

Guide:

Allocation of the CO₂ emissions based on CEN-EN 16258



Road Freight Transport

January 2014

Allocation methodology CO₂: Road Freight Transport



Allocation methodology CO₂: Road Freight Transport

This Guide was made for the benefit of the road freight transport in Europe.

This guide was drafted by:

Françoise van den Broek (Duoinlog)

Aad van den Engel (Panteia)

Hedi Maurer (Panteia)

The Members of the Advisory Board of this project were:

Rob Aarse (TLN)

Eelco den Boer (CE Delft)

Daniëlle Gevers Deynoot- de Booy (EVO)

Ton Mooren (EVO)

Jan van Rompay (Connekt/Lean and Green)

John Schellekens (Syntens)

Peter van der Sterre (Green Freight Europe)

Financial support was granted by Dinalog, EVO, Green Freight Europe and TLN.

Project Identification Code: 2014/0142

Zoetermeer, 24 January 2014

The responsibility for the contents of this report lies with Panteia. Quoting numbers or text in papers, essays and books is permitted only when the source is clearly mentioned. No part of this publication may be copied and/or published in any form or by any means, or stored in a retrieval system, without the prior written permission of Panteia. Panteia does not accept responsibility for printing errors and/or other imperfections.

Content

1	Preface	5
2	Framework of this guide	7
3	Roadmap allocating CO₂ emissions	9
4	The Uniform Calculation Unit	11
	Example 1: Voluminous cargo	11
	Example 2: Combination of lightweight and heavy load	11
	Comparing apples to oranges	12
5	Examples of Allocation	14
	Example 1: The Full Truck Load Transport (FTL-transport)	14
	Example 2: The Less than Truck Load Transport (LTL-transport)	15
	Example 3: Combination of two activities (two VOSs)	16
	Example 4: Combination of loading and unloading within a single VOS	18
	Example 5: Multiple vehicle types within the logistics chain	20
6	Possible application: estimation of CO₂ emission in outsourced transport	22
Annex I	Conversion factors	24
Annex 2	Joining in the (European) initiatives	25

1 Preface

A separate 'solution' for everyone?

Many service providers and shippers struggle with many kinds of questions when designing a CO₂ registration methodology. Questions regarding the starting point of measurement, the allocation of CO₂ to (parts of) trips and shipments, how to deal with the return trip and the transport route using various service providers and different equipment/procedures. Various service providers have already had their own software developed. On the one hand this is not a bad thing, as it forces the operators to think carefully about the form and content of the methodology. On the other hand, however, this also means that there may be software being developed or software that has already been developed which, although consistent with the wishes and needs of some (major) clients and service providers, may not necessarily be well suited to other parties or with existing standards, such as CEN EN 16258¹. Another effect is that the comparability of the results becomes greatly compromised through the proliferation of initiatives. This practical guide has been prepared on behalf of the road transport sector. With the growing number of companies measuring and reporting on their emissions and the numerous carbon footprint calculation standards (models and methodologies) being developed, this demands a practical harmonisation.

Need for standardisation within the Netherlands and internationally

The purpose of this guide is to create a common framework and definition for measuring CO₂ emissions. This will allow a standardised comparison on the quantity of carbon dioxide emitted during a given road transport service, using primary operational data that is based on the recently published European Standard *CEN-EN 16258*. The guide comprises a set of practical examples and guidelines to calculate the CO₂ emissions. These examples and calculations are all based on the methodology of CEN-EN 16258. Furthermore, the examples are aligned with one of the projects of the Seventh Framework Programme (FP7) named *COFRET*² (Carbon Footprint of Freight Transport), financed by the European Commission (EC). Reducing the carbon emissions of the transport and logistics sector is one of the focus points of the EC. In addition to already having developed a CO₂ Measurement Tool, Panteia is a knowledge partner in Green Freight Europe (GFE), whereby alongside companies, organisations such as EVO and TLN, are also affiliated. The methodology applied within GFE is also in line with CEN-EN 16258.³ *Green Freight Europe* and *Lean and Green* are supporting this guide and have acted as sounding board members. Both organisations have underwritten their ambition to create a joined approach for measuring the reduction of carbon emissions in freight transport in Europe by signing a Memorandum of Understanding for collaboration (November 2013). This guide is a practical realisation of this ambition.

¹ CEN-EN 16258, 'Methodology for calculation and declaration of energy consumption and GHG emissions of transport services (freight and passengers)'

² Please also refer to www.cofret-project.eu

³ In Annex 2, the relation and mutual reinforcement of this manual with Green Freight Europe and Connekt/Lean and Green is explained in further detail.

Allocation methodology CO₂: Road Freight Transport

Target audience for this guide

This guide is aimed at all European professionals active in road transport and refers to:

- private and public stakeholders transporting goods;
- stakeholders organising transport services by subcontracting the transport of goods;
- all other interested parties.

Future outlook

This guide shall be updated as required to suit the needs expressed by our target audience and the evolutions taking place with regards to the texts and reference data. Our ambition is to further develop this guide, based on the input received. Not only for European road transport, but for international intermodal transport as well.

2 Framework of this guide

Widely supported allocation methodology

The members of the advisory board of this project agree that it is highly desirable to formulate a widely accepted methodology to allocate CO₂ emissions to transported units. This unit is a widely accepted computational basis with a sufficient level of detail.

The Starting point is to use CEN-EN 16258⁴ as a guideline and to refine this in such a way that it meets the requirements of the various market participants. As such, the interests of the shippers, as well as the logistics service providers and possibly other stakeholders within the logistics process, can be included.

The Objective is to guarantee proper benchmarking of emissions data from various services by using correctly allocated CO₂ emissions per transport activity. This can be based on calculations that were made beforehand (e.g. for quotations/tenders) or based on calculations afterwards, as the members of Green Freight Europe do annually.

The Ambition is to establish a uniform methodology or methodologies for allocating the CO₂ emissions to a transport activity for the international or national transport by road, rail and inland navigation, for own account transport and outsourced transport. This is to guarantee comparability of the results.

The focus of this manual is on **road transport** and it is fully in line with CEN-EN 16258: 'Methodology for calculation and declaration of energy consumption and greenhouse gas emissions of transport services (freight and passengers)'. Although this standard requires that four factors (E_w , G_w , E_t and G_t ⁵) must be calculated, in this manual we only distinguish the 'well-to-wheels' fuel consumption (E_w), expressed in kilograms of CO₂ equivalent (CO₂e). However, the other factors can be established in a similar way.

Important terms that are used in this report on allocation methodology, are:

- *Distance traveled in kilometres;*
For the calculations, we use the actual traveled distances. For the allocations in the transport of less than full truck loads, the shortest distance to the unloading location is also required. To calculate this distance, we use the direct distance that would normally have been traveled by a truck. This distance can be determined through the own routing software or through external tools, such as the TLN planner, the PTV planner, Routenet or Google.

⁴ CEN-EN 16258 2012 European Standard, Methodology for calculation and declaration of energy consumption and GHG emissions of transport services (freight and passengers), 2012.

⁵ See Annex 1 for the definition.

Allocation methodology CO₂: Road Freight Transport

- *The type of vehicle;*
Generally, all calculations are performed at trip level. In addition, at least part of the emissions are determined by the vehicle that was used. The emissions therefore, have to be determined at the level of the individual trip, on the basis of the actual number of litres of fuel consumed by the vehicle.
In exception to this rule, the average fuel consumption per kilometre can be used in the allocation of CO₂ emissions, instead of the actual consumption. In which case, this choice has to be indicated.
- *The calculation unit*
The calculation unit is the unit to which the amount of CO₂ will be allocated. It is logical to choose the unit that is mentioned on the consignment note or invoice. Examples hereof are a container, pallet, or metric tonne;
- *The chain including underlying transport activities;*
Within a transport chain, one or more transport activities can be distinguished. These activities must all be described as the allocation of the CO₂ to each of these activities and must be carried out separately.
- *A transport activity;*
A transport activity is a trip including all empty mileage⁶ and any necessary extra kilometres to and from the actual transport trip and executed by a certain type of vehicle.
- *Storage and cross docking;*
CO₂ emissions of any transport related activities but not the actual transport itself, such as storage and cross docking are not included in this manual. This is because there aren't any standards available for these activities (just) yet.

In the (ex-post) **allocation** of CO₂, the actual (trip and consignment) data have to be used. However, if a tender has to be issued with corresponding CO₂ emissions, this is not practical. In such cases, one must have access (ex-ante) to a table with emission figures that have been realised and that are comparable with a price book. The (ex-post) consumption figures over a previous period could be used as the basis of this table.

The examples of allocation that are presented in Chapter 3 are based on the transport with the use of a CC container (Danish plant car, see Figure 2.1). However, this calculation unit can, when needed, be replaced by another unit, such as a Euro pallet or a 1,000 litre barrel. Generally, the roadmap (see Chapter 3) is applicable for all calculation units. When choosing the appropriate calculation unit for the allocation of CO₂, the trip assignment on the consignment note or invoice can be used.

Figure 2.1 CC-container



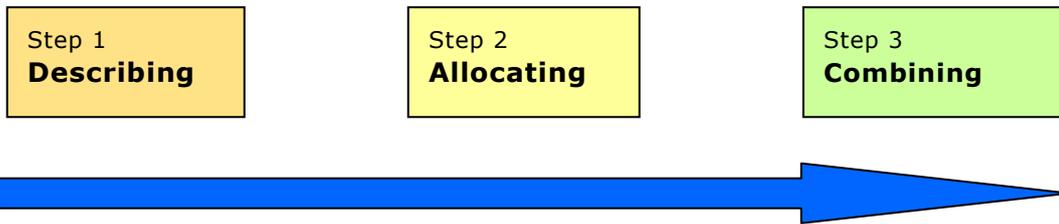
⁶ This is called a Vehicle Operation System (VOS) in the Norm CEN-EN 16258.

3 Roadmap allocating CO₂ emissions

Transport activities only

This chapter provides a brief overview of the standard procedure (roadmap) for the allocation of CO₂ to the components of the logistics chains.

In Step 1, the transport activities of a transport service from A to B are described. For each transport activity, the energy and fuel consumption are calculated and on the basis of these figures the CO₂ emissions are calculated. In Step 2, the CO₂ emissions per transport activity at shipment level are allocated to a certain calculation unit, e.g. a container. In Step 3, the results for all transport activities are added up. During this process, the allocation is always seen from the perspective of the receiver of the shipment.



Note: in this manual, only the emissions of the mileage are allocated. The allocation of other transport-related activities, such as storage and cross docking is expected to be included in the next version of this guide.

Step 1: Describing the logistics chain, calculating the fuel consumption and determining CO₂ emissions

Logistics chains

A logistics chain consists of one or more separate transport activities⁷, e.g. a transport of a box container filled with (1,000 kg) fruit juice concentrate from a terminal in port A to a distribution center in B (=transport activity 1). From there, transport takes place with a 25 tonne tanker to a retailer in C (transport activity 2).

A detailed description of a chain also offers a clear representation of the underlying (transport) activities and thus in the data that has to be collected. A starting point for the description of a chain could be the individual transport assignments.

In describing the logistics chain, it is therefore, important to collect and/or describe the following data:

- *Actual distance travelled in kilometres;*
- *(Mode and) Type of Vehicle;*
- *Calculation unit (e.g. container, pallet, metric tonne);*
- *The logistics chain and the underlying transport activities;*
- *(Beginning and end of) each transport activity.*

Considering the transport activities, we distinguish two main forms in this guide:

- Full Truck Load (FTL), and
- Less than Truck Load (LTL).

⁷ An activity is comparable to a "Vehicle Operation System" (VOS)

Allocation methodology CO₂: Road Freight Transport

The fuel consumption per transport activity is then converted into CO₂ emissions using a conversion table (see Annex 1). Since we only allocate the CO₂ emissions of the vehicle kilometres in this manual, the calculation is as follows: number of consumed litres of diesel multiplied by 3,17 kg ('well-to-wheels').

The determination of the fuel consumption takes place on the basis of a full trip⁸, and includes the possible empty miles.

Subsequently, the calculated total amount of CO₂ has to be allocated to the transport activity (Step 2).

Step 2: Allocating CO₂ emissions to the transport activities

The total CO₂ emission of a trip carried out by a truck has been calculated in Step 1. This total then has to be allocated to the performance expressed in for example, the number of transported goods for Client 1.

For the determination of the total emission in Step 3, it is essential that all allocations are performed by means of the same calculation unit. The foundation can be a cubic meter, but also a litre or similar standard loading unit. The unit mentioned on the invoice (or consignment note) is a good starting point. The examples (see Chapter 3) are always based on CC containers (= Danish plant cart). This calculation unit can be replaced by every other unit, without having to change the allocation methodology.

Step 3: Combining results and allocating to clients

In the transport of most shipments, several different freight vehicles (or VOS) are involved. These can be vehicles of one company, but parts of the transport can also be outsourced. However, CEN-EN 16258 requires that the emissions caused by the outsourced transport activities should also be included in the total emissions.

The total emission of CO₂ caused by a certain shipment is then the sum of the allocated emission of all underlying transport activities.

⁸ A drive with a particular vehicle can be seen as a "VOS".

4 The Uniform Calculation Unit

The preceding steps describe the allocation of CO₂ to clients based on the selected calculation unit. However, when different types of cargo are grouped into one vehicle, we could be dealing with different calculation units, in which case an extra step is required for the allocation of CO₂ to clients and in addition to CEN-EN 16268. This step, which goes beyond this standard, involves the identifying and applying of a generic calculation unit. In most cases, this will be a conversion to a volume or weight based unit:

- “Cubic metres” (or load length in case of non-stackable goods) for goods which weigh (far) less than 333⁹ kg/m³. The load volume in m³ of the vehicle is then the limiting factor;
- “Kilogram” for goods which weigh more than 333 kg/m³. The carrying capacity of the vehicle in tonnes is the limiting factor.

Example 1: Voluminous cargo

Imagine the following situation with goods with a particularly low weight (‘light goods’):

- Boxes and pallets lighter than 333 kg/m³ are loaded into a vehicle;
- On average, a box occupies 0,5 m³ and a pallet 2,5 m³;
- The loading capacity of the truck is 40 m³;
- The consumption of the trip is 54,1 kg CO₂e (see Chapter 5, Example 1);
- In a specific trip, 20 boxes for Client 1 and 6 pallets for Client 2 are loaded. These are loaded at one address and the delivery addresses are close together.

Allocation to client:

The volume of the shipment to Client 1: 20 boxes times 0,5 m³ = 10 m³;

The volume of the shipment to Client 2: 6 pallets times 2,5 m³ = 15 m³;

The total load volume is thus 25 m³.

CO₂ emissions allocated to Client 1: 10/25 times 54,1 kg CO₂e = 21,6 kg CO₂e

CO₂ emissions allocated to Client 2: 15/25 times 54,1 kg CO₂e = 32,5 kg CO₂e

Example 2: Combination of lightweight and heavy load

Imagine the following situation with both lightweight and heavy goods:

- Boxes lighter than 333 kg/m³ and pallets with heavy objects are loaded.
- A box weighs 50 kg and occupies on average 0,5 m³. The pallets also occupy 0,5 m³ but weigh 1,000 kg a piece;
- The loading capacity of the truck is 40 m³;
- The emission of the trip is 54,1 kg CO₂e (see Chapter 5, Example 1);
- In a specific trip, 20 boxes for Client 1 and 6 pallets for Client 2 are loaded.

Allocation to the clients:

The volume of the shipment to Client 1: 20 boxes times 0,5 m³ = 10 m³. Using the conversion factor 1 m³ = 333 kg, this shipment has a (calculated) paying weight of 3,333 kg;

⁹ 1 cubic metre (m³) is equal to 333 kg. This ratio is commonly used as a conversion factor between volume and weight. The highest weight of both (converted volume or actual) have to be used.

Allocation methodology CO₂: Road Freight Transport

The weight of the shipment to Client 2: 6 pallets times 1,000 kg = 6,000 kg;
The total weight of the load is then 9,333 kg.

Allocated CO₂ emissions to Client 1: $3,333/9,333$ times 54,1 kg CO₂e = 19,3 kg CO₂e
Allocated CO₂ emissions to Client 2: $6,000/9,333$ times 54,1 kg CO₂e = 34,8 kg CO₂e

Comparing apples to oranges

Example 2 shows that in case a truck load consists of both lightweight and heavy cargo, a substitution of the actual weight or volume by a new calculation unit is necessary, in order to allocate the total CO₂ emission of the truck in a correct way. The same challenge holds when an entrepreneur wants to sum up the total CO₂ emissions of all trucks in his company for a longer period of time. He will then also be confronted with several different calculation units.

UTP-CO₂

In order to facilitate a comparison of the CO₂ performance of individual trips over a longer period of time, a transport company has to make use of a uniform calculation unit. This uniform calculation unit has to take into account both heavy and lightweight goods. This comparing and adding up of the CO₂ performance of individual trips is made possible by using the 'Uniform Transport Performance CO₂' (UTP- CO₂). This factor combines the load factor of the truck in relation to the travelled distance and the corresponding CO₂ emissions. The UTP- CO₂ then consists of an aggregated amount per volumetonnekilometre.

The general calculation is as follows:

Number of volumetonnekm: (calculated paying weight times the number of km of the outward trip plus paying weight times the number of km of the return trip).

In the case, as depicted in paragraph 4.2, this leads to the following calculations:

- Distance travelled 70 kms; 35 kms loaded, 35 kms empty return trip;
- CO₂ emissions 54,1 kg (see Chapter 5, Example 1);
- Total paying weight cargo 3,333 kg + 6,000 kg = 9,333 kg;
- Total number of volumetonnekms: 9,333 times 35 = 326;
- UTP-CO₂: $54,1/326 = 0,17$ kg CO₂ per volumetonnekm.

Warning

Aggregated figures on CO₂ emissions for a certain period seem easily suitable for benchmarking exercises. However, a warning has to be given **to not compare apples with oranges**. Although the calculation unit seems to be the same, underlying transport activities may greatly vary. In addition, the resulting incomparability is not visible. This applies both within a transport company, as certainly also between different transport companies.

Shipment/ Amount	kg	m ³	'Limiting' factor	Conversion rule	Calculated paying weight (in kg)
Shipment 1	100	1	Weight (< 333 kg)	1 m ³ = 333 kg	333
Shipment 2	1,000	1	Weight (> 333 kg)	Actual weight	1,000
Shipment 3	500	10	Volume	1 m ³ = 333 kg	3,333
Total	(1,600)*	(12)*			4,666

* The values between the brackets are not valid and only used to clarify calculating mistakes.

Allocation methodology CO₂: Road Freight Transport

A straight adding up of weight (kg) and volume (m³) figures, leads to a false result, namely $1,600 + (12 \text{ times } 333) = 5.596 \text{ kg}$. The correct volumetonne is 4,666 kg. This explanation is especially valid in case of intra-company comparisons.

When a UTP- CO₂ is used to compare transporters with each other, the fact that the calculations are made in the same way comes to mind first.

However, even if two transport companies are nearly identical the results cannot be readily compared. Even in the same market segments and while both transport companies perform equally well in terms of fuel efficiency, differences in cargo packages and area coverage may lead to divergent outcomes.

The selection of transport companies and awarding of transport orders singly on the basis of CO₂ emissions may easily lead, even in the case of proper allocation, to wrong decisions because of the pitfall of comparing apples with oranges.

Remark:

This elaboration on volumetonnekm is no requirement in CEN EN 16258 and is intended only as a practical addition.

Lastly, with the help of the following table the user of this guide can communicate the results of the allocation of the CO₂ emission to his clients.

CO₂ emissions allocated according to the guide "Allocation of CO₂ emissions"
Based on CEN-EN 16258

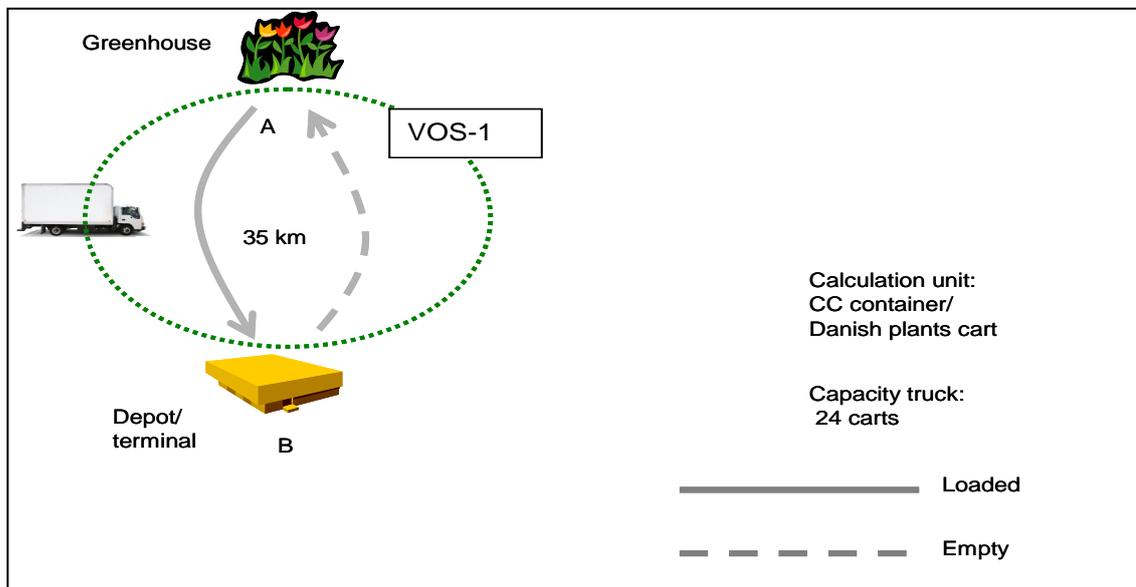
Calculation principles:

- Calculation unit (unit of transport): pallet/m³/litre/...
(see waybill or invoice)
- Number of transported units/payload (see waybill or invoice)
- Allocated number of kilogram CO₂e (WTW)
- Date and reference number (waybill/invoice)
- Allocation to a uniform calculation unit (volumetonnekm) (optional)

5 Examples of Allocation

Example 1: The Full Truck Load Transport (FTL-transport)

Figure 5.1 FTL-transport



Step 1: description of the logistics chain

- The logistics chain (see Figure 5.1):
The assignment concerns the transport of full loads to a single client. Loading and unloading of the cargo takes place at a single address. The calculation unit for the allocation is a CC-container with the dimensions of 1,350 x 565 x 1,900 mm.

Step 2: allocation to activities

- Required data:
 - o Volume of the shipment for the Client: 24 CC-containers;
 - o Cargo weight: 14,400 kg;
 - o Length of the roundtrip: 70 kilometre;
 - o Fuel consumption of the deployed freight vehicle: 24,4 litre/100 km¹⁰ (4,1 km/litre).
- Calculation of the total emission of a roundtrip in kilogram:
 - o Diesel consumption: 70 kilometre/(4,1km/l)= 17,1 litre;
 - o Emission CO₂: 17,1 litre times 3,17 kg CO₂/l¹¹= 54,1 kg CO₂e (WTW).

Remark: Generally all calculations should be made with non rounded figures. However, for the readability in the examples we present only rounded figures. This may lead to small differences between the calculated results and the figures that are presented in the examples.

¹⁰ Often the choice is made to use average fuel consumption figures instead of the realised figures.

¹¹ See conversion table in Annex I

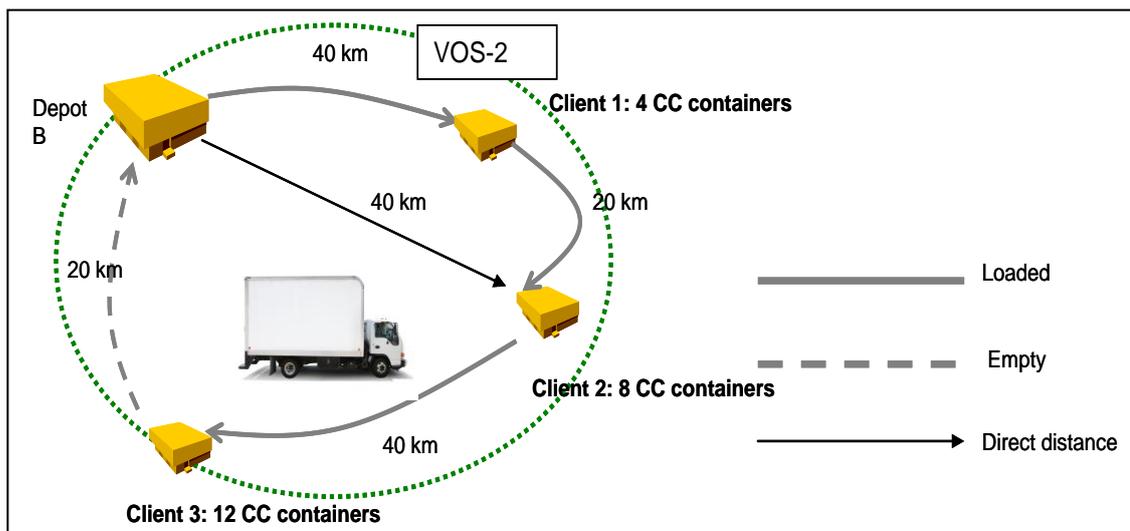
Allocation methodology CO₂: Road Freight Transport

Step 3: (adding up and) allocating to clients and/or calculation unit

- Allocating of CO₂:
 - o Per client: 54,1 kg CO₂;
 - o Per CC-container: (54,1/24 =) 2,3 kg CO₂e (WTW) per CC-container.
 - o Per client: 54,1 kg CO₂;
 - o Per CC-container: (54,1/24 =) 2,3 kg CO₂e (WTW) per CC-container.
 - o

Example 2: The Less than Truck Load Transport (LTL-transport)

Figure 5.2 LTL-transport



Step 1: description of the logistics chain

- The logistics chain (see Figure 5.2):
This is the full freight transport by vehicles for multiple clients that are loaded at a single address and unloaded at multiple addresses. To this end, one truck is fully deployed. The basis for allocation is a CC-container.

Step 2: allocation to activities

- Required data:
 - o Size of the shipment for:
 - Client 1: 4 CC-containers;
 - Client 2: 8 CC-containers;
 - Client 3: 12 CC-containers.
 - o Length of the roundtrip: 120 kilometre (40+20+40+20 km);
 - o Fuel consumption of the trucks deployed: 24,4 litre/100 km (4,1 km/litre).
- Calculation of the total emission of a roundtrip in kilogram:
 - o Diesel consumption: 120 kilometres/(4,1km/l)= 29,3 litre;
 - o Emission CO₂e: 29,3 litre times 3,17 kg CO₂e/l¹²= 92,8 kg CO₂e (WTW).

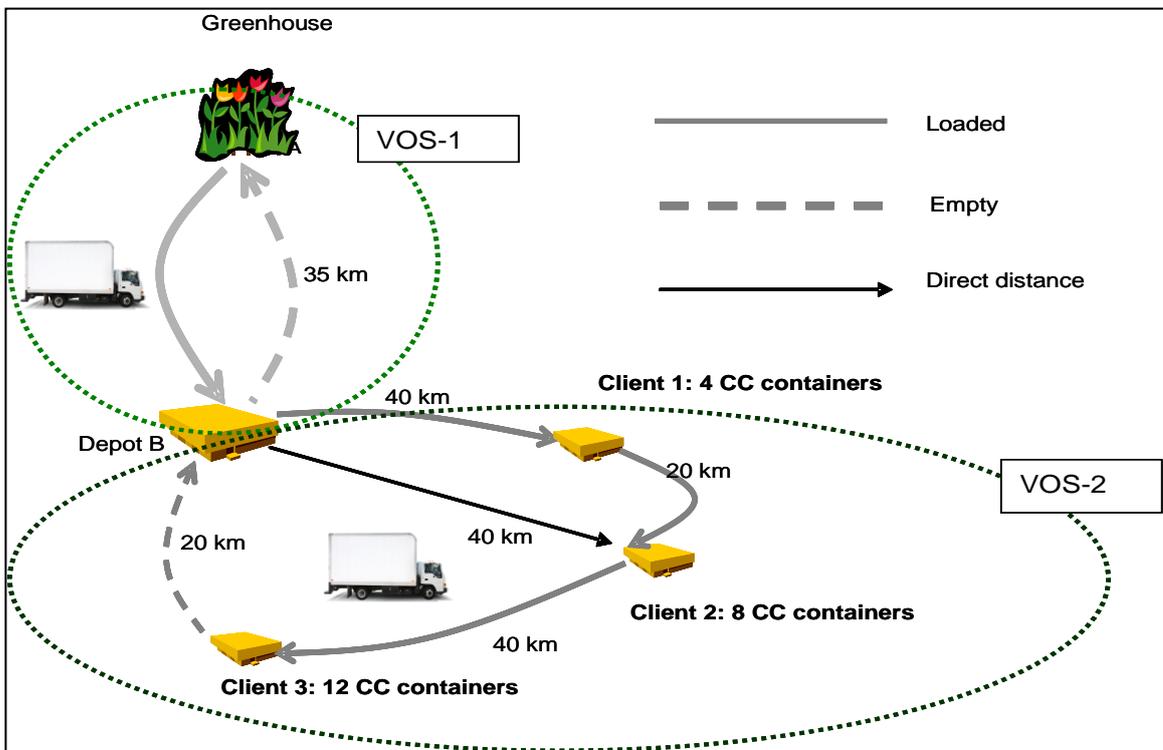
¹² See Annex I

Allocation methodology CO₂: Road Freight Transport

- Allocation of CO₂e:
 - o Per Client:
 - Client 1: 160/720 CC kms times 92,8 kg CO₂e= 20,6 kg CO₂e (WTW);
 - Client 2: 320/720 CC kms times 92,8 kg CO₂e= 41,3 kg CO₂e (WTW);
 - Client 3: 240/720 CC kms times 92,8 kg CO₂e= 30,9 kg CO₂e (WTW).
 - Total: 92,8 kg CO₂e (WTW)
 - o Per CC-container: (92,8/24 =) 3,9 kg CO₂e (WTW) per CC-container.

Example 3: Combination of two activities (two VOSs)

Figure 5.3 Combination of two VOSs (FTL + LTL-transport)



Step 1: description of the logistics chain

- The logistics chain (see Figure 5.3):

It is an activity (VOS) in transport performed by fully loaded trucks, that are loaded and unloaded at a single address. To this end, one truck is fully deployed. This transport is combined with the transport by fully loaded trucks for multiple clients that are loaded at a single address and unloaded at multiple addresses. To this end, one truck is fully deployed. The basis for allocation is a CC-container.

Allocation methodology CO₂: Road Freight Transport

Step 2: allocation to activities

- Required data VOS-1 (see Example 1):
 - o Size of the shipment for the Client: 24 CC-containers;
 - o Length of the roundtrip: 70 kilometre;
 - o Fuel consumption of the truck deployed: 24,4 litre/100 km (4,1 km/litre).
- Calculation of the total emission of a (round)trip in kilogram VOS-1:
 - o Diesel consumption: $70 \text{ kilometre} / (4,1 \text{ km/l}) = 17,1 \text{ litre}$;
 - o Emission CO₂e: $17,1 \text{ litre} \times 3,17 \text{ kg CO}_2\text{e/l} = 54,1 \text{ kg CO}_2\text{e (WTW)}$.
- Required data VOS-2 (see Example 2):
 - o Size of the shipment for:
 - Client 1: 4 CC-containers;
 - Client 2: 8 CC-containers;
 - Client 3: 12 CC-containers.
 - o Length of the roundtrip VOS-2: 120 kilometre (40+20+40+20 km);
 - o Fuel consumption of the truck deployed: 24,4 litre/100 km (4,1 km/litre).
- Calculation of the total emission of a (round)trip in kilogram VOS-2:
 - o Diesel consumption: $120 \text{ kilometre} / (4,1 \text{ km/l}) = 29,3 \text{ litre}$;
 - o Emission CO₂e: $29,3 \text{ litre} \times 3,17 \text{ kg CO}_2\text{e/l} = 92,8 \text{ kg CO}_2\text{e (WTW)}$.

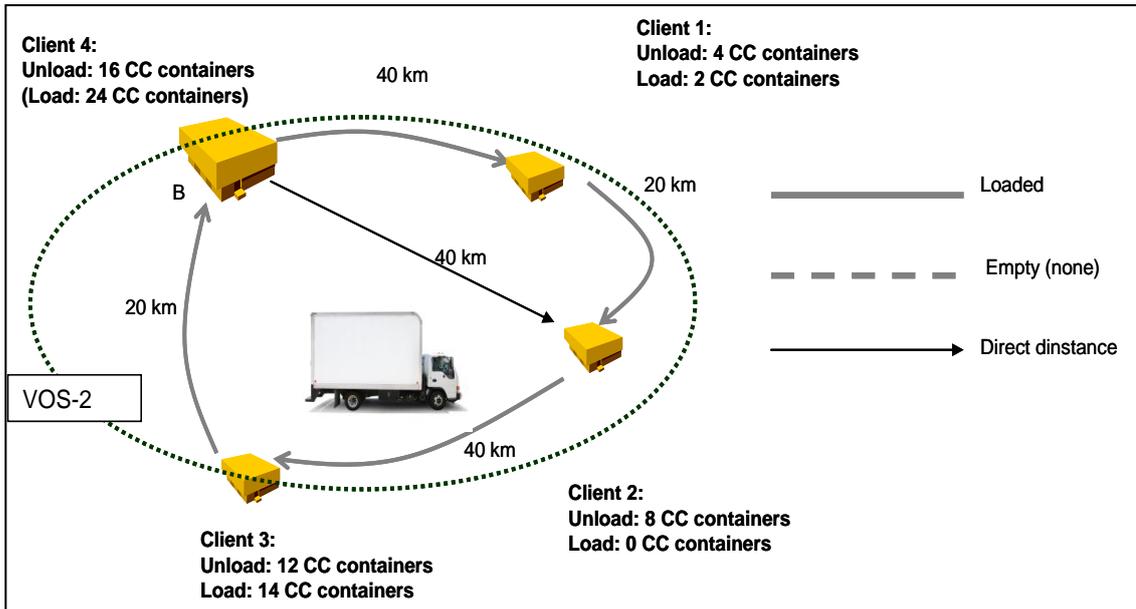
Step 3: (adding up and) allocating to clients and/or calculation basis

- Allocation of CO₂e for VOS-1:
 - o Client 1: $4 \text{ CC-container} \times 2,3 \text{ kg CO}_2\text{e per CC-container} = 9,0 \text{ kg CO}_2\text{e}$;
 - o Client 2: $8 \text{ CC-container} \times 2,3 \text{ kg CO}_2\text{e per CC-container} = 18,0 \text{ kg CO}_2\text{e}$;
 - o Client 3: $12 \text{ CC-container} \times 2,3 \text{ kg CO}_2\text{e per CC-container} = 27,1 \text{ kg CO}_2\text{e}$;
 - o Total VOS-1: $54,1 \text{ kg CO}_2\text{e (WTW)}$.
- Allocation of CO₂e for VOS-2 (see Example 2):
 - o Client 1: 20,6 kg CO₂e;
 - o Client 2: 41,3 kg CO₂e;
 - o Client 3: 30,9 kg CO₂e;
 - o Total VOS-2: $92,8 \text{ kg CO}_2\text{e (WTW)}$.
- Total allocation of CO₂ per Client:
 - o Client 1: $29,7 \text{ kg CO}_2\text{e (9,0+20,7)}$;
 - o Client 2: $59,3 \text{ kg CO}_2\text{e (18,0+41,3)}$;
 - o Client 3: $58,0 \text{ kg CO}_2\text{e (27,1+30,9)}$;
 - o Total for the logistics chain (VOS-1 + VOS-2): $147,0 \text{ kg CO}_2\text{e (WTW)}$.

Allocation methodology CO₂: Road Freight Transport

Example 4: Combination of loading and unloading within a single VOS

Figure 5.4 Combination of loading and unloading within a single VOS



Step 1: description of the logistics chain

- The logistics chain (see Figure 5.4): Starting point is at Client 4. This is transport by fully loaded trucks for multiple clients. Loading and unloading is done at multiple addresses. To this end, one truck is fully deployed. The basis for allocation is a CC-container.

Step 2: allocation to activities

- Required data:
 - o Size of the shipment for:
 - Client 1: unloaded 4 CC-containers from Client 4, loaded 2 CC-containers for Client 4;
 - Client 2: unloaded 8 CC-containers, loaded 0 CC-containers;
 - Client 3: unloaded 12 CC-containers from Client 4, loaded 14 CC-containers for Client 4.
 - o Length of the roundtrip: 120 kilometre (40+20+40+20 km);
 - o Fuel consumption of the truck deployed: 24,4 litre/100 km (4,1 km/litre).
- Calculation of the total emission of a (round)trip in kilogram:
 - o Diesel consumption: 120 kilometre/(4,1km/l)= 29,3 litre;
 - o Emission CO₂e: 29,3 litre times 3,17 kg CO₂e/l= 92,8 kg CO₂e (WTW).

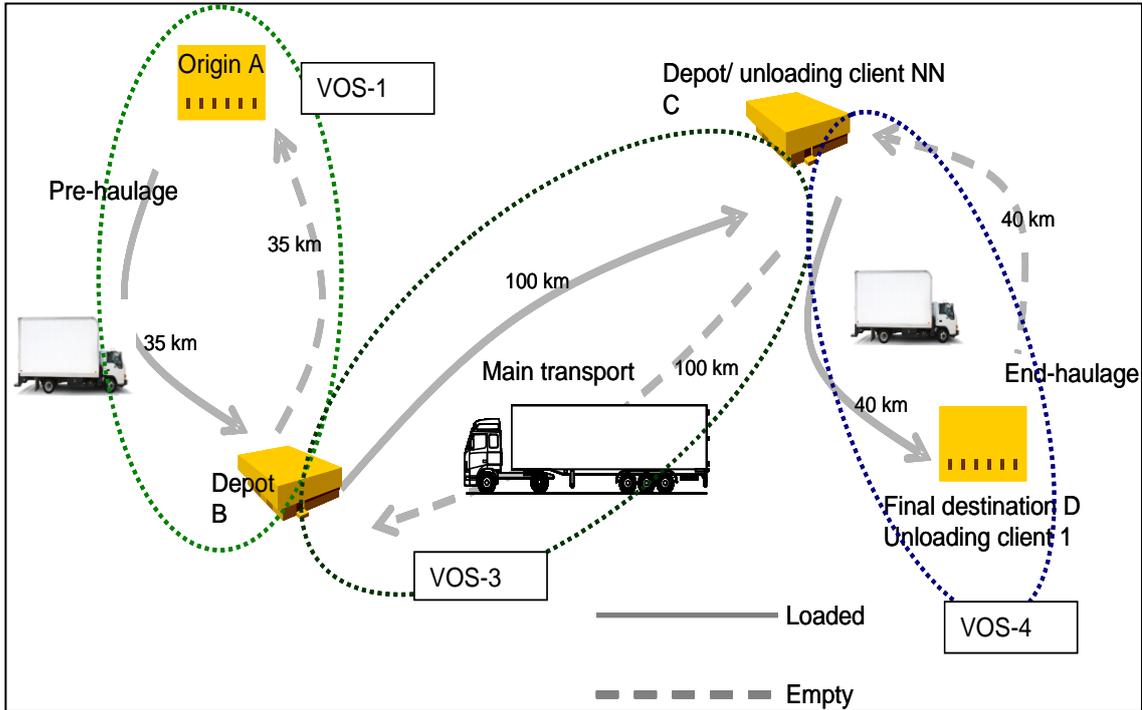
Allocation methodology CO₂: Road Freight Transport

Step 3: (adding up and) allocating to clients and/or calculation basis

- Direct distance:
 - o Depot B to Client 1: 40 km;
 - o Depot B to Client 2: 40 km;
 - o Depot B to Client 3: 20 km.
- Allocation key per Client:
 - o Client 1: 40 km times 4 CC-containers = 160 CC kms
 - o Client 2: 40 km times 8 CC-containers = 320 CC kms
 - o Client 3: 20 km times 12 CC-containers = 240 CC kms
 - o Client 4 (in depot B): 40 km times 2 CC-containers plus 20 km times 14 CC-containers = 360 CC kms
 - o Total: 1,080 CC kms.
- Allocation of CO₂e per Client:
 - o Client 1: $160/1,080$ CC kms times 92,8 kg CO₂e = 13,8 kg CO₂e (WTW);
 - o Client 2: $320/1,080$ CC kms times 92,8 kg CO₂e = 27,5 kg CO₂e (WTW);
 - o Client 3: $240/1,080$ CC kms times 92,8 kg CO₂e = 20,6 kg CO₂e (WTW)
 - o Client 4: $360/1,080$ CC kms times 92,8 kg CO₂e = 30,9 kg CO₂e (WTW)
 - o Total: 92,8 kg CO₂e (WTW).

Example 5: Multiple vehicle types within the logistics chain

Figure 5.5 Multiple VOSs within the logistics chain



Step 1: description of the logistics chain

- The logistics chain (see Figure 5.5):
The first vehicle picks up the shipment from Origin A (VOS-1), a second vehicle carries out the long-distance transport from Depot B to Depot C (unloading point Client NN; VOS-2) and a third vehicle delivers the shipment to its final destination in D to Client 1 (VOS-3).
In this example, the logistics chain goes from the loading point to the final unloading point, spread out over three different VOSs. The transport is carried out by two different types of trucks.

Step 2: allocation to activities

- Required data:
 - o Client 1: is in D and receives 24 CC-containers from Origin A, through Depot B and Depot C
 - o Client NN: is in C and receives 19 CC-containers from Depot B
 - o Pre-transport (VOS-1):
 - Size of the shipment for the Client 1: 24 CC-containers;
 - Load capacity of the truck: 24 CC-containers;
 - Fuel consumption of the truck deployed: 24,4 litre/100 km (4,1 km/litre);
 - Length of the roundtrip: 70 kilometre.
 - o Main transport (VOS-3):
 - Size of the shipment for the Client 1: 24 CC-containers;
 - Load capacity truck/trailer: 43 CC-containers;
 - Fuel consumption of the truck deployed: 33,3 litre/100 km (3,0 km/litre);
 - Length of the roundtrip: 200 kilometre;

Allocation methodology CO₂: Road Freight Transport

- Oncarriage (VOS-4):
 - Size of the shipment for the Client 1: 24 CC-containers;
 - Load capacity of the truck: 24 CC-containers;
 - Fuel consumption of the truck deployed: 24,4 litre/100 km (4,1 km/litre);
 - Length of the roundtrip: 80 kilometre.
- Calculation of the total emission of this shipment within the logistics chain :
 - VOS-1 Pre-transport: 70 kilometre/(4,1km/l)= 17,1 litre (54,1 kg CO₂e WTW);
 - VOS-3 Main transport: 200 kilometre/(3,0km/l)= 66,7 litre (211,3 kg CO₂e WTW);
 - VOS-4 Oncarriage: 80 kilometre/(4,1km/l)= 19,5 litre (61,9 kg CO₂e WTW);
 - Total consumption: 103,3 litre diesel;
 - Total emission: 327,3 kg CO₂e (WTW).

Step 3: (adding up) allocation to this shipment for Client 1

- Pre-transport (VOS-1):
 - Client 1: 54,1 kg CO₂e (WTW) (= 17,1 litre times 3,17 kg/l);
- Main transport (VOS-3):
 - Client 1: 100 km times 24 CC-containers= 2.400 CC kms;
 - Client NN: 100 km times 19 CC-containers= 1.900 CC kms;
 - Total: 4.300 CC kms;
 - Total: 211,3 kg CO₂e (WTW)
 - Allocation of CO₂e:
 - Client 1: 2,400/4,300 CC kms times 211,3 kg CO₂e= 118,0 kg CO₂e (WTW);
 - Client NN: 1,900/4,300 CC kms times 211,3 kg CO₂e= 93,4 kg CO₂e (WTW);
 - Total: 211,3 kg CO₂e (WTW)
- Oncarriage (VOS-4):
 - Client 1: 61,92 kg CO₂e (WTW) (= 19,5 litre times 3,17 kg/l).
- Total for this shipment for Client 1:
 - Pre-transport (VOS-1): 54,1 kg CO₂e (WTW);
 - Main transport (VOS-3): 118,0 kg CO₂e (WTW);
 - Oncarriage (VOS-4): 61,9 kg CO₂e (WTW);
 - Total: 233,9 kg CO₂e (WTW).

6 Possible application: estimation of CO₂ emission in outsourced transport

CO₂ emissions of any outsourced transport activities should also be included in the allocation. This requirement stems from the international agreements in the Greenhouse Gas Protocol.¹³ This guide endorses these agreements, in conformity with CEN-EN 16258. The most obvious and highly recommended approach is that the carrier that the shipment has been outsourced to, calculates this emission. These calculations should be performed as described in this manual. However, if this is not possible, or if it is not possible to perform a check on the data obtained, then a self allocation can be conducted. This self allocation is based on personal experiences. The example below shows one way in which such a self allocation could take place during the trip. However, as long as the choice is justifiable, other examples from Chapter 5 can also be used as a starting point.

Step 1: description of the logistics chain (outsourced transport activities)

- The logistics chain (available data):
 - o Volume: the transport of 12 CC-containers;
 - o Direct distance: 30 km.
- Missing data:
 - o Length of the roundtrip;
 - o (Load capacity and consumption of) the deployed vehicle.

Step 2: allocation to activities

- Required data:
 - o Size of the shipment for the Client: 12 CC-containers;
 - o Length of the roundtrip: unknown;
 - Own information (see Example 2):
 - Average length of the roundtrip: 120 km;
 - Total direct distances: 90 km;
 - Increment factor 120km/90km.
 - Allocated distance Client 1: 30 km times (120/90)= 40 km.
 - o Vehicle deployed: unknown;
 - Own information (see Example 2):
 - Load capacity: 24 CC-containers;
 - Fuel consumption: 24,4 litre/100km.
- Calculation of the total emission of a (round)trip in kilogram:
 - o Diesel consumption: 120 kilometre/(4,1km/l)= 29,3 litre;
 - o Emission CO₂e: 29,3 litre times 3,17 kg CO₂e/l= 92,8 kg CO₂e (WTW).

¹³ See www.ghgprotocol.org

Allocation methodology CO₂: Road Freight Transport

Step 3: allocation to Client 1

- Direct distance:
 - o Direct distance from loading point to destination for Client 1: 30 km;
 - o Allocated kilometres Client 1: $(120/90) \times 30 \text{ km} = 40 \text{ km}$;
 - o Total length roundtrip: 120 km;
 - o Allocated kilometres for the remaining Clients: $120 \text{ km} - 40 \text{ km} = 80 \text{ km}$
 - o Direct distances for the remaining Clients: $80 \text{ km} \times (90/120) = 60 \text{ km}$.
- Allocation keys per Client (based on direct distances):
 - o Client 1: $30 \text{ km} \times 12 \text{ CC-containers} = 360 \text{ CC kms}$
 - o Client NN: $60 \text{ km} \times 12 \text{ CC-containers} = 720 \text{ CC kms}$
 - o Total: 1.080 CC kms.
- Allocation of CO₂e per Client:
 - o Client 1: $360/1080 \text{ CC kms} \times 92,8 \text{ kg CO}_2\text{e} = 30,9 \text{ kg CO}_2\text{e (WTW)}$;
 - o Client NN: $720/1080 \text{ CC kms} \times 92,8 \text{ kg CO}_2\text{e} = 61,9 \text{ kg CO}_2\text{e (WTW)}$;
 - o Total: 92,8 kg CO₂e (WTW).

Annex I Conversion factors

A.1 Description of the mandatory emission factors

- Ew: Well-to-wheels energy consumption;
- Gw: Well-to-wheels GHG (greenhouse gas) emissions;
- Et: Tank-to-wheels energy consumption;
- Gt: Tank-to-wheels GHG emissions.

A.2 Conversion factors CEN-EN 16258:2012

Fuel type description	Density (d)	Energy Factor				GHG emission factor					
		Tank-to-wheels (e _t)		Well-to-wheels (e _w)		Tank-to-wheels (g _t)			Well-to-wheels (g _w)		
	kg/l	MJ/kg	MJ/l	MJ/kg	MJ/l	gCO ₂ e /MJ	kgCO ₂ e/kg	kgCO ₂ e/l	gCO ₂ e /MJ	kgCO ₂ e/kg	kgCO ₂ e/l
Gasoline	0,745	43,2	32,2	50,5	37,7	75,2	3,25	2,42	89,4	3,86	2,88
Ethanol	0,794	26,8	21,3	65,7	52,1	0	0	0	58,1	1,56	1,24
Gasoline/Ethanol blend 95/5	0,747	42,4	31,7	51,4	38,4	72,6	3,08	2,30	88,4	3,74	2,80
Diesel	0,832	43,1	35,9	51,3	42,7	74,5	3,21	2,67	90,4	3,90	3,24
Bio-diesel	0,890	36,8	32,8	76,9	68,5	0	0	0	58,8	2,16	1,92
Diesel/bio-diesel blend 95/5	0,835	42,8	35,7	52,7	44,0	71	3,04	2,54	88,8	3,80	3,17
Liquefied Petroleum Gas (LPG)	0,550	46,0	25,3	51,5	28,3	67,3	3,10	1,70	75,3	3,46	1,90
Compressed Natural Gas (CNG)	–	45,1	–	50,5	–	59,4	2,68	–	68,1	3,07	–
Liquefied/liquid natural gas (LNG)*)	–	48,5	–	–	–	56,2	2,70	–	69,5	3,37	–
Aviation Gasoline (AvGas)	0,800	44,3	35,4	51,8	41,5	70,6	3,13	2,50	84,8	3,76	3,01
Jet Gasoline (Jet B)	0,800	44,3	35,4	51,8	41,5	70,6	3,13	2,50	84,8	3,76	3,01
Jet Kerosene (Jet A1 and Jet A)	0,800	44,1	35,3	52,5	42,0	72,1	3,18	2,54	88,0	3,88	3,10
Heavy Fuel Oil (HFO)	0,970	40,5	39,3	44,1	42,7	77,7	3,15	3,05	84,3	3,41	3,31
Marine Diesel Oil (MDO)	0,900	43,0	38,7	51,2	46,1	75,3	3,24	2,92	91,2	3,92	3,53
Marine Gas Oil (MGO)	0,890	43,0	38,3	51,2	45,5	75,3	3,24	2,88	91,2	3,92	3,49

Source: CEN-EN 16258:2012 Table A.1 (pag. 24).

*) Source: CE Delft

In this guide, we propose the CEN-EN 16258 standard as central and therefore, use the conversion factors that are part of that publication. Other conversion tables also exist with other values. An updated table, featuring the current missing emission values for, for example, electricity, will be part of the next version of this guide.

Annex 2 Joining in the (European) initiatives

Green Freight Europe

At European level, a group of around 150 multinational organisations have united to become Green Freight Europe (GFE). A European sustainability programme in which a CO₂ monitoring ring and reporting platform is being developed where companies (both shippers and logistics service providers) can calculate the average shipment level CO₂ emissions on a yearly basis. A number of companies and organisations in the Netherlands, such as EVO, TLN and Panteia are also affiliated. The methodology applied within GFE is in line with CEN-EN 16258.

This guide follows the CO₂ emissions at trip level. This is a further refinement of what is being developed within GFE, as GFE looks at a higher level of abstraction; a CO₂ equivalent per unit per year (eg tonne-km or packages) of a particular type of service provision within a given area. Where possible, companies are asked to provide the actual data and businesses are requested to make their calculations (litres of fuel consumption, actual distance and transport performance), using this actual data. This results in an average yearly CO₂ emission for that service provision. With this emission value, clients (both shippers, forwarders and carriers) are then able to start mapping the carbon footprint of their outsourced transport. Based on the obtained data, companies can refine themselves even further.

Lean and Green and Green Freight Europe

Green Freight Europe and Lean and Green signed a Memorandum of Understanding on 12 November 2013. The two organisations are working together to realise their joint ambition for the reduction of CO₂ emission in road transport in Europe. More than 300 companies have committed to twenty percent CO₂ savings in Lean and Green. Members of Green Freight Europe and Lean and Green can profit from their cooperation within one another's programmes. Therefore, the initiative to achieve further refinement and a good guide in conformity with the CEN-EN 16258 Standard, is very actively supported by both organisations.