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IWA 16

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International harmonized method(s) for a coherent quantification of CO_2e emissions of freight transport

Méthode(s) internationale(s) harmonisée(s) pour une quantification cohérente des émissions de CO_2e par le transport de fret

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Contents

Page

Foreword

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The committee responsible for this document is ISO/TMBG, *Technical Management Board Groups*.

Introduction

Transport and logistics are based by 95 % on fossil fuels and currently contribute to an estimated 20 to 25 % of overall global CO_2 emissions (ITF International Transport Forum (2012): Greenhouse Gas Emissions: Country Data 2010. http://www.internationaltransportforum.org/Pub/pdf/10GHGcountry.pdf, Rodrigue J-P., Comtois C, Slack B (2009): The Geography of Transport Systems. New York: Routledge). Therefore, governments and industry are interested in improved efficiency of transportation and transport chains. Transport chains as considered within this IWA encompass the handling processes and transportation of goods from the producing entity to the next level(s). These transport chains connect industry and commercial processes. In order to identify best practice and to improve the efficiency of transport chains, an accepted and standardised method for calculating emissions values is needed together with a specification of data requirements. This IWA develops a framework and maps out requirements toward a global CO_2e emission calculation standard, based on existing standards.

As thorough analysis of existing standards and calculation methods has shown, there are several gaps within the currently existing methods, which leave space for interpretation in regards to calculation. A comparability of calculated results is therefore not necessarily given (see COFRET EU-project deliverables D 2.4 Methodologies for emission calculations[12], D 3.1 Assessment of typology of existing CO_2 calculation tools and methodologies[13], D 3.2 Methodology for integration of CO_2 emission calculation-tools[14] and D 3.3 Suggestions and recommendations towards global harmonization of carbon footprint calculation principles and comparable reporting[15]). Identifying these gaps and addressing them in a next standardization process step is important though, in order to ensure that ambiguities are eliminated and to achieve a compatible level of accuracy across all modes of transport as well as across all elements of the transport chain.

As analysis has shown, optimization of emissions for shipments and for networks of individual transport providers requires different approaches. All other things being equal, for isolated cargo direct routings are usually those with the lowest emissions. For transport service providers avoiding empty transportation space will often lead to optimization. Furthermore the characteristics of the various transportation modes need to be taken into consideration as well as those of handling processes, logistics hubs and transhipment centres. The calculation approach suggested in this document therefore distinguishes three levels of calculation: operation specific level, transport company network level and cargo level, reflecting the differing perspectives of carriers, logistics service providers and shippers. Transport chains are almost always very complex, often encompassing various modes of transport and handling processes or storage etc. In order to enable the calculation of emissions, this IWA suggests the approach of calculation of emissions of separate transport chain elements. Another emphasis within this IWA is given to the aspect of data quality. As tracked fuel consumption is not always available, the question of default data needs to be addressed.

Terms like logistics chain and supply chain are often used within the transport sector. For a better orientation Figure 1, originated from the COFRET project (see [11]), provides a generic example showing logistics operations as elements of the transport chain and transport chain within a supply chain. Each logistics operation forms a transport chain element (TCE), the sum of all TCEs builds the transport chain.

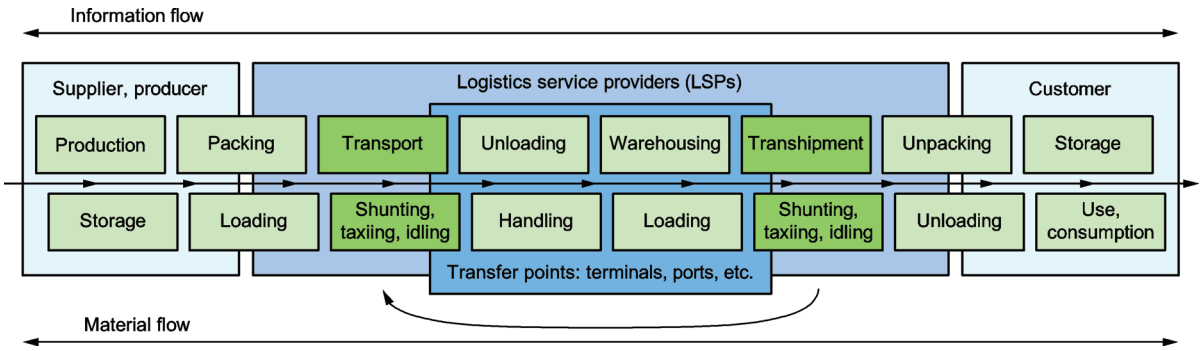

Figure 1 — Logistics operations as elements of the transport chain

International Workshop Agreement IWA 16 was launched at a workshop held in Berlin, Germany, in July 2014, and approved at workshops held in Berlin, Germany, in September 2014 and in November 2014. All workshops were hosted by DIN, the German Institute for Standardization.

This IWA was developed in the following format:

1st and kick-off meeting on 2014-07-08: Adoption of the scope and objectives of the IWA, agreement on a two-tiered approach: (1) identification of recommended existing standards suitable as basis and gaps, (2) identification of suitable approaches for closure of identified gaps;

2nd meeting from 2014-09-01 to 2014-09-02: Discussion of gaps per mode and in general, summarizing and agreement on gaps;

3rd meeting from 2014-11-13 to 2014-11-14: Discussion of suggested approaches for closing gaps and summarizing recommendations on way forward.

Between the 2nd and 3rd meeting further consultation in the format of telephone conferences took place between the workshop participants in order to complete the mode specific gap analysis.

During meetings, findings were discussed and the content of the following document was agreed.

International harmonized method(s) for a coherent quantification of CO_2e emissions of freight transport

1 Scope

This International Workshop Agreement (IWA) defines the framework for methods for coherent quantification of CO_2e emissions of freight transport (total and intensity) on the following three levels:

1) Level of operation of transport chain element (TCE).

2) Level of network including company level.

3) Level of cargo.

It provides a gap analysis identifying starting points and recommending further specification and possible alignment on mode specific and intermodal levels, including transhipment centres and warehouses. Consideration needs to be given to the practicality of the methods and the intended use of the outputs to the potential user groups, particularly providers of freight transport and logistic services as well as their customers.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1
vehicle operation system
VOS
set of vehicle operations

[SOURCE: EN 16258:2012, 2.2.22]

2.2
vehicle operation
deployment of a vehicle to fully or partially provide a transport service for one or more transport service users

[SOURCE: EN 16258:2012, 2.2.21]

2.3
vehicle
any means of transport

Note 1 to entry: Within this standard, this definition includes vessels (watercraft and aircraft like ships, boats and planes), for reasons of simplification only.

[SOURCE: EN 16258:2012, 2.1.19]

2.4
transport network
system of connections covered by transport organizers including connections covered by subsidiaries and subcontractors

2.5
cargo
collection/quantity of goods (carried on a means of transport) transported from one place to another

Note 1 to entry: Cargo can consist of either liquid or solid materials or substances, without any packaging (e.g. bulk cargo), or of loss items of unpacked goods, packages, unitised goods (on pallets or in containers) or goods loaded on transport units and carried on active means of transport.

[SOURCE: EN 14943:2005, 3.151]

2.6
intermodal container
inter-modal transport unit (ITU)
inter-modal loading unit (ILU)
transport unit which may be a container, swap body, semi-trailer or road-trailer suitable for inter-modal transport

[SOURCE: EN 14943:2005, 3.512]

2.7
transport chain
sequence of transport activities and logistics operations

Note 1 to entry: See Figure 1 which shows logistics operations as elements of the transport chain.

2.8
logistics
planning, execution and control of the movement and placement of people and/or goods and of the supporting activities related to such movement and placement, within a system organized to achieve specific objectives

[SOURCE: EN 14943:2005, 3.575]

2.9
carbon dioxide equivalent
CO_2e
unit for comparing the radiative forcing of a GHG to carbon dioxide

Note 1 to entry: The carbon dioxide equivalent is calculated using the mass of a given GHG multiplied by its global warming potential.

[SOURCE: ISO 14064-1:2006, 2.19]

3 Initiatives and documents included into the gap analysis

Different tools are taken into consideration in the gap analysis and in the way forward in addressing these gaps. These tools are listed in the gap-analysis tables and in Bibliography.

4 Boundaries of analysis

4.1 General

It is important that for all three levels of calculation it is defined which processes and elements are included and which not.

4.2 Processes included

4.2.1 On operation level

Calculations on vehicle operational level shall include operation of all on-board vehicle systems including propulsion and ancillary services.

4.2.2 On network level

Calculation on network level includes all segments within the commercial boundaries of one operator or logistics service provider. It covers all transport modes, all services and activities of the operator's network.

Calculation on network level also includes processes consisting of short-term assistance to the vehicle for security or movement reasons, with other devices like tugboats for towing vessels in harbours, aircraft tractors for planes in airports, etc.

4.2.3 On cargo level

Calculation on cargo level includes all transport elements and services from the commercial boundaries of the shipper to the commercial boundaries of the next receiving unit which is performing substantial changes to the cargo and its elements.

4.2.4 Definition and use of transport chain elements

Given the complexity of transport chains the notion of transport chain element (TCE) as a modular and independent operation that brings the goods close to their final destination is introduced (see also COFRET D.3.1[13], there referenced as supply chain element). Figure 2 presents an example of a transport chain composed of TCEs. Not only transport operations are considered as TCEs, but terminal and warehousing operations are also treated as standalone TCEs. The resulting CO_2e emissions at the product level are the sum of the emissions resulting from the TCEs that constitute the transport chain.

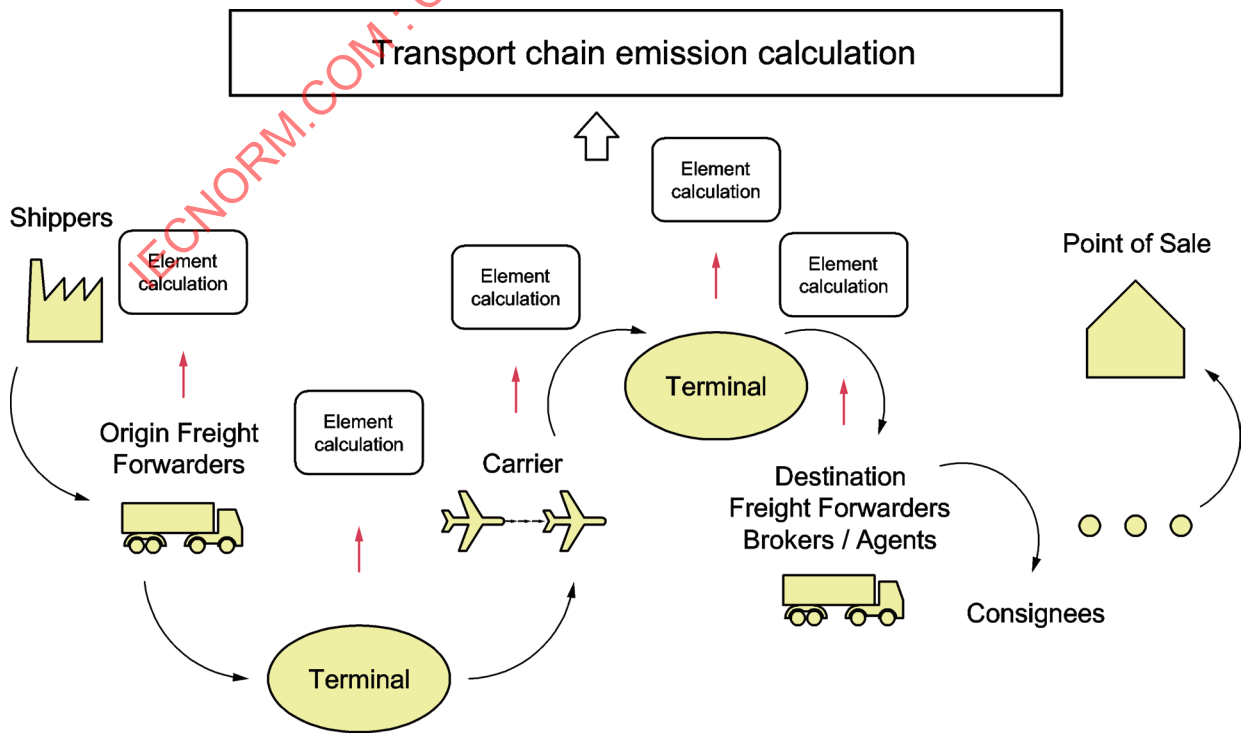

Figure 2 — Example of a transport chain split into transport chain elements

The division of any transport chain into a number of sequential TCEs greatly simplifies the effort necessary to compute cargo-level emissions. Any transport chain can be decomposed on a limited number of TCEs, such that TCEs can be used and reused in any arbitrary situation, functioning as building blocks. The Logistics Node Elements (LNE), such as terminals and warehouses include processes of external handling or transhipment devices for the movement or transhipment of freight. Furthermore, handling operations that take place inside platforms, and which consist of loading and unloading of parcels or pallets of express delivery services and other transport services organized in networks, belong to this category of processes.

4.3 Processes included on all calculation levels

4.3.1 Energy operational processes

The assessment of energy consumption and Greenhouse Gas (GHG) emissions of TCE shall include both vehicle operational processes and energy operational processes that occur during the operational phase of the lifecycle.

The vehicle operational processes shall include operation of all on-board vehicle systems including propulsion and ancillary services.

The energy operational processes shall include:

— for fuels (except electricity): extraction or cultivation of primary energy, refining, transformation, transport and distribution of energy at all steps of the production of the fuel used;

— for electricity: extraction and transport of primary energy, transformation, power generation, losses in electricity grids.

4.3.2 Fugitive emissions

Direct emissions of GHG resulting from leakage during operational processes (e.g. of refrigerant gas or natural gas) should be included.

4.4 Processes not included

Processes not to be included in the analysis are:

— processes for the construction, maintenance and scrapping of vehicles and logistic nodes;

— processes of construction, service, maintenance and dismantling of transport infrastructures used by vehicles;

— non-operational energy processes, like the production or construction of extraction equipment of transport and distribution systems, of refinery systems, of enrichment systems, of power production plants, etc. so as their reuse, recycle and scrap;

— additional impacts of combustion of aviation fuel in high atmosphere, like contrails, cirrus, etc.

4.5 Processes and issues that should be assessed as to their inclusion

Processes at the administrative (overhead) level of the organisations involved in the transport and logistics services might be relevant for the overall emission result. It is to be assessed in detail to which extent and how they are to be included on the three calculation levels.

Consideration of the extension of the approach to local air pollutant emissions in context of calculation of CO_2e/GHG emissions should be given.

5 Gap analysis

5.1 General aspects

The following aspects apply to gaps on all three levels of the defined framework (operation, network, cargo) and need to be unambiguously defined and included in the next standardization efforts on a global level.

a) Appropriateness in emission allocation:

   1) Consistent set of CO_2, GHG and CO_2e emissions factors to be used in calculations in order to provide a truly comparable set of outputs for well-to-tank, tank-to-wheel and well-to-wheel fuel life cycle phases for the main commercial transport fuels. This is needed at the global level to take into account regional or national differences in fuel specification/composition and/or production processes as well as to ensure consistency across modes/between operators (GLEC has recently initiated a study on this topic).

   2) Consistent approach to electricity emissions – this is crucial in the railway sector and is being addressed by ECO TransIT, EN 16258, French info CO_2 transport law, GHG Protocol and UIC among others. These all quote or are developing electricity emission factors by country, based on national generation, consumption or other (e.g. railway-specific purchase) mixes, but a consistent approach across the transport chain within and between countries and modes still needs to be developed.

   3) Consistent approach to definition of empty runs across all modes and mechanisms to establish industry recognized default data sources to be used are needed where they are not present. GLEC has recently initiated an initial scoping study on this.

   4) Consistent approach to definition of default load factors across all modes is required (in the circumstances where actual/average data are not available and an aggregated approach is to be applied).

   5) Aligned allocation rules for vehicles carrying e.g. freight and passengers at the same time or consolidated freight, and also at nodes and terminals when handling freight.

b) Quality of data:

   1) Consistent approach to:

      i) requirements for operational data collection (frequency, granularity) and data quality, especially towards data quality measurement and quality indicators. Guidelines for the monitoring and verification of real input data as well as rules for the use of real input data on the basis of sampling, e.g. definition of application fields, frequency, sampling size. Definition of time frame of data, e.g. on yearly base to avoid influence of temporal, seasonal and economic effects;

      ii) use of default data in absence of tracked information;

      iii) define data quality levels (mix between use of measured data and default data) and provide guidance on how to apply and to declare them.

   2) Definition of TCEs scope and their boundaries, including definition of standard VOS examples as well as auxiliary processes, to be included in the calculation.

   3) Consistency of reporting (metric vs. imperial).

   4) Standardization of reporting.

5) A quality verification process.

c) Consistent approach to definitions of an operator's network and its organizational boundaries (e.g. overhead) needs to be developed.

d) Transport auxiliary processes (e.g. tugboat, cold ironing, shunting, yard logistics, air-conditioning of goods) including (indirect) emissions caused by auxiliary material consumption (e.g. lubricants, additives, packaging).

e) Consistent approach to consideration and avoidance of double counting.

5.2 Mode specific gap analysis

In addition to the general aspects and gaps listed already, the following tables reflect mode specific gaps.

For this analysis the most appropriate and best aligned starting points (per mode and for logistics hubs) have been used as the basis and reference for future standardization, as indicated in the following tables. Based on these suggested starting points the most pressing gaps that still need to be addressed were identified.

The gap analysis for the transport mode road is given in Table 1.

Table 1 — Gap analysis road

Investigated aspect	Starting points		Identified gaps and comments
	EN 16258	Smartway	
TTW/WTW (Tank-To-Wheel/ Well-To-Wheel)	TTW/WTW	TTW	Consistency of approach Reliable information about upstream processes
CO_2/CO_2e	CO_2e	CO_2	Consistency of approach
Allocation units in general	Preferred unit is tkm (tonne kilometre), but other units can be used if they are justified Marginal accounting is not allowed	CO_2/ton mile Also CO_2/vehicle mile and CO_2 per cubic foot mile	Unified allocation units per type of cargo and/or transport service
Specific allocation units	Preferred allocation unit for collection and distribution: tkm based on GCD (Great Circle Distance)	—	use of this allocation unit in practice (recommendation: uniform calculation unit for every service type: dense network transport, loose network transport, point-to-point-transport)
Energy consumption of auxiliary processes	Only on-board processes are included, they are not specified in detail though	Not specified	Treatment of temperature control/reefer to be consistent across all modes
Processes included	Loaded and unloaded (empty) trips, subcontractor's transports, on-board handling if measured	Own fleet Empty running included	Auxiliary processes (e.g. non-onboard handling), secondary energy used for temperature controlled processes, maintenance, preparation and aftercare of vehicle and transportation units (e.g. cleaning of tank containers)
Allocation notes	—	—	—

Table 1 *(continued)*

Investigated aspect	Starting points		Identified gaps and comments
	EN 16258	Smartway	
Vehicle operation systems (VOS) descriptions	Concept of VOS and fleet is introduced	This is taken into account by the benchmarking by service type in which the information is presented	Standard categories of/ descriptions for VOS would help comparability General internationally applicable clustering of vehicles into categories needs to be specified, granularity of data
Procedure for measured energy consumption data	The standard categorises data into the groups of specific measured values, transport operator specific values and transport operator fleet values. It is not specified though, how these values are generated	Fuel and CO_2 based on measured data Other pollutants modelled using national emissions factors and protocols	Guidelines for measurement and use of measured data are needed Guidelines on uncertainties
Procedure for absence of measured energy consumption data	Procedures and sources for default data referenced in annex, use not specified	Not applicable	Guidelines for use and selection of data in case of absence of measured data are needed
Fuel-based versus activity based	Fuel-based preferred but other approaches accepted	Fuel-based	fuel (including electricity) based preferred as aspiration, other approaches need to be accepted in the meantime
Data sources (default data)	—	—	Guidelines for use and selection of data in case of absence of measured data are needed
Specific factors	Given in EN 16258, Annex A	National emission factors from Argonne National Laboratory	Need of a standard procedure for the approach to emission factors across all modes
Gaps in existing coverage/comments	—	—	—
Allocation unit and intensity	—	—	Mass/volume relation and distances need to be unified
Calculation of distances	Actual distance travelled For allocation: Great Circle Distance or shortest feasible distance	Actual distance driven	Harmonized approach to consideration of distance is required
Reporting	Energy use and CO_2e on both TTW and WTW basis	Benchmarked reporting based on 5 groups ranked according to CO_2 per ton mile within each of several operational business sectors	Definition of reporting factors for the specific purpose required (for all modes)
Accuracy labels	—	—	Accuracy labels for reporting to be developed

Table 1 *(continued)*

Investigated aspect	Starting points		Identified gaps and comments
	EN 16258	Smartway	
Harmonization note	It is recommended that national or regional regulations take into account the Transnational dimensions of transport	Wide range of perfectly logical/reasonable ways of doing things is confusing. Harmonization must serve a purpose for people to adopt or change what they are doing	Standard(s) need(s) to specify clearly which of the following three levels for coherent quantification of CO_2e emissions of freight transport (total and intensity) they refer to: (1) Level of operation of TCE; (2) Level of network including company level; (3) Level of cargo
General comments and thoughts	Use of TCE's to allow disaggregation of supply chain into manageable, consistent, discrete elements is widely acknowledged across all Action Group areas, although the way that this is done and described varies a lot.		

The gap analysis for the transport mode rail is given in Table 2.

Table 2 — Gap analysis rail

Investigated aspect	Starting points			Identified gaps and comments
	EN 16258	EcotransIT	Smartway (rail module)	
TTW/WTW	TTW/WTW	TTW/WTW	TTW	Consistency of approach Reliable information about upstream processes
CO_2/CO_2e	CO_2e	CO_2e	CO_2	Consistency of approach
Allocation units in general	Preferred unit is tkm, but other units can be used if they are justified Marginal accounting is not allowed	Net-tonne kilometres related to vehicle (wagon) (as a product of specific emission factor of vehicle and capacity utilization of vehicle)	g CO_2/ton mile Also g CO_2/vehicle mile	Only using several average values for gross weight and payload
Specific allocation units	—	EcoTransIT application of EN 16258 includes factors for different industry sectors according to cargo density	—	Special Case: Allocation rules in case of combined passenger and freight trains
Energy consumption of auxiliary processes	Only on-board processes are included, they are not specified in detail though	Upstream emissions for energy	Not specified	Treatment of temperature control/ reefer to be consistent across all modes

Table 2 *(continued)*

Investigated aspect	Starting points			Identified gaps and comments
	EN 16258	EcotransIT	Smartway (rail module)	
Processes included	Loaded and unloaded (empty) trips, subcontractor's transports, on-board handling if measured	Loaded and unloaded (empty) trips	Own fleet Empty running included Fuel used by main power source	Auxiliary processes (e.g. non-onboard handling), secondary energy used for temperature controlled processes, maintenance, preparation and aftercare of vehicle and transportation units (e.g. cleaning of tank containers)
Allocation notes	—	—	—	Emissions of shunting processes need to be considered
Vehicle operation systems (VOS) descriptions	Concept of VOS and fleet is introduced	VOS for block trains, intermodal trains and trains with single waggons are given. Empty return trips are included. An explanation on how it is done will be published in December 2014	Reporting according to overall fleet operations and also disaggregated by bulk and other operations	Standard categories of/descriptions for VOS would help comparability VOS for rail transport have to be specified and included in a calculation methodology
Procedure for measured energy consumption data	The standard categorises data into the groups of specific measured values, transport operator specific values and transport operator fleet values. It is not specified though, how these values are generated	No procedure for measured data available	Fuel and CO_2 based on measured data Other pollutants modelled using national emissions factors and protocols	Guideline is needed for railway operators for calculation of trip or round trip (e.g. for block trains or shuttle trains in intermodal transport) related emissions
Procedure for absence of measured energy consumption data	Procedures and sources for default data referenced in annex, use not specified	Only using default data but only partly based on public available data, there is not a description how the data were aggregated for the calculation	Not applicable	Default database should be completely publicly available/ accessible to ensure transparency and trust
Fuel-based versus activity based	Fuel-based preferred but other approaches accepted	Fuel and electricity based	Fuel-based	Fuel (including electricity) based preferred as aspiration, other approaches needs to be accepted in the meantime

Table 2 *(continued)*

Investigated aspect	Starting points			Identified gaps and comments
	EN 16258	EcotransIT	Smartway (rail module)	
Data sources (default data)	—	UIC statistics and national survey data as well as Ex-Tremis database (not validated by a neutral body)	—	A regularly update process of data or data sources needs to be considered. (Many data are not published and are not be validated by neutral bodies.)
Specific factors	Given in EN 16258, Annex A	Given in EcoTransIT Tables 25 and 26	National emission factors from Argonne National Laboratory	Need a standard procedure for the approach to emission factors across all modes
Gaps in existing coverage/comments	—	Calculation only rely on not open access data sources mixed with some average data assumptions Ex-ante and Ex-post calculations have same results	—	Database should become more transparent and extended to different train types (block, trains, intermodal transport trains, single waggon load trains) Further empty runs should be measured and allocated more transparent
Allocation unit and intensity	—	Calculation starts from train energy consumption per gross-tonne kilometre and deviated data for net-tonne kilometre	—	Mass/volume relation and distances need to be unified For intermodal trains emissions per load unit (e.g. TEU) should be added

Table 2 *(continued)*

Investigated aspect	Starting points			Identified gaps and comments
	EN 16258	EcotransIT	Smartway (rail module)	
Calculation of distances	Actual distance travelled For allocation: Great Circle Distance or shortest feasible distance	Routing with resistant factors based on railway line attributes	Actual distance travelled	Not clear how resistance factors were calculated; Empty return trips need to be transparently calculated; Number of additional stops are only considered in average in default data sources but the real energy consumption is strongly depending on the number of stops, e.g. due to in siding tracks to get over by faster trains This is harmonized for rail transport, for further standardization developments harmonization across modes is needed
Reporting	Energy use and CO_2e on both TTW and WTW basis	Emissions by net-tonne kilometre of a shipment	Reporting according to CO_2 per tonne mile	Definition of reporting factors for the specific purpose required (for all modes)
Accuracy labels	—	Partly based on average assumptions and not special ex-post calculation	—	Accuracy labels for reporting to be developed
Harmonization note	It is recommended that national or regional regulations take into account the Transnational dimensions of transport	—	Wide range of perfectly logical/ reasonable ways of doing things is confusing. Harmonization must serve a purpose for people to adopt or change what they are doing	Standard(s) need(s) to specify clearly which of the following three levels for coherent quantification of CO_2e emissions of freight transport (total and intensity): (1) Level of operation of TCE; (2) Level of network including company level; (3) Level of cargo
General comments and thoughts	Use of TCE's to allow disaggregation of supply chain into manageable, consistent, discrete elements is widely acknowledged across all Action Group areas, although the way that this is done and described varies a lot.			

The gap analysis for the transport mode inland waterways is given in Table 3.

Table 3 — Gap analysis inland waterways

Investigated aspect	Starting points				Identified gaps and comments
	EN 16258	Smartway	IMO MEPC.1/circ.684	STREAM International	
TTW/WTW	TTW/WTW	TTW	TTW	TTW/WTW	Consistency of approach Reliable information about upstream processes
CO_2/CO_2e	CO_2e	CO_2	CO_2	CO_2e	Consistency of approach
Allocation units in general	Preferred unit is tkm, but other units can be used if they are justified Marginal accounting is not allowed	g CO_2/ton mile g CO_2/vehicle mile g CO_2/cubic foot mile	g CO_2/unit for transport work done (usually tonne kilometre, but others are possible)	g CO_2e/tkm	Consistency of reporting
Specific allocation units		—			Allocation rules for inland waterways need to be clarified regarding specifics of loaded/unloaded upstream (up the river) and downstream (down the river) transports
Energy consumption of auxiliary processes	Only on-board processes are included, they are not specified in detail though	Not specified	Not specified	Not specified	Treatment of temperature control/reefer to be consistent across all modes
Processes included	Loaded and unloaded (empty) trips, subcontractor's transports, on-board handling if measured	Own fleet Empty running included Fuel used by main power source	Own fleet All fuel used by main power source in operation, so empty running included by default	Empty running included by use of utilization factor	Auxiliary processes (e.g. non-onboard handling), secondary energy used for temperature controlled processes, maintenance, preparation and aftercare of vehicle and transportation units (e.g. cleaning of tank containers)
Allocation notes	—	—	—	—	—

Table 3 *(continued)*

Investigated aspect	Starting points				Identified gaps and comments
	EN 16258	Smartway	IMO MEPC.1/circ.684	STREAM International	
Vehicle operation systems (VOS) descriptions	Concept of VOS and fleet is introduced	Reporting according to overall fleet operations and also disaggregated by bulk and other operations	Reporting according to different types of cargo operation	Reporting according to different types of cargo operation	Standard categories of/ descriptions for VOS would help comparability
Procedure for measured energy consumption data	The standard categorises data into the groups of specific measured values, transport operator specific values and transport operator fleet values. It is not specified though, how these values are generated	Fuel and CO_2 based on measured data Other pollutants modelled using national emissions factors and protocols	—	—	Default database should be completely publicly available/accessible to ensure transparency and trust
Procedure for absence of measured energy consumption data	Procedures and sources for default data referenced in annex, use not specified	Not applicable			Guidelines for use and selection of data in case of absence of measured data are needed
Fuel-based versus activity based	Fuel-based preferred but other approaches accepted	Fuel-based	Fuel-based	Activity-based Energy use and pollutant emissions modelled on different types of vessel	Fuel (including electricity) based preferred as aspiration, other approaches needs to be accepted in the meantime
Data sources (default data)		—	—	ECOTransIT HBEFA Dutch national stats EU Averages	A regularly update process of data or data sources needs to be considered. (Many data are not published and are not be validated by neutral bodies.)
Specific factors	Given in EN 16258, Annex A	National emission factors from Argonne National Laboratory	Uses international factors sourced by IMO	Uses Defra factors	Need a standard procedure for the approach to emission factors across all modes
Gaps in existing coverage/ comments	—	—	—	—	—

Table 3 *(continued)*

Investigated aspect	Starting points				Identified gaps and comments
	EN 16258	Smartway	IMO MEPC.1/circ.684	STREAM International	
Allocation unit und intensity	—	—	—	—	Mass/volume relation and distances need to be unified
Calculation of distances	Actual distance travelled For allocation: Great Circle Distance or shortest feasible distance	Actual distance travelled	Actual distance travelled	Actual distance travelled	—
Reporting	Energy use and CO_2e on both TTW and WTW basis	Reporting according to CO_2 per tonne mile	—	—	Definition of reporting factors for the specific purpose required (for all modes)
Accuracy labels	—	—	—	—	Accuracy labels for reporting to be developed
Harmonization note	It is recommended that national or regional regulations take into account the Transnational dimensions of transport	Wide range of perfectly logical/reasonable ways of doing things is confusing. Harmonization must serve a purpose for people to adopt or change what they are doing			Standard(s) need(s) to specify clearly which of the following three levels for coherent quantification of CO_2e emissions of freight transport (total and intensity): (1) Level of operation of TCE; (2) Level of network including company level; (3) Level of cargo
General comments and thoughts	Use of TCE's to allow disaggregation of supply chain into manageable, consistent, discrete elements is widely acknowledged across all Action Group areas, although the way that this is done and described varies a lot. Use of emissions/TEU as a measure is useful in Europe where maritime containers can be shipped by barge/short sea ferry. Need to develop other maritime sectors than containerized transport.				

The gap analysis for the maritime transport is given in Table 4.

Table 4 — Gap analysis maritime transport

Investigated aspect	Starting points			Identified gaps and comments
	EN 16258	Clean Cargo Working Group	IMO MEPC.1/circ.684	
TTW/WTW	TTW/WTW	TTW	TTW	Consistency of approach Reliable information about upstream processes
CO_2/CO_2e	CO_2e	CO_2	CO_2	Consistency of approach
Allocation units in general	Preferred unit is tkm, but other units can be used if they are justified Marginal accounting is not allowed	g CO_2/TEU km	g CO_2/unit for transport work done (usually tkm, but others are possible	Transfer into CO_2e for TEU is needed across all containerized transport
Specific allocation units		Use of TEU for containerised maritime transport is beneficial due to uncertainty over leading of individual containers	No	Recognized, specific industry guidance is beneficial, currently exists for containerized transport (all types of ships); needs to be expanded to other maritime sectors, e.g. bulk, tanker
Energy consumption of auxiliary processes	Only on-board processes are included, they are not specified in detail though	Includes a factor to allow for the energy consumption of reefers	Not specified	Treatment of temperature control/ reefer to be consistent across all modes
Processes included	Loaded and unloaded (empty) trips, subcontractor's transports, on-board handling if measured	Own fleet Empty running included Fuel used by main power source Industry average loading factor for TEU per vessel	Own fleet All fuel used by main power source in operation, so empty running included by default	Auxiliary processes (e.g. non-onboard handling), secondary energy used for temperature controlled processes, maintenance, preparation and aftercare of vehicle and transportation units (e.g. cleaning of tank containers) Load factor process needs to be defined
Allocation notes	—	—	—	—
Vehicle operation systems (VOS) descriptions	Concept of VOS and fleet is introduced	A trade lane approach is taken for vessels travelling on the most common journey combinations	Reporting according to different types of cargo operation	VOS needs to be defined for transport segments which are not containerized

Table 4 *(continued)*

Investigated aspect	Starting points			Identified gaps and comments
	EN 16258	Clean Cargo Working Group	IMO MEPC.1/circ.684	
Procedure for measured energy consumption data	The standard categorises data into the groups of specific measured values, transport operator specific values and transport operator fleet values. It is not specified though, how these values are generated	Fuel and CO_2 based on measured data wherever possible using information supplied through the CCWG data collection process	Raw data input: fuel used, distance travelled, transport work done (transport work not defined and therefore not comparable)	Harmonization of the use of measured data are needed
Procedure for absence of measured energy consumption data	Procedures and sources for default data referenced in annex, use not specified	Industry standard factors for the main trade lanes based on the CCWG data collection process	Industry standard factors for conversion of fuel into CO_2 based on IMO guidelines	Default database should be completely publicly available/ accessible to ensure transparency and trust
Fuel-based versus activity based	Fuel-based preferred but other approaches accepted	Fuel-based	Fuel-based	Fuel (including electricity) based preferred as aspiration, other approaches needs to be accepted in the meantime
Data sources (default data)	—	CCWG industry-derived values	—	A regularly update process of data or data sources needs to be considered. (Many data are not published and are not be validated by neutral bodies.)
Specific factors	Given in EN 16258, Annex A	Uses international factors sourced by IMO	Uses international factors sourced by IMO	Need a standard procedure for the approach to emission factors across all modes
Gaps in existing coverage/comments	—	Focused on container shipping only - IMO guidelines provide the opportunity for other maritime sectors	IMO guidelines provide the opportunity for other maritime sectors (not container) but more specific guidance is needed within these segments to ensure comparability	Need to develop other maritime sectors than containerized transport
Allocation unit und intensity	—	—	—	—

Table 4 *(continued)*

Investigated aspect	Starting points			Identified gaps and comments
	EN 16258	Clean Cargo Working Group	IMO MEPC.1/circ.684	
Calculation of distances	Actual distance travelled For allocation: Great Circle Distance or shortest feasible distance	Direct distance + 15 %	Actual distance travelled	Gap between shortest distance (applied by users) and actual distance (applied when calculating emission factors) for other segments than container vessels
Reporting	Energy use and CO_2e on both TTW and WTW basis	—	—	CO_2e and WTW needs to be aligned Definition of reporting factors for the specific purpose required (for all modes)
Accuracy labels	—	—	—	Accuracy labels for reporting to be developed
Harmonization note	It is recommended that national or regional regulations take into account the Transnational dimensions of transport	Important to consider how the application to container transport through terminals and on rail or road feeder journeys can be addressed in a consistent manner	—	Standard(s) need(s) to specify clearly which of the following three levels for coherent quantification of CO_2e emissions of freight transport (total and intensity): (1) Level of operation of TCE; (2) Level of network including company level; (3) Level of cargo
General comments and thoughts	Use of TCE's to allow disaggregation of supply chain into manageable, consistent, discrete elements is widely acknowledged across all Action Group areas, although the way that this is done and described varies a lot. Use of average emissions/TEU over a lane avoids need to track individual routing of each shipment (which can vary due to port omissions, port delays, weather impacts, etc.). Need to develop other maritime sectors than containerized transport.			

The gap analysis for the transport mode air is given in Table 5.

Table 5 — Gap analysis air

Investigated aspect	Starting points		Identified gaps and comments
	EN 16258	IATA RP1678	
TTW/WTW	TTW/WTW	TTW	Consistency of approach Reliable information about upstream processes

Table 5 *(continued)*

Investigated aspect	Starting points		Identified gaps and comments
	EN 16258	IATA RP1678	
CO_2/CO_2e	CO_2e	CO_2	Consistency of approach
Allocation units in general	Preferred unit is tkm, but other units can be used if they are justified Marginal accounting is not allowed	Allocation based on mass and tkm	Unified allocation units per type of cargo and/or transport service
Specific allocation units	Allocation for belly freight uses actual mass of passengers and baggage or allowance for passengers	Allocation for belly freight uses mass of passengers plus an allowance for each seat, even if not occupied	Consistency of approaches is crucial
Energy consumption of auxiliary processes	Only on-board processes are included, they are not specified in detail though	Auxiliary power usage included (as defined in the IATA's Fuel Measurement Protocol)	Treatment of temperature control/reefer to be consistent across all modes
Processes included	Loaded and unloaded (empty) trips, subcontractor's transports, on-board handling if measured	Empty running and repositioning included in network approach Subcontractor's transports included	Auxiliary processes (e.g. non-onboard handling), secondary energy used for temperature controlled processes, maintenance, preparation and aftercare of vehicle and transportation units (e.g. cleaning of tank containers)
Allocation notes	—	—	—
Vehicle operation systems (VOS) descriptions	Concept of VOS and fleet is introduced	Can be taken on a leg-based or network approach	VOS has to be defined including alignment of terminology across all modes of transport
Procedure for measured energy consumption data	The standard categorises data into the groups of specific measured values, transport operator specific values and transport operator fleet values. It is not specified though, how these values are generated	IATA fuel measurement protocol	Recognized, specific industry guidance is beneficial
Procedure for absence of measured energy consumption data	Procedures and sources for default data referenced in annex, use not specified	IATA fuel measurement protocol	Default database should be completely publicly available/accessible to ensure transparency and trust
Fuel-based versus activity based	Fuel-based preferred but other approaches accepted	Fuel-based following IATA fuel measurement protocol	Recognized, specific industry guidance is beneficial; Fuel (including electricity) based preferred as aspiration, other approaches needs to be accepted in the meantime
Data sources (default data)	—	—	A regularly update process of data or data sources needs to be considered. (Many data are not published and are not be validated by neutral bodies.)

Table 5 *(continued)*

Investigated aspect	Starting points		Identified gaps and comments
	EN 16258	IATA RP1678	
Specific factors	Given in EN 16258, Annex A	CO_2 emission factor taken from IPCC	Need a standard procedure for the approach to emission factors across all modes
Gaps in existing coverage/comments	—	—	
Allocation unit und intensity	—	—	—
Calculation of distances	Actual distance travelled For allocation: Great Circle Distance + 95 km or shortest feasible distance	Great circle distance (GCD) GCD+95 km is allowed	consistency of approach (and with other modes)
Reporting	Energy use and CO_2e on both TTW and WTW basis	—	CO_2e and WTW needs to be aligned Definition of reporting factors for the specific purpose required (for all modes)
Accuracy labels	—	—	Accuracy labels for reporting to be developed
Harmonization note	It is recommended that national or regional regulations take into account the Transnational dimensions of transport	—	Standard(s) need(s) to specify clearly which of the following three levels for coherent quantification of CO_2e emissions of freight transport (total and intensity): (1) Level of operation of TCE; (2) Level of network including company level; (3) Level of cargo
General comments and thoughts	Use of TCE's to allow disaggregation of supply chain into manageable, consistent, discrete elements is widely acknowledged across all Action Group areas, although the way that this is done and described varies a lot.		

The gap analysis for logistics hubs is given in Table 6.

Table 6 — Gap analysis logistics hubs

Investigated aspect	Starting points			Identified gaps and comments
	Green Efforts	Green Logistics	ITEC	
TTW/WTW	TTW/WTW	TTW	WTW (TTW possible, not desired)	—
CO_2/CO_2e	CO_2e	CO_2e	CO_2e	—

Table 6 *(continued)*

Investigated aspect	Starting points			Identified gaps and comments
	Green Efforts	Green Logistics	ITEC	
Allocation units in general	TEU throughput	Transhipment centres: allocation based on weight (tons) Warehouses: allocation based on space use (average stock level)	Transported Loading Unit (Transported = transhipped in the intermodal terminal from one mode to the other; Loading Unit = freight container > 20', e.g. according to ISO 668, EN 284, EN 452 and semi-trailer)	No harmonized allocation units Need to distinguish between transhipment centres and warehouses Consistency of reporting
Specific allocation units	Green Efforts has focused on maritime container terminals. The focus has been on throughput rather than a measure of dwell time or number of processes within the terminal due to practicality considerations	Green logistics project has considered a range of logistics facilities (air freight terminals, letter/parcel sorting centres, storage/transhipment centres for general cargo)	Internally: different units depending on the process group, e.g. trains, trucks, loading units, which are finally transferred into "Loading Unit" using measured figures of the intermodal terminal	Allocation rule for temperature control/reefers of high practical relevance and should be consistent to maritime
Energy consumption of auxiliary processes	Generally included, depending on what data are available	Electricity, heating, packaging materials, refrigerants	Included in main process groups, e.g. offices, lightning	Treatment of temperature control/reefer to be consistent across all modes.
Processes included	No reliable method for the consumption by reefers while at the terminal as yet	All warehouses/transhipment centres of logistics network	Main process groups inside the functional boundaries of the intermodal terminal: transhipment operations (different types of RMG, RTG, Reach Stacker, ...), rail operations (last mile, incl. shunting, different types of line and shunting locomotives), truck operations, additional services (e.g. depot, reefer, internal movement), supply/disposal	
Allocation notes	—	—	—	—
Vehicle operation systems (VOS) descriptions	not applicable (n.a.) - not based on VOS	n.a. - not based on VOS	VOS described within main process groups (distances, times, specific energy consumption)	Definition of boundaries especially with regard to onshore power supply (OPS)

Table 6 *(continued)*

Investigated aspect	Starting points			Identified gaps and comments
	Green Efforts	Green Logistics	ITEC	
Procedure for measured energy consumption data	Collect as much original fuel use data as possible May require data to be collected for many different processes and separate operating entities	Operators have access to original fuel use data and material consumption data on a yearly base. In general no further measurement or sampling is needed. Data collection must be specific for each warehouse/transhipment centre	Collect as much as possible real process data and energy use from terminal (terminal operating company, terminal owner, service partners)	Default database should be completely publicly available/ accessible to ensure transparency and trust
Procedure for absence of measured energy consumption data	—	We are looking to develop indicators to model energy consumption based on size, operation type, goods type and processes	Technical data sheets of all kinds of vehicles and engines used in terminals as well as experience values from other comparable terminal processes by process group and specific energy consumption	Guidelines for use and selection of data in case of absence of measured data are needed
Fuel-based versus activity based	Fuel (energy) based	For own warehouses and transhipment centres: fuel (energy) based For external warehouses and transhipment centres: estimation based on size, operation type, goods and processes (see above)	Mixed approach: activity based and fuel-based for details as well as comparison of results.	Fuel (including electricity) based preferred as aspiration, other approaches needs to be accepted in the meantime

Table 6 *(continued)*

Investigated aspect	Starting points			Identified gaps and comments
	Green Efforts	Green Logistics	ITEC	
Data sources (default data)	Electricity consumption is an important element of terminal energy use, so consistency of approach and values with rail (and other modes) is important	Electricity: Important to differ between various options of electricity generation. General approach (e.g. WTW) must be in line with other elements of logistics network (rail, road etc.) Default values will differ from rail transport, because of rail specific electricity production. Heating: Important to differ between various options of heat generation. Default values should be in line with other elements of logistics network (e.g. use of natural gas for heating and trucks)	Background data on trucks (by type), country-specific electricity data, European Diesel data, different types of heating; Self-learning database on intermodal terminals	A regularly update process of data or data sources needs to be considered. (Many data are not published and are not be validated by neutral bodies.)
Specific factors	—	—	Emission factors compliant with the European reference life cycle database	Need a standard procedure for the approach to emission factors across all modes
Gaps in existing coverage/comments	Non-container terminals not directly covered, but should be straightforward to consider similar approach using appropriate measure of throughput	Indirect emissions of use of packaging materials should not be neglected. Especially if warehouse/transhipment centre does not need heating and has low emissions due to the use of green energy. Distinction between warehouse and transhipment centre is needed	Intermodal terminals rail/road covered; barge/road tested, others could be included following the same methodology. Total life-cycle-approach, including energy and materials used to build the equipment as well as the terminal infrastructure not yet applied	Ports and associated terminals are important due to the large throughput and significant localized influence. Warehousing is also important due to its high frequency in most transport chains
Allocation unit und intensity	—	—	—	—
Calculation of distances	n.a.	n.a.	Measures distances for the different process groups, if applicable	—

Table 6 *(continued)*

Investigated aspect	Starting points			Identified gaps and comments
	Green Efforts	Green Logistics	ITEC	
Reporting	—	information on size and throughput of transhipment/ warehouse centre required	I-Report, with values on entire terminal and differentiate by main process groups	CO_2e and WTW needs to be included Definition of reporting factors for the specific purpose required (for all modes)
Accuracy labels	—	—	As accurate as possible	Accuracy labels for reporting to be developed
Harmonization note	Need to ensure consistent approach to boundaries between transhipment centres and transport elements for all modes. E.g. fuel used by vehicles that primarily operate outside the terminal will most probably be recorded under the transport mode and should not be double counted	Need to ensure consistent approach to boundaries between transhipment centres and transport elements for all modes. E.g. fuel used by vehicles that primarily operate outside the terminal will most probably be recorded under the transport mode and should not be double counted In contrast, vehicles that only run on the ground of transhipment/warehouse cannot be neglected (e.g. reach stackers, lifting truck for swap bodies)	Functional (VOS-based) definition of intermodal terminal; "external vehicles", e.g. barges, wagon sets, trucks operating inside the functional boundaries of the terminal (defined by quay wall, reception/ departure track, terminal gate) is included. Double counting is however possible if external modes of transport include these as an "overhead" on their transport part of the transport chain. Nevertheless it is meaningfully to include this into the terminal functional boundaries due to the dependency from each other. Example: the far distance rail operator will hardly know about the local shunting operations	Need to consider what processes to include and exclude. Standard(s) need(s) to specify clearly which of the following three levels for coherent quantification of CO_2e emissions of freight transport (total and intensity): (1) Level of operation of TCE; (2) Level of network including company level; (3) Level of cargo
General comments and thoughts	It would be helpful to have standard estimates to use for vehicle operations (e.g. fork lift truck operations) based on tonnes of goods handled in typical warehousing operations. All logistics hubs, e.g. airport and air cargo logistics hubs, should be taken into account.			

5.3 Level specific gaps

The extent to which degree the above gaps listed in Clause 4 and Clause 5 are to be included on the three calculation levels needs to be assessed in detail in order to ensure a transparent, robust and practical methodology.

6 Closing the current gaps

6.1 General aspects

It is strongly recommended to build any next step on currently implemented international standards. This includes ISO 14064 series, GHG Protocol Scope 3 and ISO/TS 14067.

Beyond the comments listed in the gap analysis (Clause 5), the following recommendations are made for future standardization efforts:

— Coverage of upstream CO_2e emissions (WTW aspects).

— Unambiguous definition of use of default values in absence of measured information; identification and use of appropriate default data.

— Use of individual trip level calculations only for one-off products; otherwise use averages on annual basis.

— Development of guidelines for calculation of subcontracted services.

— Coverage of pipelines as transport modes.

— Definition of reporting format and related technical specifications and data quality requirements within transport chains as well as towards third parties.

— Coverage of transhipment centres and logistics hubs.

— Any assumptions related to measurement and calculation should be clearly documented.

Developments contributing to closure of gaps should find a practical, easy and comparable approach to apply the metrics set out therein. Therefore, for each sector minimum procedures need to be defined. A basic standardized approach for all sectors, including terminals and warehouses in order to achieve level standards need to be aimed for.

6.2 Recommended next steps and format for next standardization developments

Successful harmonization of the calculation methods used for freight transport carbon footprinting depends on:

— Widespread agreement towards the approach among the various industry stakeholder groups (carriers, Logistics Service Providers LSP, shippers and terminal operators) who have differing perspective and needs.

— Close cooperation especially between industry and independent, international developers of standards such as GHG Protocol or ISO.

— Widespread acceptance by the businesses that will implement the methodology and collect/report the necessary data.

— Supporting guidance towards those who need support in moving from current to new practice.

— Involvement of policy makers and regional as well as international initiatives involved in carbon accounting and sustainability reporting, carbon reduction initiatives, quality labelling, etc.

Therefore industry groups (individual companies and associations representing different modes and functions within the transport chain) need to lead the work collaboratively to develop and implement a workable methodology framework. This framework should pull together the most appropriate elements of the existing methodologies and balances the need for sufficient accuracy with simplicity and transparency in the calculations.

The methodology framework should take into account the recommendations from this IWA regarding the gaps difference and anomalies and be supported by an action plan so that, where the recommendations

