INTRODUCTION TO THE CALCULATION OF CO_2 EMISSIONS FOR PARTICIPATION IN LEAN & GREEN

The basics of establishing the baseline of CO_2 emissions of road transport, inland shipping, rail transport, warehouses/distribution centers and terminals, for participation in national chapters of Lean & Green

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INTRODUCTION

One of the first steps in Lean & Green is to establish the baseline:
the CO_2 emissions[1] related to a part of a supply chain for a shipper, or
related to your companies activities for a transporter. The baseline is used to develop
an action plan to reduce the overall emissions by 20% or more.

Establishing a baseline may be the first time someone is exposed to
CO_2 emissions calculations for transport. This document provides a simple, step-by-
step plan for calculating CO_2 emissions[2].

You will be guided through the process of determining the CO_2 emissions
of the most common transport modes (road, inland shipping and rail
transport), as well as those of warehouses, distribution centers and terminals.

We will explain step by step:

> Where you should start
> What data you need and where you can collect them
> How to calculate your CO_2 emissions
> How to calculate your emissions per unit

[1] The official indicator for GHG emissions is CO_2e , the normalized effect of a GHG gas. In this
   document CO_2 is used as a shorthand for GHG emissions expressed in CO_2e.
[2] The method for calculating emissions is derived from the GLEC framework, and is compliant with
   this methodology.

2 THE STEP-BY-STEP PLAN

There are four steps involved in calculating your CO_2 emissions. This chapter explains these four steps and identifies a number of general principles. In the chapters that follow the step-by-step plan is applied, firstly to calculate the CO_2 emissions of transport and then to calculate those of warehousing.

The step-by-step plan is part of the process of developing an action plan as preparation for participation in Lean & Green[3]. This step-by-step plan completes the following sections of the action plan: "The CO_2 Baseline Measurement" and "Scope".

2.1 STEP 1. Determining the scope

In the first step you choose the activities for which the CO_2 emissions will be calculated. You can include all the logistics activities within your organization.
However, for Lean & Green at least 50% of the CO_2 emissions and/or volume of activities must be in scope, for the following functions:
> Own DC/warehouse (if applicable)
> Outbound transport (distribution to customer, transport to own DCs)

2.2 STEP 2. Collecting the data

The second step involves collecting the data used to calculate the CO_2 emissions. The data must correspond to the scope selected in step 1 and must relate to one full year.

You need
> details of the fuel consumed for outbound transport
> the amount and type energy consumed by your warehouse or terminal, plus the GHG emissions of cooling fluid for conditioned warehouses
> the quantity of goods transported or handled

This quantity can be expressed in terms of the number of tons, the number of m3, the number of packets, the number of pallets or your own unit. Preference is given to the number of tons. The requirements differ between modes and are indicated in the specific chapters.

Logistics services providers use their own data, while shippers can use data obtained from their logistics services providers.

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[3] Applicable for Award and Star phases. The second Star requires a different scope.

2.3 STEP 3. Calculating your CO_2 emissions

In step 3 you calculate CO_2 emissions on the basis of the data collected in step 2, and calculate a specific consumption factor to be used by customers for their own calculation. The consumption factor is necessary for a shipper who outsources transport to calculate their particular footprint, especially in shared (barge, rail, LTL and distribution) transport.

For a warehouse the amount and type of energy is converted to CO_2 emissions. For instance, electricity is converted with the applicable local emission factor (kg CO_2 /kWh) to CO_2 emissions.

> **Emission factors can be found in (inter-)national databases (such as https://co2emissiefactoren.nl/ for The Netherlands, or GLEC as a fallback for default factors). The used emission factor must be mentioned explicitly. As a standard WTW (well-to-wheel) emission factors are used by Lean & Green, so electricity or other sources of energy can be compared to diesel.**

The total amount of emissions is divided by the number of outbound goods in a year to generate the specific consumption factor (kg CO_2 /unit).

For a terminal the same method is used to calculate the absolute amount of CO_2 emissions, to be divided by the number of units handled to generate the specific consumption factor (for instance kg CO_2/TEU).

A transporter can use the total amount of fuel, to be multiplied with the emission factor of 3.23 kg CO_2 per liter of diesel to calculate the total amount of emissions.

For transport the specific consumption factor can be calculated in a various manners. The more sophisticated the manner of calculation, the more accurate the consumption factor will be.

The most simple manner[4] is to use:
> > The number of units shipped in a year (# units)
> > The amount of kilometers driven in a year (# km's)
> > The amount of fuel used in a year, converted to total CO_2 emissions

The consumption factor is than calculated as total CO_2 emissions/ # units.# km's

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[4] A more sophisticated approach allocates emissions based on shortest-feasible-distances driven, multiplied by the amount to that destination (see GLEC framework). The preferred method in the second Star and further is to use the Great Circle Distance (GCD) allocation method and Lean Analytics tools, as explained in Lean & Green Analytics.

Shippers use all these consumption factors to calculate the amount of emissions in a part of a supply chain, and to add them up.

For them the emissions are calculated by multiplying the number of units by the length of the trip for transport, or to multiply the number of units by the specific consumption factor of (for instance) a terminal.

If a shipper cannot get these consumption factors from their transporters of terminals or warehouses, standard consumption factors are to be used. In The Netherlands https://co2emissiefactoren.nl/ gives these for The Netherlands. In other countries other references can be used, or the GLEC consumption factors as a fallback for default factors. If default consumption factors are used, the source must be mentioned.

2.4 STEP 4. Calculating the emission for unit

The final step involves calculating the emission per unit as a KPI. This KPI has practical benefits for the reduction realization as it compensates for changes in volume over the years. It gives:

1 Insight into your CO_2 emissions per unit of goods transported and/or stored/ transshipped.
2 Overview of your own performance and comparison with your peers. That means you will know how you are performing in relation to other companies.
3 Potential areas for action: Based on this insight and overview you will know where you can make improvements.

1 SCOPE 2 DATA 3 CO_2 4 KPI

3 CALCULATING CO₂ EMISSIONS OF TRANSPORT

This chapter describes how you calculate CO_2 emissions for road, inland shipping or rail transport. Chapter 3 deals with warehouses. At the end of this chapter 3 examples are given of how the step-by-step plan can be applied to calculate CO_2 emissions.

3.1 Determining the scope for Lean & Green Award

As explained in the previous chapter, 50% of the CO_2/volume for warehousing/DC's and outbound transport must be in scope. Shippers must also have 50% of their total CO_2 and/or volume in scope, even if this has been outsourced.

3.2 Collecting the data

To calculate the CO_2 emissions, you need to collect data on fuel and the quantity of goods transported. The way in which these data can be collected, differs from one mode to another. Ideally, you should work with a single unit of measurement. If you have several units, we advise you to recalculate them using conversion tables (e.g. 1 TEU = 10 tons or 1 cubic meter = 333 kg).

ROAD TRANSPORT

Fuel The total quantity of liters of diesel purchased over an entire year. You can find these data in the fuel accounting records provided by your fuel supplier or in your own financial accounts, for example.

Quantity of goods transported The unit for the quantity of goods transported is the same as the unit you used to charge your customers for your services. This may be tons, m3, packets, pallets or another unit. The preferred unit is tons. You will find these data in the TMS or on the invoices sent to your customers.

INLAND SHIPPING TRANSPORT

Fuel The total quantity of liters of diesel purchased over an entire year. This relates specifically to 'Marine Diesel Oil' or 'Heavy Fuel Oil'. These data can be found in the fuel accounting records provided by your fuel supplier or in your own financial accounts, for example.

Quantity of goods transported The unit for the quantity of goods transported is the same as the unit you used to charge your customers for your services. This may be tons, m3, packets, pallets or another unit. The preferred unit is tons. You will find these data in the TMS or on the invoices sent to your customers.

RAIL TRANSPORT

Fuel The total quantity of liters of diesel purchased over an entire year. These data can be found in the fuel accounting records provided by your fuel supplier or in your own financial accounts, for example.

Quantity of goods transported The unit for the quantity of goods transported is the same as the unit you used to charge your customers for your services. This may be tons, m3, packets, pallets or another unit. The preferred unit is tons. You will find these data in the TMS or on the invoices sent to your customers.

If you are a logistics services provider and have no insight into your actual fuel consumption, or a shipper who cannot obtain this information from your logistics services provider, you can calculate it using the distance traveled.

ROAD TRANSPORT

Kilometers The total number of kilometers actually traveled over an entire year. You can use actual distances or planned distances if the actual distance traveled is not available. You will find these data in your Transport Management System (TMS) or on the invoices sent to your customers.

INLAND SHIPPING TRANSPORT

Kilometers The distance actually traveled in kilometers. You will find these data in the logbook or can calculate them based on the final annual readings. Otherwise you can use the invoices sent to your customers or a printout of your tachograph.

RAIL TRANSPORT

Kilometers The total number of kilometers traveled over an entire year. You can use data from your TMS,the planned distances based on the rail infrastructure or those indicated on the invoices sent to your customers.

Once you have calculated the distance, you can convert this to CO_2 on the basis of: Fuel consumption per kilometer. Let's say you have traveled 10,000 km, with average consumption of 3.5 km per liter. That means you have consumed 10,000/3.5 = 285.7 liters of diesel. Emission factors, as found in www.co2emissiefactoren.nl or GLEC

3.3 Calculating your CO_2 emissions

You can calculate your CO_2 emissions by multiplying the quantity of fuel by the corresponding conversion factor.

The table below shows the emission factors for fuel for each mode.

	Fuel	CO_2 emission factor[5]
Road transport	**Diesel**	**3.230 kgCO$_2$ / L**
Inland shipping transport	**Marine Diesel Oil**	**3.530 kg CO$_2$ / L**
	Heavy Fuel Oil	**3.310 kg CO$_2$ / L**
Rail transport	**Diesel**	**3.230 kg CO$_2$ / L**

If for a shipper a logistics services provider supplies the average CO_2 emissions per unit of goods transported and the quantity of goods transported, the total CO_2 emissions for the shipper is found by multiplying the quantity of goods transported by the average CO_2 emissions per unit of goods transported.

[5] All CO_2 emission factors in this document originate from http://co2emissiefactoren.nl/
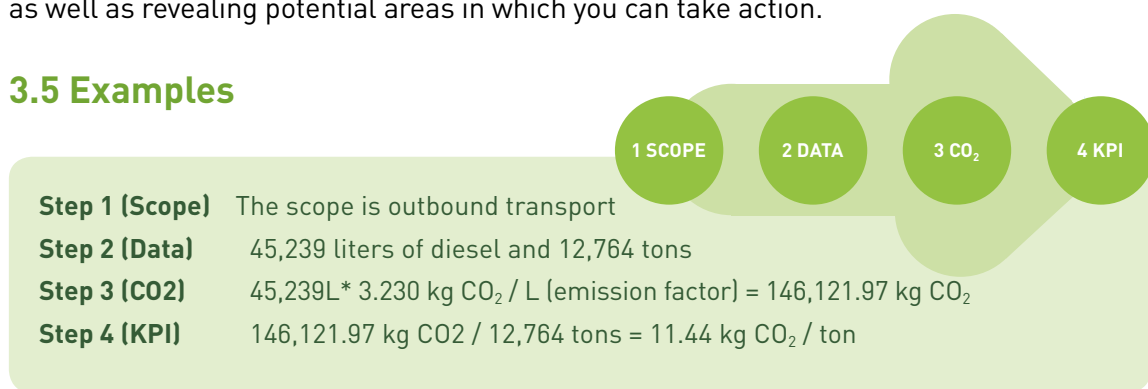
If a shipper only has a specific consumption factor (kg CO_2 emissions/unit.km),
it is necessary to estimate the length of the traveled distances per delivery order.
So per order the following data is necessary:

> Amount (units)
> Shortest feasible distance (km)
> Specific consumption factor (kg CO_2 emissions/unit.km) The multiplication
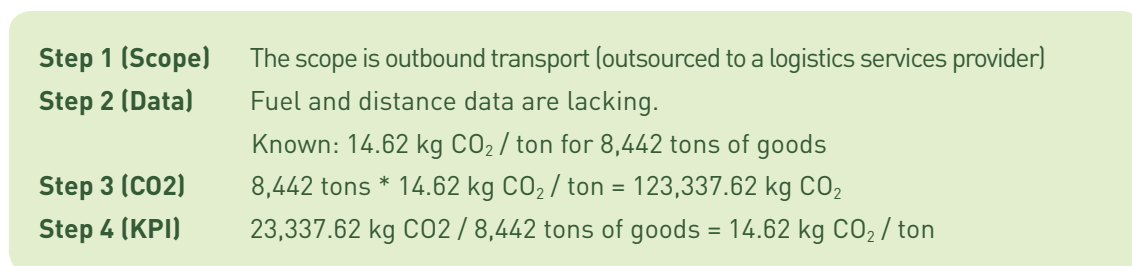of these three gives the amount of CO_2.

3.4 Calculating the KPI

The KPI (kg CO_2 per ton) indicates the CO_2 emissions per unit of goods transported.
You calculate the KPI by dividing the CO_2 emissions by the quantity of goods transported.
The KPI guides you in the area of sustainability by offering you an insight and an overview,
as well as revealing potential areas in which you can take action.

3.5 Examples

| 1 SCOPE | 2 DATA | 3 CO_2 | 4 KPI |

Step 1 (Scope)	The scope is outbound transport
Step 2 (Data)	45,239 liters of diesel and 12,764 tons
Step 3 (CO2)	45,239L* 3.230 kg CO_2 / L (emission factor) = 146,121.97 kg CO_2
Step 4 (KPI)	146,121.97 kg CO2 / 12,764 tons = 11.44 kg CO_2 / ton

3.5.1 Example: Outbound road transport

A logistics services provider with its own trucks transports goods to the customer itself.
In 2016 its fleet of trucks purchased a combined total of 45,239 liters of diesel. Over the
same year 12,764 tons of goods were transported.

Step 1 (Scope)	The scope is outbound transport (outsourced to a logistics services provider)
Step 2 (Data)	Fuel and distance data are lacking.
	Known: 14.62 kg CO_2 / ton for 8,442 tons of goods
Step 3 (CO2)	8,442 tons * 14.62 kg CO_2 / ton = 123,337.62 kg CO_2
Step 4 (KPI)	23,337.62 kg CO2 / 8,442 tons of goods = 14.62 kg CO_2 / ton

3.5.2 Example: Outsourced road transport (groupage)

A shipper has outsourced its transport to a logistics services provider. The logistics
services provider cannot provide any details on fuel or kilometers. It is possible,
however, to indicate that the CO_2 emissions per ton are 14.62 kg CO_2 / ton and that
8,442 tons were transported over the entire year.

Step 1 (Scope)	The scope is all the transport carried out by this operator.
Step 2 (Data)	Marine Diesel Oil: 86,415 L, 16,565 TEU
Step 3 (CO2)	Emission factor for Diesel Oil:
	3.530 kg CO_2 / L. 86,415 L * 3.530 kg CO2 / L = 305,044.95 kg CO_2
Step 4 (KPI)	305,044.95 kg CO_2 / 16,565 TEU = 18.41 kg CO_2 / TEU

3.5.3 Example: Inland shipping transport

An inland shipping transport operator transports containers for several customers between two terminals. 16,565 TEU are transported annually. The operator has received a final statement from its fuel supplier indicating that 86,415 liters of Marine Diesel Oil have been purchased.

4 WAREHOUSING AND TRANSSHIPMENT TERMINALS

This chapter describes the process of determining the CO2 emissions of warehousing and terminals.

4.1 Determining the scope

As explained in chapter 2, 50% of the CO_2/volume for warehousing and outbound transport must be in scope. Your outbound transport was dealt with in chapter 3. This chapter focuses on warehousing.

If you use a logistics services provider (for warehousing and/or transport), you must also have 50% of your total CO_2 and/or volume in scope, even if this has been outsourced.

4.2 Collecting data

To determine your CO_2 emissions, the first figure you need is the quantity of goods. With a view to achieving a simple calculation method that avoids double counting, we use the quantity of outbound goods. The unit used can be tons, m^3, packets, pallets or another unit. Preference is given to tons, however. You will find these data in the WMS or on your invoices.

Besides the quantity of goods, you also need the amount of energy consumed:
> Electricity (kWh)
> Gas
> Diesel

These data can be found in your financial accounts or in the annual statement from your energy supplier, for example. You need to ensure that electricity, for instance, is not counted twice, if both warehousing and transshipment activities have been included in the scope.

4.3 Calculating your CO_2 emissions

You can calculate your CO_2 emissions by first calculating the CO_2 emissions for each energy carrier and/or fuel. The CO_2 emissions for an individual energy carrier and/or fuel are calculated by multiplying the amount of energy or fuel by the corresponding conversion factor. You then add up the CO_2 emissions for each energy carrier and/or fuel.

Relevant emission factors are shown in the table below.

Fuel	Conversion factor[6]
Natural gas	**1.887 kg CO_2/Nm3**
Electricity - non-renewable	**0.526 kg CO2/kWh**
Diesel	**3.230 kg CO2/Liter**
LPG	**1.806 kg CO2/Liter**

4.4 Determining the KPI

Calculate the KPI by dividing the CO_2 emissions by the quantity of goods stored/transshipped. The KPI guides you in the area of sustainability by offering you an insight and an overview, as well as revealing potential areas in which you can take action.

4.5 Example

A logistics services provider has a warehouse. Two electric forklift trucks operate in the warehouse and a terminal truck is used on the site. A total of 564,023 pallets were stored in 2016. The energy supplier charged for 54,230 kWh and 1,423 Nm3 of natural gas. In 2016 the terminal truck used 450 L of diesel.

[6] All CO_2 emission factors in this document originate from http://co2emissiefactoren.nl/

Step 1 (Scope)	The scope relates to the goods stored in a warehouse. It is therefore the outbound flow that is considered.
Step 2 (Data)	564,023 outbound pallets left the warehouse. This resulted in the following fuel/energy consumption: a Electricity: 54,230 kWh b Natural gas: 1,423 Nm3 c Diesel: 450 L
Step 3 (CO2)	The emissions are calculated for each fuel: a Emission factor for electricity: 0.526 kg CO2/kWh. 54,230 kWh * 0.526 kg CO2/kWh = 28,524.98 kg CO2 b Emission factor for natural gas: 1.887 kg CO2/Nm3 1,423 Nm3 * 1.887 kg CO2/Nm3 = 2,685.2 kg CO2 c Emission factor for diesel: 3.230 kg CO2/Liter 450 L * 3.230 CO2/Liter = 1,453.5 kg CO2 Total: 28,524.98 kgCO2 (Electricity) + 2,685.2 kgCO2 (Gas) + 1,453.5 kgCO2 (Diesel) = 32,663.68 kgCO2
Step 4 (KPI)	32,663.68 kg CO2/564,023 pallets = 0.058 kg CO2/pallet

The above example also introduces the next chapter, as the various factors shown above are added together. In the next chapter you will see how this can be done for different modes or a complete supply chain.

5 COMBINING RESULTS

Imagine that your supply chain is made up of a number of different elements/modes. You can calculate the KPI for this chain. This chapter explains how to do this and what you need to take into account.

5.1 Adding up your KPIs

In chapter 3 you calculated your KPI for each mode. The KPI for your warehouse was calculated in chapter four. To calculate the emissions for your overall transport chain, you can add up the individual KPIs. There are a number of points that you need to take into account here:

> The unit (quantity of goods) must be the same for all elements. If you perform the calculation for one mode in emissions per ton, you cannot use emissions per pallet for a different mode.
> Please note that you should only add up the KPIs that are applicable (to the transport chain you are calculating).

5.2 Example

A logistics services provider wants to calculate its CO_2 emissions per ton. It manages a transport chain that is structured as follows:

WAREHOUSE **INLAND SHIPPING** **ROAD TRANSPORT** **CUSTOMERS**

Using the step-by-step plan the logistics services provider has calculated the CO_2 emissions per ton transported or stored for its warehouse, inland shipping transport and road transport:

> Warehouse: 0.089 kg CO_2/ton
> Inland shipping transport: 4.15 kg CO_2/ton
> Road transport: 11.44 kg CO_2/ton

You can then calculate the KPI by simply adding up these elements:

> 0.089 kg CO_2/ton + 4.15 kg CO_2/ton + 11.44 kg CO_2/ton = 15.679 kg CO_2/ton
> Imagine that this logistics services provider has transported 10,000 tons. Its CO_2 emissions are therefore:
> 15.679 kg CO_2 per ton x 10,000 tons = 15,679 kgCO_2

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