LEAN & GREEN EUROPE

3

Analytics

Relating GHG emissions of transport to operational performance

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1 Introduction

A number of different methods and programs[1] are used to calculate greenhouse gas emissions (expressed in kg CO_2e) resulting from transport, either as a total quantity or as emissions per kilometer traveled or per product kilometer (e.g. ton-kilometer). In many cases total emissions can be estimated reasonably well, but the figure calculated has no operational meaning, i.e. it cannot be used to identify potential improvements or monitor operational performance. This means that the figure calculated serves merely as an indicator expressing the organization's corporate social responsibility.

An indicator that relates directly to operational performance has many potential benefits:

- Potential for improvement can be identified much more easily.
- Improvement measures can be modeled and their impact subsequently monitored.
- The costs and effort involved in collecting data are compensated for in the form of cost savings and increased competitiveness and are therefore easier to justify.

A second demand from the market is for data and indicators that can be used to provide customers with good emissions data, but cannot be misused (from the perspective of the party supplying the information) as justification for demanding lower prices. Shippers request emissions data from their carriers/logistics services providers, who in turn ask their subcontractors to supply this information.

[1] *GLEC, Ecostars, CO_2 Objective*
[2] *Lean and Green Logistics, Metrics for continuous improvement of the supply chain performance, 2014.*

A third demand is for comparable data: if a shipper receives data from several carriers, or a logistics services provider receives data from several subcontractors, the aim is to ensure that these figures have the same basis of calculation, which should be consistent from one data set to another and over time.

In 2014 a methodology was developed[2] within the framework of the Lean & Green program that is capable, in theory, of fulfilling these demands. Initially, collecting the data sets (fuel consumption and goods transported) correctly proved to be an obstacle, but in 2016 it became clear that all kinds of companies are now capable of supplying these data sets.

2 Applying EN 16258

European standard EN 16258 *(Methodology for calculation and declaration of energy consumption and GHG emissions of transport services)* represents a significant step towards harmonizing the many commonly used emissions calculations. When it comes to operational implementation, however, certain choices have to be made regarding how the standard is applied. In 2014 Connekt, TNO and Cap Gemini developed an approach[3], drawing on the additional work of the COFRET project.

The method is based on the principle that the added value of transport is the movement of goods from one place to another. The mode of transport or route over which the goods are transported generally does not add any value.

This transport needs to be related to the emissions required for the transport to take place. In the case of a (round) trip by road or water or a train journey[4] the quantity of goods to be transported as well as the origin and destination are known from the consignment note or order document. It is also known who the customer is.

The total emissions for a trip can be calculated from the total energy consumption or fuel consumption required for the trip[5]. The next question that arises is how these emissions can be allocated in a justifiable and reproducible manner to the shipment transported.

[3] Lean and Green Logistics, Metrics for continuous improvement of the supply chain performance, 2014.
[4] For simplicity the term 'trip' will be used from this point on.
[5] Or a combination of trips.

COFRET has defined the following allocation method:

- The distance between the origin and destination of the goods transported (per line item in the consignment note) is determined on the basis of the Great Circle Distance (GCD), also known as the birds' flight distance.
- This distance is weighted based on the quantity transported between these two points, where quantity is a measure of the capacity utilization of the mode of transport[6].
- The relative proportion of quantity x distance is the relative proportion of the total emissions in the CO_2e allocation.

Although certain criticisms can be made regarding this allocation method, it is relatively simple, reproducible and intuitive: goods that are transported further account for a larger share of CO_2e emissions than those transported a short distance. The same applies to quantity: the more goods, the greater the CO_2e emissions allocated to a customer, shipper or shipment. This method was therefore used for the purposes of the study. An example calculation is provided below:

A truck transports 20 tons for one customer from A to B (GCD = 10 km_{gcd}) and 10 tons for another customer from A to C (GCD = 30 km_{gcd}), then returns home empty. Ten liters of diesel are consumed for the overall trip. The transport performance is 200 tkm_{gcd} from A to B and 300 tkm_{gcd} from A to C. The total transport performance is therefore 500 tkm_{gcd}.

A to B thus represents a share of 40% (200 out of 500 tkm_{gcd}) and A to C a share of 60% (300 out of 500 tkm_{gcd}) of total emissions.
The amount of CO_2e can be calculated using the well-to-wheel factor for diesel (3.17 kg CO_2e/liter), i.e. a total of 31.7 kg CO_2e.
The 40% allocation for the first section (A to B) = 12.68 kg CO_2e and the 60% allocation for the second section of the trip (A to C) = 19.02 kg CO_2e.

It is now possible to calculate the KPIs for the carrier:
- *The average (!) emissions per ton = 1.056 kg CO_2e per ton (31.7/30)*
- *The average (!) emissions per tkm_{gcd} = 0.0634 kg CO_2e per tkm_{gcd} (31.7/500).*

[6] *Tons for weight-restricted shipments, m^3 for volume-restricted shipments and volumetric weight or another practical unit, such as roller container, for everything in between.*

This information can also be passed on specifically to the individual customers, with different figures for emissions per ton, but identical emissions (by definition) for tkm_{gcd}.

1 *12.68 kg CO_2e to transport 20 tons over 10 km_{gcd}*

- *0.635 kg CO_2e per ton*
- *0.0634 kg CO_2e per tkm_{gcd}*

2 *19.02 kg CO_2e to transport 10 tons over 30 km_{gcd}*

- *1.9 kg CO_2e per ton*
- *0.0634 kg CO_2e per tkm_{gcd}*

This example calculation shows that the emissions per tkm_{gcd} for a trip are the same for all customers! For the customer this figure is sufficient to allow it to calculate its own emissions as an absolute value per unit transported. Every shipper knows what its own number of units is and the GCDs between the origin and destination.

This allocation method (and the use of the indicator by customers) also works if the granularity of the consumption data is less fine. If, for example, only the total consumption for a week is known for a set of trucks, the calculation is performed based on the combination of all consignment notes for the set of trucks concerned over that week. On the basis of the indicated emissions per tkm_{gcd}, customers can then again calculate their emissions per unit of product delivered themselves.

Generally speaking, the carrier always has access to detailed information on past orders and the associated details (customer, quantity, origin and destination), as this forms the basis for the invoicing process. In practice, this assumption appears to be correct.

If other fuels are used, these can easily be converted into an emissions figure. In the case of electric transport, emissions per kWh of non-renewable electricity are employed, unless green electricity has been explicitly used.

3 Data collection

Detailed data were supplied by more than 20 companies of differing sizes from a range of different sectors. These data relate to road transport only[7].

The sectors concerned are:

- FMCG
- food
- construction
- recycling/waste
- pallet and container pooling
- industry
- packaging
- hygiene
- transport technology

First of all, a distinction was made based on the quality of the source data. The following classification was defined in advance.

- **Gold+: Perfect data**
  There is a clear insight into diesel consumption per trip (possibly calculated based on average consumption measured per kilometer and km traveled per trip). Information on trips is therefore required in addition to information on shipments.
- **Gold: Direct data**
  There is a clear insight into diesel consumption per month and per category of trip. (category = comparable in terms of loading factor, vehicle and load carrier).
- **Silver: Actual data**
  Diesel consumption has been derived (using estimated trip distance or trip planner and standard consumption) or several elements have been derived using calculation rules.
- **Bronze: Estimated data**
  Norm data or industry averages (e.g. using consumption factors) used.

[7] In this study the data have been restricted to road transport only to optimize the test. Other modes will be included in a follow-up study.

The data sets revealed that many of these companies had access to much more, and much more finely granulated, information than initially expected. The increasing use of fuel cards and on-board systems means that a large amount of digital consumption data is readily available and it appears that this can be easily linked to the order data found in consignment notes. As, in many cases, volumetric weight is used as a calculation unit for invoicing, these data on the load (capacity utilization) are also readily available.

	NUMBER OF COMPANIES
Gold+: Perfect data: consumption per trip known	1
Gold: Direct data: consumption per type of trip known	9
Silver: Derived data: diesel consumption has been derived	10
Bronze: Estimated data: diesel consumption has been estimated	2

4 Analyses of data sets

The data sets made available were subsequently analyzed using Qlikview.

Reports were produced containing various averages:

- **Tonnage[8] and emissions per ton (absolute, total)**
  - linked to delivery location
  - linked to customer
  - linked to time period
  - linked to quantity at that location over that time period
- **Tonnage[9] and emissions per tkm$_{gcd}$ (absolute, total)**
  - linked to delivery location
  - linked to customer
  - linked to time period
  - linked to quantity at that location over that time period
- **Consumption figures per vehicle registration number**
  - related to distance to customer
  - related to weight transported

[8] and [9] For simplicity the term tonnage or tons has been used, although a different measure, e.g. roller container, may be more practical depending on the carrier in question.

Outliers were highlighted in these reports, as well as opportunities for improvement. The reports produced were then discussed, over a number of iteration cycles, with the operational management of these companies, resulting either in more detailed questions or improvements in the quality of the data set.

In all cases the results were directly recognizable and relevant for the management, even though on occasion the initial reaction to the results and insights was one of disbelief. The analysis stood up to critical assessment by the company in every case. In a few cases direct steps were taken to make improvements that had been identified as opportunities in the analysis.

5 Examples

As the data are commercially and competitively sensitive, anonymized graphs are presented. Many of these contain data for fictitious companies (results derived from data sets that do not exist or manipulated data sets).

The figures below provide an impression of the possible insights that could be gained from analyzing the data collected in the manner described. A number of different forms of analysis are possible. Those presented below are examples that were discussed with the participants and resulted in a significant response and reaction or provided answers to questions that had arisen and could not be answered using existing tools.

Figure 1 shows how individual customers can be analyzed to identify the most inefficient trips, possibly by delivery address.

Figure 2 shows one of the network-dashboard variants, which highlights the match between the network and the demand for transport. The size of the circles indicates the volume, while the color indicates the emissions per unit (absolute) or per tkm_{gcd}. A good network only has red at the edges and for small volumes.

Figure 3 shows the emissions by province, **Figure 4** by customer and **Figure 5** over time.

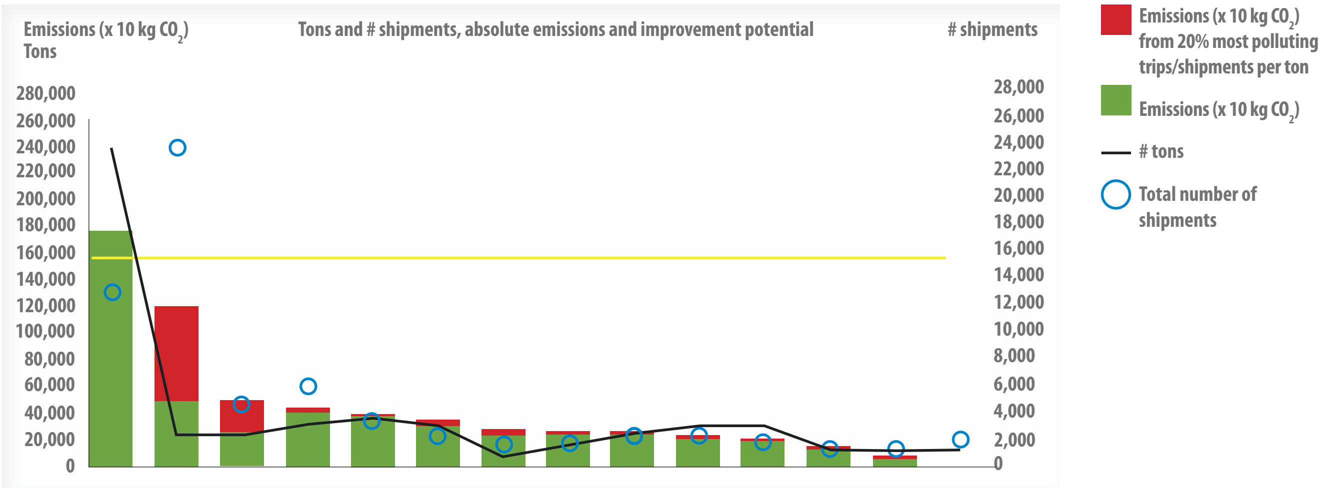
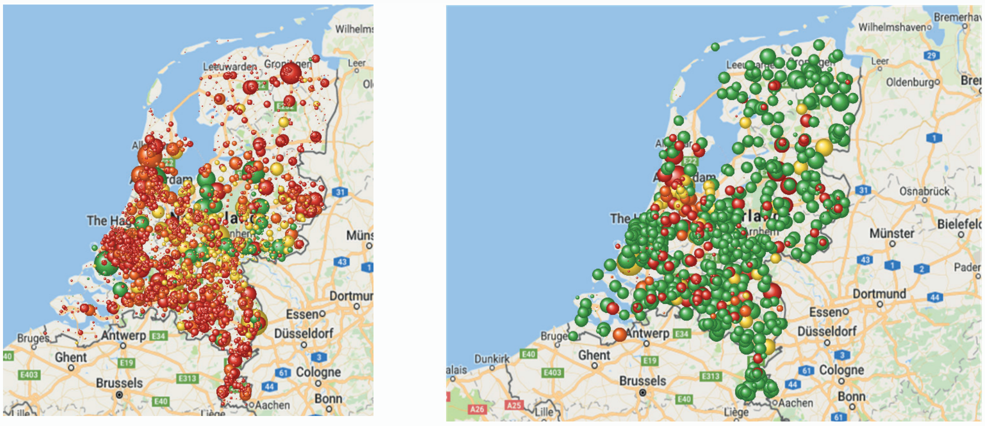


Figure 1 Emissions per recipient for a random company

By analyzing the data, it is possible to focus on the 20% of trips/shipments with the highest emissions per unit (e.g. tons).

Figure 1 provides an insight into the absolute CO_2e emissions per shipper/address. It presents the number of tons transported as well as the number of shipments and the CO_2e emissions attributable to these recipients. This has been calculated per shipment. The results (CO_2e emissions) have been sorted on the basis of efficiency. The least efficient 20% of shipments are shown in red and reveal the recipient for which the fewest inefficient trips are made.

From the analyses already performed it emerges that this 20% portion of shipments accounts for around 25-40% of total CO_2e emissions. A direct insight is therefore gained into the savings potential.



CO_2 emissions per ton (color) vs number of orders (size of circle)

CO_2 emissions per tkm_{gcd} (color) vs number of orders (size of circle)

Figure 2 KPI: emissions per ton and emissions per tkm_{gcd} for a fictitious company

The left-hand side of Figure 2 shows the CO_2e emissions per ton for each delivery location. This highlights the match between the demand for transport and the logistics services provider's network. The figure on the right-hand side shows the CO_2e emissions per tkm_{gcd} for a fictitious transport company in Amsterdam. This reveals that medium- and long-distance trips are more efficient for this fictitious company than local trips. Regular local runs are planned/carried out less efficiently, something that frequently emerged from the real data sets.

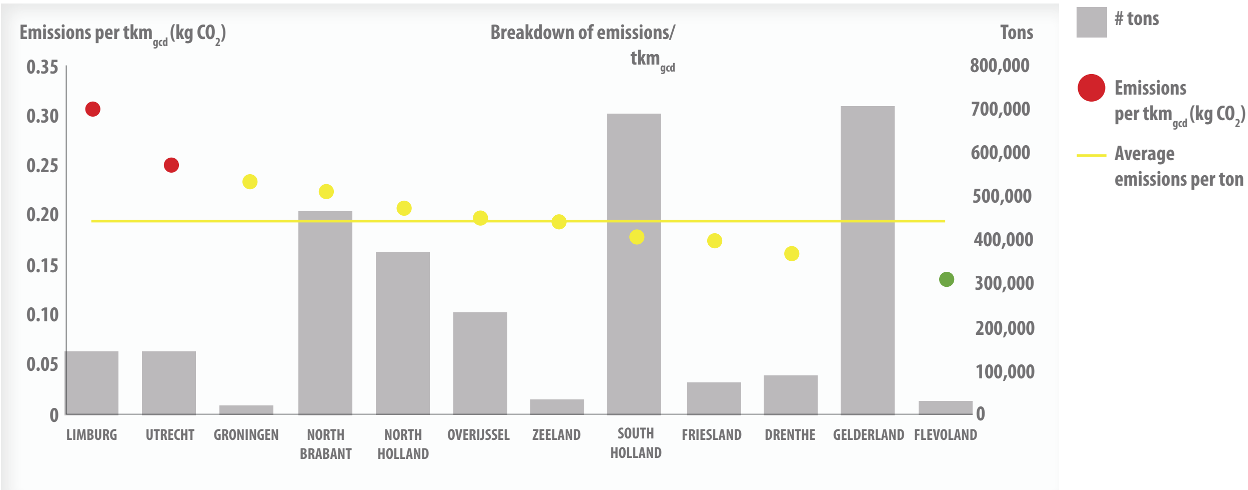


Figure 3 Emissions per tkm_{gcd} per province for a fictitious company

Figure 3 shows the breakdown by province in relation to the average. This provides management information on a province-by-province basis.

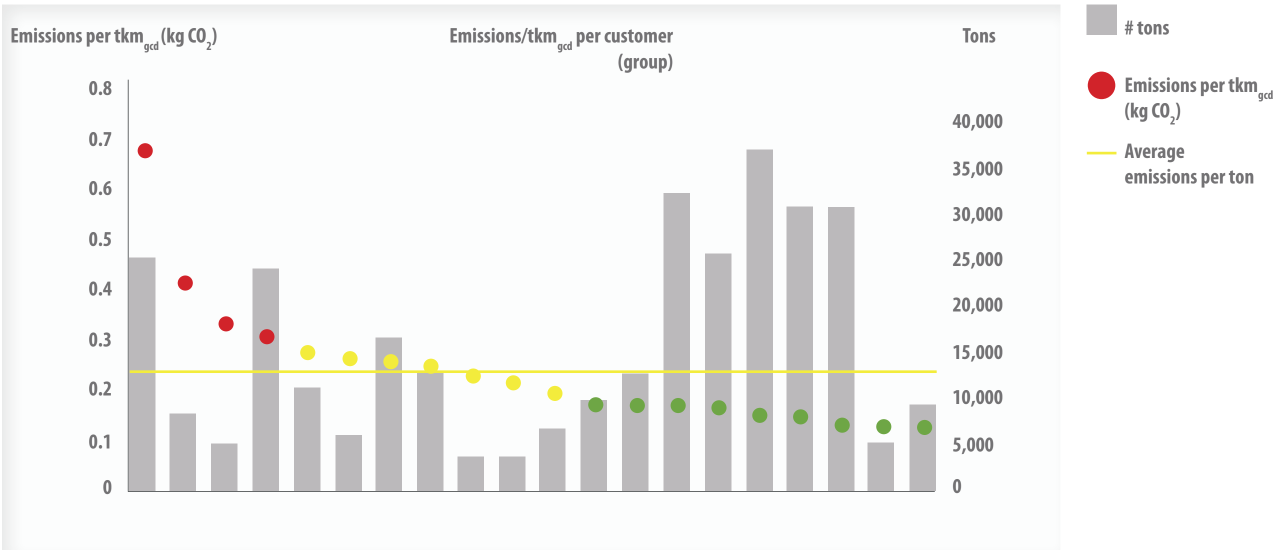


Figure 4 Emissions per tkm$_{gcd}$ per recipient for a random company

Figure 4 shows the emissions per tkm$_{gcd}$ for each recipient compared with the company's own average.

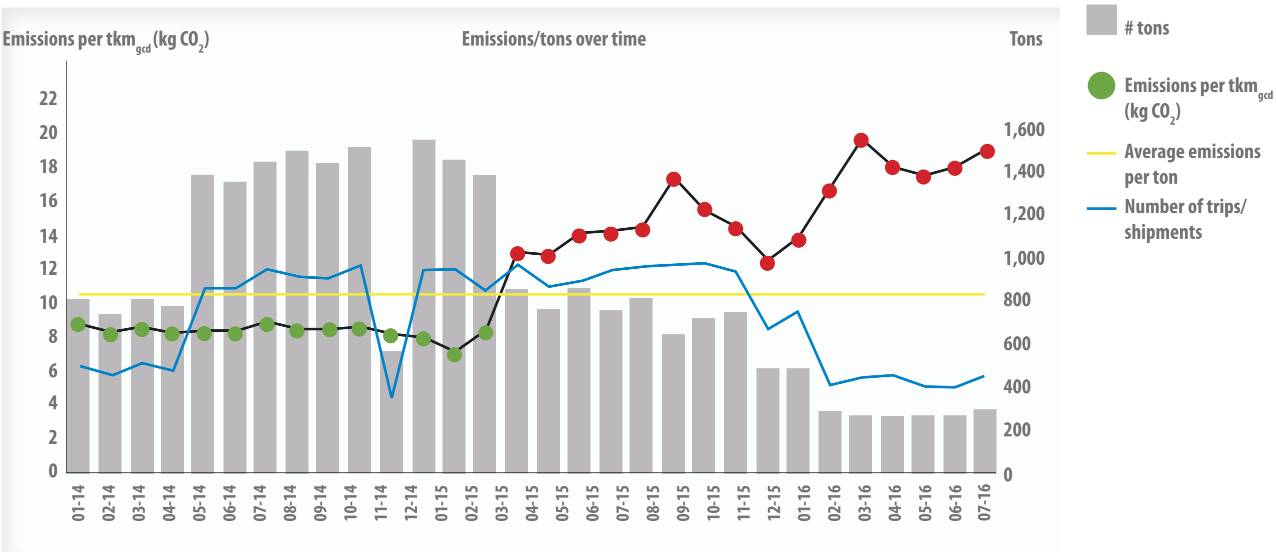


Figure 5 Emissions per ton per recipient for a random company

Figure 5 shows the emissions per recipient per period, together with the volume. This example (derived from practice) reveals that a change in ordering behavior was not followed by a change in the transport used, as emissions per unit immediately shoot up.

6 Conclusions

Enough data of sufficient quality are available to allow this methodology to be applied in practice.

Due to the increase in the amount of data collected electronically/digitally, the level of data quality that can be achieved in practice is good enough to deliver relevant and significant (difference of more than 10%) results.

This method of collecting and analyzing data can provide extremely relevant insights from an operational perspective and highlights where improvements can be made.

To the surprise of many participants, this method has proven to offer insights that are not provided by familiar IT systems (SAP, etc.) and have a high degree of relevance. Even where data are of a lower quality, the results are still relevant and offer useful insights: this means it is possible to start off with a simple approach and gradually collect better and more finely granulated data if this proves to be relevant.

The methodology provides a good dashboard for monitoring developments.

Weekly or monthly reports can be easily produced and highlight where anomalies are arising.
It would seem to be relatively simple to drill down and examine causes in greater depth and detail, if such detailed data are available. This is something that the party in question can decide.

The results are reproducible and verifiable.

Based on the quality of the data, it is possible to draw conclusions about the quality of the indicators calculated: the calculations are reproducible and verifiable.

Allocation to customers is feasible for subcontractors and logistics services providers.

The calculation rules result directly in the allocation of emissions to customers as part of the calculation. With just one figure (CO_2e emissions per tkm_{gcd}) supplied to customers by the carrier or subcontractor it is possible for customers to calculate their emissions themselves per line item and delivery location.

The information supplied to customers can be aggregated in such a way that it is accurate, but cannot be traced back directly to financial parameters.

In our opinion, working with a KPI per trip for all customers on the trip concerned does not provide any insight that could be detrimental to the carrier from a commercial perspective. However, should this be a concern, a carrier who collects data with a high level of detail for its own analysis and use can easily recalculate these data for customers in aggregated form to cover a certain period of time and a number of trucks. This KPI can therefore be used for all customers concerned.

The information calculated can be used for CSR purposes.

The result of the calculations is a verifiable measure of the emissions resulting from transport and allows progress to be monitored over time.

7 Follow-up study

The follow-up study will involve:

- Analyzing synchromodal or multimodal chains in the same way
- Analyzing international chains, for which a smaller amount of data is often available
- Comparing the COFRET allocation method with other methods

Other publications in this series

2013	1	Giving significance to big data in supply chains
2015	2	Metrics for continuous improvement of the supply chain performance
2016	**3**	**Analytics**
2016	4	Introduction to the calculation of CO_2 emissions for paticipation in Lean & Green
2017	5	Carbon productivity in global supply chains

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