	45.7	47.8	50.1	52.7	55.8	59.5	63.9

Source: Alan McKinnon, based on data from Coyle, 2007

b. Rail

The average CO_2-emission factor recommended by McKinnon for calculation of CO_2-emission from rail transport operations is **22 gCO_2/ tonne-km**. This value is based on an extrapolation of a range of emission factors reported by reliable sources across Europe (see Table 3), taking into account the following factors:

- the average split between diesel and electric haulage;
- the average carbon intensity of the electrical power source;
- the average energy efficiency of the locomotive;
- assumptions about average train load factors.

The emission factors for rail freight can however vary widely between countries depending on the carbon intensity of their electrical power and the split between electricity and diesel locomotives, making it difficult to establish a representative emission factor for the whole of Europe. For more information on country specific data see IFEU report (EcoTransIT, Ecological Transport Information Tool for Worldwide Transports - Methodology and Data, 2010).

Table 3

Published Emission Factors for Rail Freight Movement (gCO_2/tonne-km)

Organization	all rail freight	diesel-hauled	electric-hauled
ADEME	7.3	55	1.8
NTM	15	21	14
AEA Technology	20		
DEFRA	21		
INFRAS	22.7	38	19
TRENDS	23		
Tremove	26.3		
IFEU		35	18
McKinnon / EWS		18.8	

Source: Alan McKinnon

C. Inland Waterways

Using published data of average emission factors for barge movements on inland waterways (see Table 4 below), McKinnon is recommending an average value of **31 gCO_2/tonne-km**.

Table 4
Published Emission Factors for Inland Waterway/Barge Movements

Organisation	gCO_2 / tonne-km
INFRAS	31
TRENDS	31
Tremove	32.5
IFEU	28-35

Source: Alan McKinnon

In the process of establishing these guidelines additional more differentiated information in respect of CO_2 emissions factors associated with barge transportation has been identified. Table 5 provides specific emission factors, associated with different waterway conditions (upstream, downstream or canal) and vessel sizes. This allows to expand on the above emission values quoted by McKinnon.

Table 5
Barge CO_2-emission factors (gCO_2 / tonne-km)

Ship type	Upstream	Downstream	Canal
Container Barges *	**gCO_2/tonne-km**		
Small (90TEU)	63.4	31.3	44.5
Medium (208 TEU)	28.3	14.7	17.4
Large (500 TEU)	19.6	10.2	
Tank / Solid Bulk Barges 50% load factor**	**gCO_2/tonne-km**		
800 t	70.8	27.3	39.3
1250 t	62.6	24.1	34.3
1750 t	57.7	22.3	31.1
2500 t	46.0	18.1	25.8

Source
* Verkehrsrundschau 44/2009
** Verkehr im Umweltmanagement - Anleitung zur betrieblichen Erfassung verkehrsbedingter Umwelteinwirkungen – Sept 2009 based on Borken et al. 1999

The above data for tank/solid bulk barges, based on research from Borken et al. 1999, are the only data from a scientific source that could be found in respect of emission factors for tank/solid bulk barge transportation. More recent data from barge operators are indicating that technology has advanced, resulting in lower emission factors. However, given that such information is not backed up by data from a neutral third party, it was decided not to include these data.

d. Maritime Transport

Table 6, compiled by McKinnnon, gives an overview of published emission factor values for different types of maritime vessels.

Table 6
Published Emission Factors for Maritime Transport

	gCO_2/tonne-km	Source
Bulk ships		
Small tanker (844 tonnes)	20	DEFRA
Large tanker (18,371 tonnes)	5	DEFRA
Deep-sea tanker (120,000 tonnes)	5	NTM
Small (solid) bulk vessel (1,720 tonnes)	11	DEFRA
Large (solid) bulk vessel (14,201 tonnes)	7	DEFRA
Container vessels		
Small container vessel (2,500 tonnes)	13.5	DEFRA
Larger container vessel (20000 tonnes)	11.5	DEFRA
Average deep-sea container vessel	8.4	BSR/Clean Cargo
(assuming mean 11 tonne load per TEU)		
All maritime	**14**	**TRENDS**

Source: Alan McKinnon

For ***short-sea shipping*** McKinnon recommends an average emission factor of **16.0 gCO_2/ tonne-km.**

For **deep-sea shipping** Mckinnon is proposing an average of **8.4 gCO_2/tonne-km** for **container shipping** (based on a study carried out by Clean Cargo / BSR using a sample of nine deep-sea container shipping lines, making no allowance for the repositioning of empty containers). For deep-sea tanker operations McKinnon is recommending an average emission factor of **5 gCO_2 / tonne-km** (based on data provided by NTM).

In the process of establishing these guidelines additional more differentiated information in respect of CO_2 emissions factors associated with maritime shipping has been identified:
IMO published emission factors for various categories of ships (see Table 7 below). This allows to expand on the above emission values quoted by McKinnon.

Table 7
Estimates of CO_2 emission factors for cargo ships

Type of ship	Size	Emission factor (gCO_2 / tonne-km
Products tanker	60,000 + dwt	5.7
Products tanker	20,000-59,999 dwt	10.3
Products tanker	10,000-19,999 dwt	18.7
Products tanker	5,000-9,999 dwt	29.2
Products tanker	0-4,999 dwt	45.0
Chemical tanker	20,000 + dwt	8.4
Chemical tanker	10,000-19,999 dwt	10.8
Chemical tanker	5,000-9,999 dwt	15.1
Chemical tanker	0-4,999 dwt	22.2
LPG tanker	50,000+m^3	9.0
LPG tanker	0-49,999 m^3	43.5
LNG tanker	200,000+m^3	9.3
LNG tanker	0-199,999 m^3	14.5
General cargo	10,000+dwt	11.9
General cargo	5,000-9,999 dwt	15.8
General cargo	0-4,999 dwt	13.9
General cargo	10,000 + dwt, 100 + TEU	11.0
General cargo	5,000-9,999 dwt, 100 + TEU	17.5
General cargo	0-4,999 dwt, 100 + TEU	19.8
Refrigerated cargo	All	12.9
Container	8,000 + TEU	12.5
Container	5,000-7,999 TEU	16.6
Container	3,000-4,999 TEU	16.6
Container	2,000-2,999 TEU	20.0
Container	1,000-1,999 TEU	32.1
Container	0-999 TEU	36.3
Vehicle	4,000 + ceu	32.0
Vehicle	0-3,999 ceu	57.6
Ro-Ro	2,000 + lm	49.5
Ro-Ro	0-1,999 lm	60.3

Source: Second IMO Greenhouse Gas Study 2009

e. Intermodal Transport

Once a set of emission factors has been determined for individual transport modes, these values can be used to derive composite emission factors for intermodal operations. These composite values need to be weighted by the relative distances travelled for each of the modes in the course of the intermodal journey. Chemical companies often do not know the routing of intermodal consignments and hence the distance split between the modes.

Although there will be significant differences in the distance travelled by road in pre- or on-carriage as a portion of the total distance travelled, Table 8 below is showing a range of emission factors for different types of intermodal service with the road share of the total distance travelled varying from 5% to 20%. Until more data is provided by intermodal operators, McKinnon proposed to assume an average 10% road feeder distance (second column in Table 8).

Table 8
Composite Emission Factors for Intermodal Combinations (gCO_2/tonne-km)

Intermodal combination		Road distance as % of total			
		5%	**10%**	15%	20%
Road/rail	average railfreight	24.0	**26.0**	28.0	30.0
	electrified rail (EU average)	21.2	**23.3**	25.5	27.6
	diesel rail	25.9	**27.8**	29.7	31.6
Road/barge		32.6	**34.1**	35.7	37.2
Road/short-sea	ro-ro ferry - truck	49.7	**50.3**	51.0	51.6
	ro-ro ferry - rail	38.3	**39.5**	40.8	42.0
	small tanker (844 tonnes)	22.1	**24.2**	26.3	28.4
	large tanker (18371 tonnes)	7.9	**10.7**	13.6	16.4
	small bulk vessel (1720 tonnes)	13.6	**16.1**	18.7	21.2
	large bulk vessel (14201 tonnes)	9.8	**12.5**	15.3	18.0
	small container vessel (2500 tonnes)	15.9	**18.4**	20.8	23.2
	larger container vessel (20000 tonnes)	14.0	**16.6**	19.1	21.6
	all short-sea	18.3	**20.6**	22.9	25.2

Source: Alan McKinnon

f. Air freight

Published carbon emission factors for airfreight vary widely, reflecting differences in the length of haul and nature of the operation (see table 9 below). Two sources, WRI / World Business Council for Sustainable Distribution and NTM, have provided different emission factors for each distance range. As the mean length of haul for airfreight movements in the Cefic survey was 7000 kms, an average of the two long haul emission factors i.e. **602 gCO_2 / tonne-km** is proposed by McKinnon.

Table 9
Published Emission Factors for Air Transport

Short haul	Medium haul	Long haul	Source
1580	800	570	WRI/WBCSD (2003)
1925	867	633	NTM (2005)
	673		INFRAS/TRENDS (2004)

Source: Alan McKinnon

g. Pipeline

The only published figure that Mckinnon was able to find for pipeline appeared in a report published by the UK Royal Commission on Environmental Pollution in 1994. This study assigned a value of 10 gCO_2/tonne-km to pipelines. Since then the carbon content of electricity has reduced as a result of the switch to gas-fired stations and renewables. It is also likely that the energy efficiency of pipeline pumping equipment will have improved. McKinnon therefore recommended to use a lower value of **5 gCO_2 / tonne-km** at present, pending further enquiries.

h. Overview of recommended average CO_2-emission factors

The following table summarizes the average CO_2-emission factors recommended by McKinnon for chemical transports.

Table 10
Recommended Average Emission Factors

Transport mode	gCO_2/tonne-km
Road transport	62
Rail transport.	22
Barge transport	31
Short sea	16
Intermodal road/rail	26
Intermodal road/barge	34
Intermodal road/short sea	21
Pipelines	5
Deep-sea container	8
Deep-sea tanker	5
Airfreight	602

Source: Alan McKinnon

When conditions for a mode of transport are known to be more or less favorable than the conditions associated with the average default values recommended by McKinnon, companies are encouraged to use emission factors that are more representative for the characteristics of their logistics operations. It is recommended to clearly document the rationale of using such specific emission factors, in order to be able to justify the calculated emission values.

4.3. CALCULATION TEMPLATE

The following table provides a standard format for the calculation of a chemical company's' overall CO_2-footprint from freight transport operations, using the activity-based approach.
Depending on the availability of data and differences between individual supply chains, companies may disaggregate and differentiate this calculation by region, country, business unit and/or product group.

Table 11

Calculation Template for CO_2-Emissions from Freight Transport Operations (activity-based approach)

Mode of Transport	Volume (Tonnes)	Average distance (km)	Tonnes-kms	g CO_2/ tonne-km	Tonnes CO_2
Road	100.000	500	50.000.000	62	3.100
Rail	100.000	500	50.000.000	22	1.100
Barge	100.000	500	50.000.000	31	1.550
Short sea	100.000	500	50.000.000	16	800
Intermodal road/rail	100.000	500	50.000.000	26	1.300
Intermodal road/barge	100.000	500	50.000.000	34	1.700
Intermodal road/short sea	100.000	500	50.000.000	21	1.050
Pipelines	100.000	5	500.000	5	3
Deep-sea container	100.000	5.000	500.000.000	8	4.000
Deep-sea tanker	100.000	5.000	500.000.000	5	2.500
Airfreight	1.000	5.000	5.000.000	602	3.010
TOTAL	**1.001.000**		**1.335.500.000**		**20.113**

5. MANAGEMENT OF TRANSPORT EMISSIONS: OPPORTUNITIES TO REDUCE CO_2 EMISSIONS

This section provides a generic overview of opportunities and approaches for companies to reduce CO_2 emissions associated with transport operations. Companies may use this table as a kind of a check list, judging the potential associated with each opportunity, going through the considerations for implementation and applying these to their specific supply chains and associated transport operations.

In very broad terms, opportunities to reduce CO_2 emissions from transport operations can be divided into:

- Modal shift opportunities, shifting transport operations to “greener” modes of transport, i.e. those which emit the least CO_2 per ton-kilometer
- Supply chain management related opportunities, such as product swaps, peak smoothing, optimization of transport planning or logistics network optimization efforts
- Measures which increase vehicle utilization, i.e. minimize empty running and maximize the load factor of vehicles (payload optimization)
- Measures which increase the fuel efficiency of vehicles or reduce the carbon intensity of fuels

While the majority of measures are within the decision making domain of chemical companies, logistics service providers can play a proactive role in highlighting opportunities. Logistics service providers can however have a direct impact on the fuel efficiency of their vehicles.

Opportunities	***Description***	***Considerations for implementation***	***Parties involved***
A. Modal shift	**Shift to 'greener' transport modes**		
1. Shift from Bulk Road to Single Wagon (SW) Rail Transport	Bulk road transport is replaced by transport in single wagon rail tank cars.	Availability of a direct rail connection at despatching and receiving location. Availability of sufficient storage capacity at dispatching and receiving location. Willingness of customer to receive bigger quantities. Frequency and reliability of SW rail service. Transit time. Cost. Product constraints.	- Shipper - Consignee - LSP
2. Switch from road to intermodal short sea transport (SS)	Road transport is replaced by intermodal short sea/road transport (road-SS-road) whereby the goods are transported over the major part of the distance by sea in ro-ro ferries or container ships. The transfer from road to SS and vice-versa is carried out at intermodal sea terminals. If a rail connection is available, the first and last mile can also be done by rail instead of road.	Availability of an intermodal sea terminal close to the point of origin and the point of destination. Frequency and reliability of intermodal SS service. Availability of sufficient intermodal SS capacity. Transit time. Cost. Product constraints	- Shipper - Consignee - LSP
3. Switch from road to intermodal barge/road transport	Road transport is replaced by intermodal barge/ road transport (road-barge-road) whereby the goods are transported over the major part of the distance by barge in containers. The transfer from road to barge and vice-versa is carried out at intermodal barge/road terminals.	Availability of intermodal barge/road terminals sufficiently close to the point of origin and the point of destination. Frequency and reliability of intermodal barge service. Availability of sufficient intermodal barge capacity. Transit time. Cost Product constraints	- Shipper - Consignee - LSP

4. Switch from road to intermodal short sea transport (SS)	Road transport is replaced by intermodal short sea/road transport (road-SS-road) whereby the goods are transported over the major part of the distance by sea in ro-ro ferries or container ships. The transfer from road to SS and vice-versa is carried out at intermodal sea terminals. If a rail connection is available, the first and last mile can also be done by rail instead of road.	Availability of an intermodal sea terminal close to the point of origin and the point of destination. Frequency and reliability of intermodal SS service. Availability of sufficient intermodal SS capacity. Transit time. Cost. Product constraints	- Shipper - Consignee - LSP
B. Supply Chain Management	**Reduce total tonne-kms through improved supply chain management**		
5. Product swap arrangements	Manufacturers of the same product agree to deliver the product to each others customers located in the area close to the respective manufacturing sites to avoid the need for long distance transport.	Willingness of commercial parties to engage in products swaps. Need for standardisation of product specifications and grades. Ability to demonstrate cost savings. Compliance with competition rules.	- Shipper - Consignee
6. Relax monthly order-invoice cycles	Most chemical companies invoice at the end of each month, giving their customers an incentive to order at the start of the month. This induces wide variations in the volume of product flows making it difficult for carriers to manage their vehicle capacity efficiently. By moving to a system of rolling credits, the average utilisation of logistics assets would be improved.	Need for a fundamental change in corporate culture and a relaxation of long-established traditions in sales and finance departments in both the chemical industry and its customer base.	- Shipper - Consignee
7. Maximize direct deliveries	Allow larger consignments to bypass warehouses of distributors and external warehouses, to travel directly from production plant to customers. This eliminates a link in the supply chain, reducing t handling and cutting the total tonne-kms.	High vehicle load factors need to be maintained. Agreement with distributor when the sale is handled by the distributor.	- Shipper - Distributor

8. Improved routing	Sub-optimal routing of products, both at a supply chain level via intermodal terminals, warehouses and tank cleaning stations, and on the road and rail networks can generate unnecessary tonne-kms.	Use more advanced logistics planning and vehicle routing tools. In the case of hazardous chemicals, more careful routing also reduces the risk of accidents. Transit time. Cost implications.	- Shipper - LSP
C. Increase vehicle utilisation by decreasing the proportion of empty running	**Avoid empty returns or long repositioning journeys by increasing the proportion of vehicles with a back load**		
9. Flexibilization of loading and unloading time windows	Vertical collaboration between shippers and their LSPs to streamline loading and unloading operations and optimize transport planning in order to reduce empty running.	Optimization of plant opening hours (e.g. 16 hours). Implementation of flexible time slot booking systems. Allow driver self loading/unloading.	- Shipper - LSP
10. Flexibility of delivery dates	Exploiting opportunities to load or deliver x days earlier or later, in order to reduce empty running (provided the characteristics of the supply chain allow such operation).	Requires sufficient inventory at both loading point and discharge point.	- Shipper - LSP - Consignee
11. Increase availability of tank cleaning stations at key locations	By improving the geographical spreading of SQAS assessed tank cleaning stations, it will be easier for carriers to clean their vehicles in the vicinity of the unloading point and find backloads close to the unloading point. In this way the empty running of vehicles will be reduced.	Investment in cleaning stations to fill gaps in the geographical coverage.	- Tank cleaning stations - Carrier
12. Reduce black lists of previously loaded products	For some products chemical companies do not accept certain products as previous tank load, in order to minimize the risk of product contamination.	Chemical companies should keep their black lists of previous loads as short as possible and only maintain it for products with high contamination risk. The need to forbid certain previous loads may be prevented by upgrading the tank cleaning requirements.	- Shipper

13. Horizontal cooperation between logistics service providers	Horizontal cooperation amongst logistics service providers to increase the possibility to exploit back-loading opportunities.	Willingness of LSP's to cooperate. Cost incentive for cooperation. Trust of shippers that cooperation will not have an impact on the quality of the service. Compatibility of equipment	- LSP
14. Shared use of dedicated fleets (tank & silo transport)	Horizontal cooperation between chemical shippers to establish product dedicated shared use of tank fleets in order to minimize empty positioning.	Agreement between shippers on product compatibility.	- Shipper - LSP
D. Increase vehicle utilisation by increasing the payloads			
15. Increase maximum authorised vehicle weights	In some countries maximum road vehicle weights are restricted to 40 T, whereas in other countries there are national derogations allowing 44T or more.	National derogations for 44T should be introduced in all European countries. The maximum vehicle weight should be harmonised of 44T at European level.	- National & European authorities
16. Expand storage capacity at delivery points	Optimal vehicle loading is partly constrained by the storage capacity of silos and tanks at customers' premises.	Available infrastructure to increase storage capacity. Investment by customers in building additional storage capacity. Need to obtain permits for extending storage capacity. Increased working capital (inventory) for customers.	- Shipper - Consignee
17. Vendor Managed Inventory (VMI) or Haulier Managed Inventory (HMI)	In a system of VMI or HMI the supplier/haulier is responsible for replenishing the customers' stocks within certain agreed limits. This gives the producer/ haulier more control on the supply chain, allowing to manage the transport capacity more efficiently	Customers and suppliers / hauliers need to agree on systems and detailed arrangements. Availability of experience, equipment and systems (telemetrics) to manage this.	- Shipper - Consignee - LSP

E. Fuel efficiency of vehicles	Reducing the amount of fuel consumed per km driven		
18. Improve vehicle design	The fuel efficiency of vehicles can be increased considerably by improving the vehicle design which includes the fuel efficiency of the engine, the vehicle tare weight, the aerodynamic profiling of the vehicle and the use of low resistance tyres.	Cost - benefit of equipment improvements. Life-time of current vehicle park. Incentives to change and invest.	- LSP - Vehicle manufacturer
19. Improve vehicle maintenance	Technical defects can prevent a lorry from operating at optimum fuel efficiency: these include under-inflated tyres, miss-alignment of axles and poor engine tuning. More regular and thorough maintenance will reduce fuel consumption.	Cost-benefit of improved maintenance. Impact of more regular maintenance on availability of equipment.	- LSP
20. Improve vehicle operation (eco-efficient driving)	The operation of a vehicle can be improved by driver training, reduced speeds, driver incentive schemes etc. Driver training can be supported by intelligent electronic systems that monitor driving behaviour and fuel- consumption.	Cost-benefit of different measures. Potential impact on service levels.	- LSP
F. carbon intensity of fuel			
21. Make use of energy sources with a lower carbon intensity	Increase use of alternative fuels with lower carbon intensity (e.g. bio-fuel).	Sufficient cost advantage. Availability of technology and suitable equipment.	- LSP - Shipper