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The Logistics Institute – Asia Pacific

Accounting, Controlling and Management of CO_2 Emissions

A Collaboration Between

The Logistics Institute Asia Pacific

NUS National University of Singapore

Georgia Institute of Technology

The Sustainable Supply Chain Centre Asia Pacific

A Collaboration Between DHL & TLI – Asia Pacific

The Logistics Institute – Asia Pacific

Accounting, Controlling and Management of CO_2 Emissions

An Invited THINK Executive Whitepaper

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Preface

It is our distinct pleasure to preface this invited paper from the team of colleagues at DP DHL.

We first came across the reported work done by Michael and his co-authors recently and were immediately struck by what was a well thought through piece of work in sustainability, conducted by industry for the benefit of the whole community of practice. We hence engaged Michael in several discussions and invited him to share this thought piece at our first sustainability Think Executive event of 2011. He readily agreed and in turn co-opted his colleagues Stefan and Klaus to provide an update through an equally thought provoking foreword.

Our collaboration with DP DHL through our joint Sustainable Supply Chain Centre – Asia Pacific makes this an ideal platform to delve into the background behind accounting, controlling and management of CO_2 emissions.

It is our mutual intention to further research this area and to invite other leading thinkers in the community to come forward with their own contributions that will serve to develop the agenda for targeted sustainability research in the near term.

We hope you enjoy reading this contribution as much as we have.

Looking forward to our fruitful exchange of ideas.

Robert de Souza (Dr.)	Laura Bolton
Executive Director	Director
The Logistics Institute - Asia Pacific	Sustainable Supply Chain Centre - Asia Pacific

FOREWORD

Emissions of carbon dioxide (CO_2) are a major driver of climate change. As, according to IPCC statistics, the transportation sector - thus the logistics industry - accounts for around 13% of global CO_2 emissions, CO_2 is an important topic to the industry.

Deutsche Post DHL, as a market leader in logistics, takes up its responsibility in this field and has set itself ambitious goals to improve the CO_2 efficiency of its services.

These goals are not lip service, but aim to take every operation of our business down a road towards carbon efficiency which starts with understanding our footprint, as the paper presented here shows. This paper provides an insight into our considerations on how to gain transparency on our CO_2 target achievements. We are striving to support management actively in achieving our efficiency goals, from strategic decision making down to a day-to-day business level.

Our work to understand how to gain transparency has led to DP DHL's "Carbon Accounting and Controlling" (CAC) program being a group-wide initiative led by Finance. CAC is a major contributor to the "Achieve Transparency" pillar of our "GoGreen" Environmental Protection program, which cares for the active management of CO2, and broader environmental impacts. But at the same time CAC is positioned as an independent counterpart fully integrated and connected in the Finance world of DPDHL.

Although Carbon Accounting being in the hands of Finance still seems to be a quite unusual constellation, it has proven to be fruitful and efficient. Already in 2008, when Finance and GoGreen founded our first "Carbon Accounting Working Group" to replace previous manual calculations, it soon became evident that joining forces between environmental and finance experts to bring in accounting know-how, controlling mindset and a powerful infrastructure was a key to transparency.

Given the goal for carbon accounting to support day-to-day management decisions, one of the first logical steps is to raise the question of an adequate choice of methods for the measurement of carbon efficiency. This paper presented explains why therefore we prefer so called "direct" methods, which ensure we capture our actual consumption of energy, for example from invoices and bills, over "indirect" methods, which estimate footprints based on statistical averages. This choice for a "direct" method led to the practical development of an overall carbon accounting approach. This approach results in the capture of our scope 1 and scope 2 energy consumption on a monthly basis, on a global scale, for all individual entities belonging to the group. For more than 18 months now, carbon accounting processes have been running alongside our financial data processing, with emission data analyzed together with the same rigour as our financial data in our corporate reporting system. A benefit of this approach is the ability to embed carbon-related information in standard reports and to validate emissions against financial and other non financial key performance indicators.

Yet, as the paper outlines as well, there is still a significant challenge remaining to capture Scope 3 emissions in a manner which fulfils the needs for managing efficiency as well. While the paper describes a number of methods to do so, most of them remain indirect methods, as data is either estimated based on activity (e.g. flights) information or is based on less specific aggregates. Although we are advancing in implementing such methods as well, from a methodological point of view, we would still prefer direct methods: Having a certified "footprint on the invoice", based on harmonized consumption based recording, would be ideal, not only as it would capture all relevant aspects, but as well be lean and practical from an accounting point of view.

All in all, this paper presents a number of tangible approaches, and we hope that the examples provided ease the understanding of the concepts behind. It is important to stress that some concepts are still abstract and need to be substantiated with regards to specific business models given the complexity and diversity of supply chain operations. For example a product view, as outlined in the article, in network businesses within DP DHL like MAIL or EXPRESS may differ significantly from the way it could be implemented in a business that does very individualized, tailored services like SUPPLY CHAIN.

But the paper, and this is what makes it worth reading, already mentions a number of aspects that we experience to be crucial when it comes to CO_2 efficiency management support and therefore should be a good basis from which to start further discussions.

Stefan Freigang   Klaus Hufschlag

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1. Introduction

“With GoGreen we aim to improve our CO_2 efficiency and reduce the CO_2 emissions we generate for every letter and parcel sent, every ton of cargo transported and every square meter of real estate space used. Our aim is to improve CO_2 efficiency throughout the Group, including the transport services provided by subcontractors, by 30 percent by the year 2020, compared to our 2007 baseline.” This target set by the Chairman of the Board of Management of Deutsche Post DHL, Dr. Frank Appel, can only be achieved with the aid of a dedicated carbon accounting and controlling system. The CO_2 emissions need to be measured, compared with reference values and reduced by 30 percent by the year 2020 while maintaining output. The difficulties and solution approaches used in measuring emissions and reference values, as well as the assessment and interpretation options, are described and explained in the following sections using examples from Deutsche Post DHL’s area of operations.

2. Deutsche Post DHL’s efficiency target

Deutsche Post DHL is the first logistics company with a global presence to have set itself a binding climate protection target. By the year 2020, the CO_2 efficiency of all of the services provided by Deutsche Post DHL and its subcontractors is to be improved by 30 percent. The efficiency of the services we provide ourselves is to be 10 percent higher by the year 2012 than it was in 2007. In order to achieve these targets, the volume of shipments needs to increase while maintaining the same level of emissions or, conversely, the level of CO_2 emissions needs to decrease while maintaining the same volume of business. Therefore, for target tracking purposes, not only the data on the Group’s emissions and those of the subcontractors hired but also reference values, such as the number of letters dispatched, are required in order to determine the level of efficiency. Because of Deutsche Post DHL’s multifaceted operations, depending on the division, different reference values are required for different areas to enable useful interpretation.

In order to achieve the climate protection target, the GoGreen program, which integrates all of the activities aimed at climate protection for the Group, was established in 2008. As outlined below, the GoGreen program is divided into five pillars.

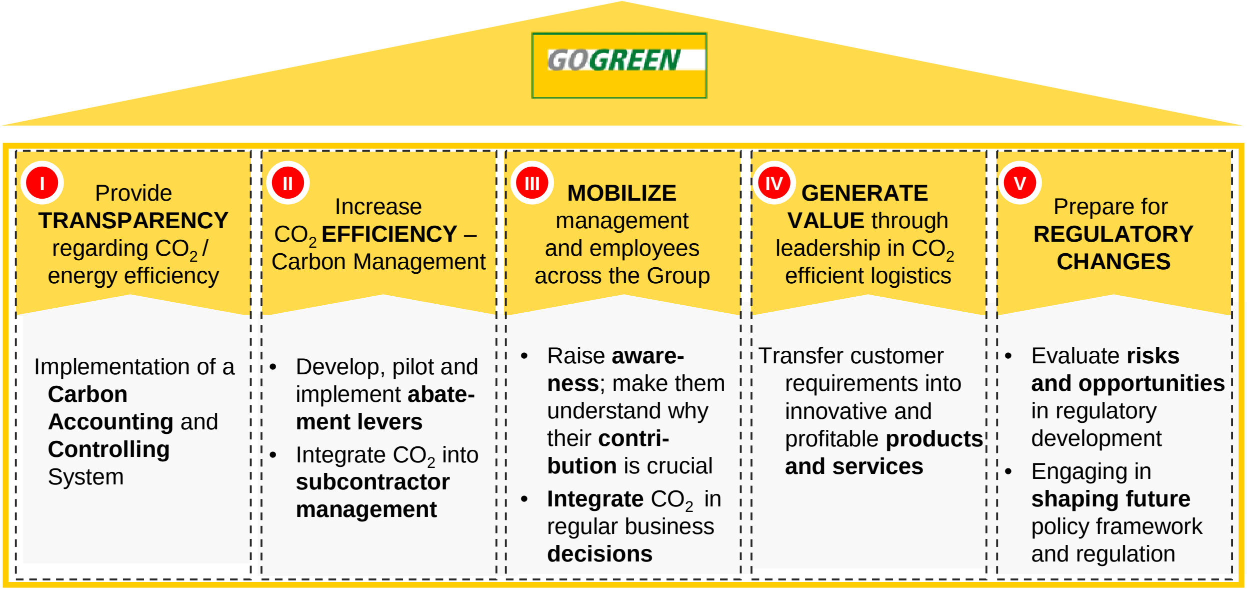


Figure 1: The five pillars of the GoGreen climate protection program at Deutsche Post DHL for the holistic management of efficiency improvement targets

Pillar II, “Improving CO_2 efficiency”, is the basis for reducing energy consumption in operations on the road, at sea, in the air or in buildings and facilities. The focus of energy efficiency improvement is both on Deutsche Post DHL’s own fleet and own buildings and on the services that are provided by our subcontractors. A reduction in CO_2 is, for instance, achieved by using vehicles with innovative power trains and alternative fuels, by optimizing networks or by adding winglets to our aircraft. The third pillar – mobilizing management and employees – comprises motivation measures, training sessions or even the fundamentally important adjustment of Group guidelines to incorporate the criterion of energy efficiency into day-to-day management decisions. Dimension IV, “Generating market value with efficient solutions”, is based on further developing the portfolio of green products and solutions jointly with customers and providing the market with energy-efficient alternatives. The fifth dimension, “Shaping the political agenda”, safeguards the connection with the legislature and public organizations, ensuring active involvement in bodies that deal with issues such as standardization in the area of CO_2 calculation.

The first dimension, “Providing transparency”, is the fundamental prerequisite for the other four dimensions as CO_2 management is only possible if transparency has been provided regarding consumption and emissions. Carbon accounting and controlling is hence the first step that is required before a decision can be made regarding efficiency improvements in the form of CO_2 reduction projects. First of all, therefore, information on which branches, vehicles and networks still have optimization potential is needed before decisions on measures or even investments can be made.

The provision of transparency appears to be focused primarily on reporting the global CO_2 footprint for each division and mode of transport, particularly with a view to satisfying the interest shown by the general public and organizations in this regard. From Deutsche Post DHL's perspective, however, there are three other consumers of CO_2 reports to whom more attention is currently being devoted. Local managers want to know the emissions for their area of responsibility and the CO_2 data is to be allocated to customers and products on a cost-center basis and shown as a CO_2 footprint (see also Figure 5).

3. Measurement of CO_2 emissions and reference values at Deutsche Post DHL

3.1 Introduction of a Group-wide CO_2 efficiency index

The measurement of CO_2 emissions is just a first step towards achieving the efficiency target of 30 percent. However, transparency is still far from being provided by correctly recording the CO_2 emissions. The CO_2 emissions also need to be linked to further information in order to make the consumption comparable and to initiate the correct reduction measures.

Comparing the energy consumption of two hubs, H1 and H2, for instance, H1's energy consumption and hence its CO_2 emissions are much higher than H2's. The investment decision regarding building insulation and energy-efficient lighting is therefore made in favor of H1 as the savings potential is seen as being greater there. However, a closer analysis reveals that H1 is in Finland and H2 in Sicily and that the higher energy consumption can therefore be attributed to the hub's geographical location. The investment decision in favor of H1 still makes more sense because the aim is to make more efficient use of thermal heat in Finland. Furthermore, a deeper examination shows that H1 in Finland is a state-of-the-art, high-tech hub of the latest design, with oversized insulation and optimum lighting. H2, on the other hand, has extremely old and inefficient technology and an uninsulated building. The investment decision wavers. The example clearly shows that measuring buildings' CO_2 emissions (footprint) alone is not sufficient to initiate measures in accordance with pillars II to V of the GoGreen program – *you can't manage what you don't measure.*

However, it is only possible to make a proper assessment in this case if the productivity level in the two buildings is also taken into consideration. Are there areas that are heated and lit but not used? How much energy is expended for each parcel "produced"? Only by intelligently linking all of the factors relating to the building, production and energy data is it possible to make useful statements about energy efficiency.

Therefore, in order to initiate reduction measures based on energy consumption and CO_2 emissions, particularly in the area of logistics, what is required is both the actual recording of the CO_2 value and the introduction of a unit of output that relates the energy expended to the output produced.

In order to track and display the change in CO_2 efficiency, a so-called CO_2 efficiency index is created. The latter comprises the linked and indexed emission data in the numerator and the reference values in the denominator.

$$\mathrm{CO}_2\ \mathit{efficiency\,index} = \frac{\text{emissions}}{\text{units of output}}$$

The unit of output can describe different attributes. Specific units of output are defined for each division of Deutsche Post DHL. They may be the number of letters dispatched, the number of tons transported or the square meters of real estate space used. The overall index for Deutsche Post DHL is formed from the weighted total of the individual indices, similarly to a share price index. The total CO_2 emissions generated by the respective division are used as the measure for the weighting. For the baseline year 2007, the index ratio was set to 100 percent. An improvement in CO_2 efficiency is reflected in a falling index value.

3.2 Direct and indirect recording of CO_2 emissions and units of output

The CO_2 emissions that are allocated to a Business Unit or Division are based on the consumption data from its own network and on the data provided by subcontractors. Based on the Greenhouse Gas Protocol developed by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD), the emissions at Deutsche Post DHL are divided into three classes, so-called scopes.

Scope 1 corresponds to all direct emissions generated by Deutsche Post DHL's own processes. The emissions generated by purchased electricity and long-distance heating are included in Scope 2. These two emission classes can be directly controlled by Deutsche Post DHL. The bulk of the emissions, however, can be allocated to Scope 3, which covers the CO_2 emissions generated by outsourced transport services. The recording of Scope 3 emissions is more complicated and entails greater expense as the generators of these emissions are operating outside the Group and therefore cannot be directly controlled.

The emissions are generally obtained from consumption data via specific emission factors. The emission factors vary depending on the fuel consumed or the kilowatt hours consumed and depending on the country. In the 27 EU countries, for instance, owing to the mandatory addition of 5 percent biodiesel, a factor of 2.55 kg of CO_2 per liter of diesel burned applies, whereas in the USA, 2.68 kg of CO_2 per liter of diesel are emitted. Currently, there are no globally binding and uniform emission factors and they also change at irregular intervals as a result of improved determination methods. At Deutsche Post DHL, emission factors that have been coordinated throughout the Group are used. They are centrally managed and are adjusted if changes occur.

The bulk of the emission calculations which are used for the values in the numerator of the efficiency index are therefore based on consumption figures generated by shipments and other services. The consumption data can be recorded in two ways (also see example below).

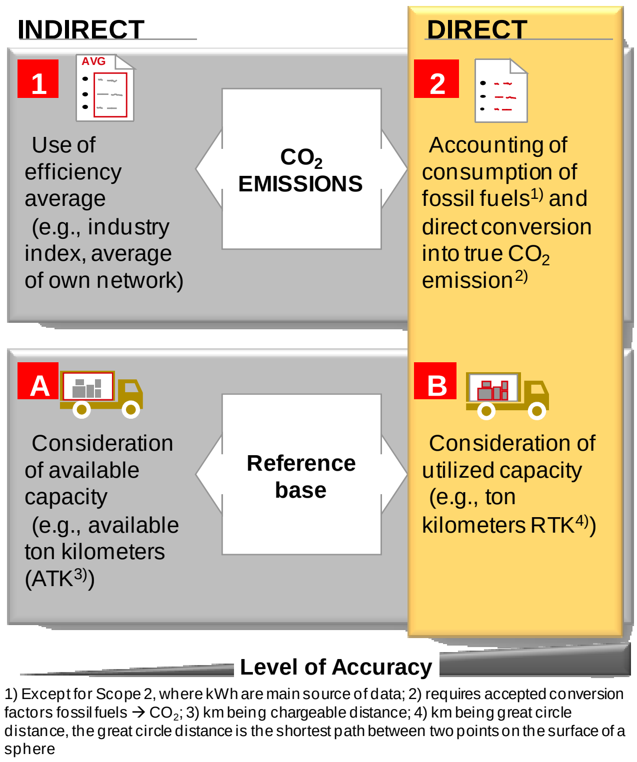


Figure 2: Direct and indirect measurement method for recording CO_2 (energy consumption) in the numerator and the unit of output in the denominator.

In the indirect method (1A), the consumption figures are estimated based on industry indices or mean values from Deutsche Post DHL's own network. These indices are generally indicated in relation to a reference value and consequently additional values are required in order to calculate the emissions (cf also RTK example in Figure 5). If these are likewise only mean values, the resulting emission data is relatively imprecise and does not reflect the actual CO_2 emissions. An example: According to the manufacturer, a certain vehicle consumes eight liters of diesel fuel per 100 kilometers. The consumption data is the basis for the CO_2 industry index. At Deutsche Post DHL, these vehicles are used mainly for fuel-intensive pick-ups and deliveries. It is very probable, therefore, that the vehicles consume more fuel than stated by the manufacturer as a result of frequent starting and stopping. On the other hand, reduction measures, such as fuel-saving driving techniques, are not reflected by industry averages. The diesel consumption figure that is produced by multiplying by the kilometers driven does not reflect the actual consumption and can only be interpreted to a limited extent. In order to calculate the units of output, use is often made of the statistically recorded average load on trucks, e.g. 45 percent. If the actual figure differs from the latter, this distorts your own efficiency calculation.

Direct recording of consumption (2B) provides greater accuracy with regard to CO_2 data. Currently, this method can only be used for determining Scope 1 and Scope 2 emissions. The quantities of fuel required for Deutsche Post DHL's own shipments and for heating its own buildings are shown in accounts payable. The same applies to the quantity of kilowatt hours purchased for heating buildings and from long-distance heating that are responsible for Scope 2 emissions. Quite a few buildings also have their own electricity meters, meaning that consumption can be recorded not only via the accounts but also via the meter reading.

3.3 Scope 3 – recording subcontractor data

At present, it is only possible in a few cases for a logistics company to calculate the CO_2 emissions generated by subcontractors directly, in other words, based on primary data (2B), as information on the quantity of fuel consumed for a specific shipping order is generally not provided by the subcontractor.

Hence, the indirect determination method (1A), based on the use of secondary data, plays an important role in calculating the emissions generated by a subcontractor. Depending on the mode of transport, data that can be used to calculate the CO_2 emissions generated is available in more or less standardized form and in varying levels of detail. Here, we see clear differences between the individual modes of transport, which are reflected in two modes of transport outlined below.

In air transport, the known information on the type of aircraft and the distance flown between origin and destination (the great circle distance – GCD, Figure 7 – between airports, corrected by a factor that takes detours caused by traffic and the weather into account) means that some basic data is available as standard practice. This – in conjunction with average emission values for aircraft types, separated according to take-off, landing phase and cruise – then allows the total emissions for the flight to be calculated.

The distribution of emissions over the freight carried or the passengers becomes more demanding because the relevant load factor needs to be used for this purpose. Airline-specific (average) values may be helpful as a first step in this regard.

In our view, IATA and ICAO but also the introduction of the European Union Emission Trading Scheme (EU eTS) generally play an important role in standardizing the calculation of emissions in the area of aviation.

A greater challenge with regard to gauging the emissions generated by shipping orders fulfilled by a subcontractor is posed by road transport.

Logistics companies are usually faced with an extremely complex and diversified subcontractor portfolio, which moves a shipping order in a dense network of additional subcontractors and customers. That means that information which is fundamental for calculating emissions generated, such as distances actually traveled, load factors of vehicles and types of vehicles used, has to be filtered out of this dense network.

To the above-mentioned high complexity can be added the fact that there is very little data available on average emission values for commercial vehicles. At present, such data can only be accessed from a small number of sources, which, as a rule, tend to be national sources. The bulk of the information originates from scientific studies on fuel consumption of different vehicle classes under simulated operating conditions.

The Environmental Protection Agency (EPA) calculates data in a different way using a platform called SmartWay (USA and parts of Canada). Using this platform, key data from several thousand subcontractors is collected and analyzed each year. Taking existing standards into account, such as the standards set by the WRI/WBCSD, we consider the (geographical) expansion of these types of programs to be an important milestone on the path towards achieving transparency regarding the CO_2 emissions generated by subcontractors in road transport.

The benefits of these types of programs are multifaceted and are felt not only by the logistics companies, to whom the programs provide additional data for calculating emissions and information for managing CO_2 efficiency. The standardization that this type of program would bring about would also help the subcontractors who currently already have to respond to a large number of different requests.

We therefore see standardization and the reduction of complexity as being the focus, which is why the establishment of neutral bodies for recording, calculating and providing the relevant information needs to come before a company-specific, individual solution (see also Figure 3).

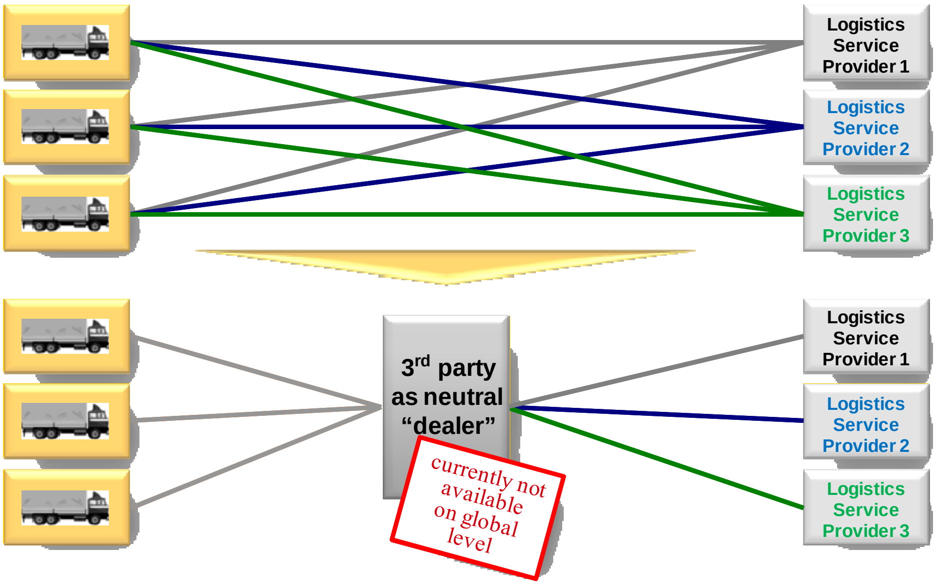


Figure 3: Ways of recording data provided by subcontractors to calculate CO_2 emissions

3.4 Linking CO_2 emissions to the service provided

Besides the measurement of CO_2 data, an additional difficulty is defining and recording the relevant unit of output. The definition of the "correct" reference value varies from division to division as it depends heavily on the business model used. For products that are dispatched in large volumes via a fixed network, it is logical to use the number of standard products as the reference value. Within a country, for instance, the number of shipments dispatched can be used as the reference value for CO_2 efficiency. The total CO_2 emissions are put in relation to the total volume of shipments, thereby producing a CO_2 value per shipment (top-down method of calculation).

With geographically more expansive, variable and complex business models in which nearly all shipments are transported over large distances via different routes using different modes of transport, a different unit of output needs to be defined. If the index value were applied to a single shipment, the emissions for a surfboard being transported from Sydney to New York by sea could be compared to an express item weighing two kilos being transported from Oslo to Stockholm. It is a similar situation for the divisions that do not offer transport services but operate warehouses and refrigerated warehouses as part of the supply chain, meaning they are unable to determine any shipment volumes.

The most common unit of output for transport services is the so-called Revenue Ton Kilometer (RTK), which is calculated based on the product of the weight carried and the length of the transport route.

There are also different ways of determining these reference values. Generally, the maximum possible capacity of a means of transport is used as the starting point and it often does not correspond to the capacity that is actually used. This may, for instance, be because of large volumes that utilize the capacity of a vehicle in volume terms but not in weight terms. The actual load factor rarely reaches 100 percent.

The calculation of the route is not always unproblematic either. With air, sea and rail transport, the length can be determined relatively clearly as none of these means of transport can or needs to make unplanned detours. Transport by road, on the other hand, can hardly be controlled as drivers adjust their routes to the traffic situation.

Another important variable with regard to interpreting and assessing the network is the great circle distance (GCD, see also section 4.3), which indicates the minimum distance between two points on the globe and is calculated based on the longitudes and latitudes of these locations. If more precise information is not available, air transport always has recourse to this distance. The great circle distance between the starting point and the destination of a shipment is exactly the distance that a customer orders from a transport service provider and subsequently also pays for, irrespective of the route actually taken. However, loads and customer orders are, in most cases, consolidated and transported via a network. This is perfect from the transporting company’s perspective; customers, on the other hand, only consider and pay for their individual shipments. As the great circle distance does not correspond to the actual transport route, it cannot be a substitute for more precise information and can only supplement the latter depending on the purpose of the assessment.

The direct method looks at the capacity actually used and the distance actually traveled, which, for the company’s own operations, should be known. Poor capacity utilization is hence reflected in a low tonnage, which leads to a fall in CO_2 efficiency.

The situation is similar with regard to the divisions that mainly provide stationary services. The CO_2 emissions are, in most cases, related to the square footage of the buildings used. This is the most sensible and most easily interpretable reference value for office buildings. For production halls and warehouses, the throughput, measured in weight or volume of quantities handled, may be more valid.

Here, too, the direct and indirect methods lead to different results. Whereas the indirect method assumes the maximum or an average capacity, the direct method records actual capacity utilization. Measures and their impact in terms of improving efficiency can only be shown if direct measurements are used.

4. METHODS USED AT DEUTSCHE POST DHL

4.1 Example 1: Differences in the CO_2 footprint resulting from the determination method

When recording the CO_2 footprint, Deutsche Post DHL pursues two approaches that are determined by the differences in the availability of data described above. The quantities of fuel and electricity consumed for the Deutsche Post DHL's own shipments can be recorded directly, whereas the emissions generated by subcontractors are determined on the basis of secondary data, in other words, emission factors.

In the case of Scope 1 and Scope 2 emissions, recording could be integrated into existing, proven processes and existing systems and organizations could be used. All of the costs incurred for fuel consumed by Deutsche Post DHL itself and for purchased electricity are recorded in an accounting system upon receipt of the invoice. Financial data is recorded accurately and in accordance with strict regulations as it has to stand up to internal and external audits. This data is consolidated at different levels in the global financial system. For carbon accounting purposes, one additional step needs to be added to this data collection process. Every entry relating to fuel and electricity invoices should include not only the monetary amount but also details of the output produced, in the form of liters or kilowatt hours consumed. This solution is efficient as it does not require any additional software solutions or involve a great deal of additional work for the reporting departments. A person only enters an invoice into a system once. With an additional, parallel carbon accounting tool, every invoice would need to be processed twice: Once for financial accounting purposes and once more in order to enter the consumption data. Reported CO_2 relevant data could be allocated to the department responsible based on the same structure as that used for financial figures. An additional benefit would be the increased quality of the data. Because existing processes are being used, the CO_2 data, just like the financial data, would be verifiable and would achieve a similar degree of accuracy. Consumption values would be converted into CO_2 based on emission factors stored in the system, which would be adjusted centrally if changes occurred.

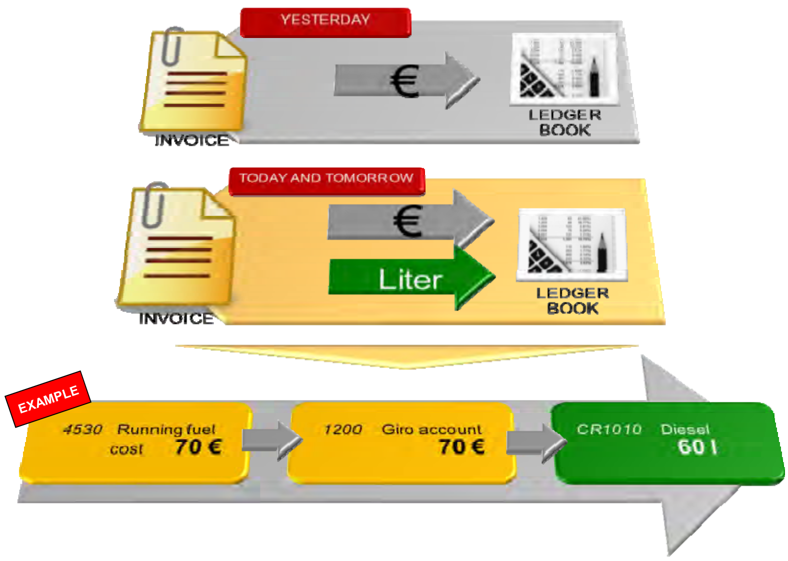
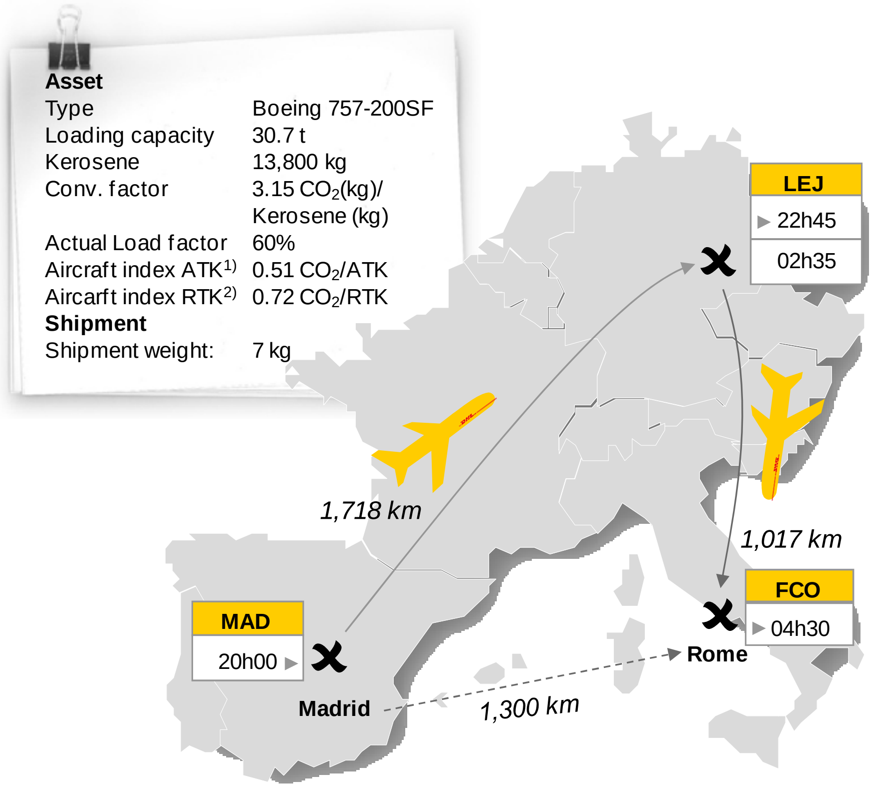


Figure 4: Even now, it is possible both to record monetary data and to enter consumption data into the financial system in order to accurately calculate CO_2

The determination of reference values varies greatly depending on the mode of transport and the logistics operation. Here, too, both top-down and bottom-up calculations are performed with assumptions in order to arrive at the relevant unit of output. For shipments, Revenue Ton Kilometers (RTK) mainly apply, while for buildings, square meters are used in office settings and throughput in volume or kilograms is used for logistics buildings. This approach is adequate for the efficiency index for each division and for the overall index for the Group. To obtain valid index values for each customer or at product level, additional information is required, such as the weights carried and the length of the transport routes as well as precise details of the load volume in relation to the total capacity. This information is only sporadically available in the system environments that are common today. The different operational systems, each containing parts of the information that is required, are not necessarily linked to one another. Currently, for CO_2 footprint calculations, the data has to be manually extracted from the different systems and usefully combined.

As shown in Figure 2 above, there are four possible methods for calculating a shipment's CO_2 footprint, two of which (only direct and only indirect) are to be examined in more detail. Depending on whether the CO_2 emissions and the reference value are recorded directly or indirectly, different calculations result and these are outlined below:

In a highly simplified example, the difference in the CO_2 footprint that results from the choice of recording method is illustrated using a shipment transported from Madrid to Rome. On account of the network structure, this shipment is not flown directly but is routed via Leipzig. The emissions generated by ground transport and handling at the terminals are not included here as they are negligible and would make the example unnecessarily complicated.



Source: DPDHL emission factor v0,95; Aircraft specific CO2 per RTK Database; actual fuel consumption record 1) ATK is available ton kilometers which is based on full capacity of the plane; 2) Airline RTK is calculated based on ATK x 70% (industry avg. load factor)

Figure 5: CO_2 production and product calculation for a shipment transported from Madrid to Rome in a highly simplified example

The total emissions for this shipment (product footprint) are calculated as follows:

Method 1A: emissions and reference value are determined indirectly.

It is assumed that maximum utilization is made of the aircraft's capacity. This influences both the indirect CO_2 factor used and the percentage of the total load accounted for by the shipment.

$$\left[\text{aircraft index (ATK)} \times \text{loading capacity} \times \text{distance flown}\right] * \frac{\text{shipment weight}}{\text{loading capacity}} = CO_2 \text{ footprint}$$

$$\left[\frac{0.51\text{ kg } CO_2 \times 30.7\text{ t} \times 2{,}735\text{ km}}{\text{tkm}}\right] * \frac{0.007\text{ t}}{30.7\text{ t}} = 9.76\text{ kg } CO_2$$

Method 2B: emissions and reference value are determined directly.

The quantity of kerosene actually burned and the aircraft capacity actually utilized are used as a basis.

$$\left[\text{kerosene burned (kg)} \times \text{emission factor kerosene}\right] * \frac{\text{shipment weight}}{\text{loading capacity utilized}} = CO_2 \text{ footprint}$$

$$\left[13{,}800\text{ kg kerosene} \times 3.15\,\frac{\text{kg } CO_2}{\text{kg kerosene}}\right] * \frac{0.007\text{ t}}{0.60 \cdot 30.7\text{ t}} = 16.52\text{ kg } CO_2$$

Determining the individual components directly results in a CO_2 value for this individual shipment that is almost twice as high. This margin between the results makes it impossible to interpret the footprint. As the shipment involves express delivery, it is not possible to base the calculations on industry averages.

Once all the data is available, offering sufficient accuracy and detail, sensible allocation rules need to be defined that link the emissions and reference values. This is the only way data from the various financial and operational systems can be automatically accessed and values that belong together can be linked.

4.2 Assessment of CO_2 emissions and their addressees

The emissions measured are consolidated at different levels according to the addressee's needs. As such, four different report requirements have been defined.

Figure 6: Different addressees of CO_2 reporting

The first report level is indispensible for achieving the efficiency target. The emissions need to be shown at the location where they are generated in order to initiate reduction measures and to monitor their progress. All consumption data needs to be allocated to a management unit. In some cases, it is possible to use the allocation mechanisms used in financial accounting. Unit costs can be allocated directly and, in the case of overheads, keys that are derived from other variables, such as share of revenue, can be used. These mechanisms are transferred to the allocation of emissions. When allocating emissions, it is important to adapt them to actual management levels. Some managers are responsible for sorting systems, others are responsible for global trade lanes. When allocating emissions to shipments, it is important to ensure that emissions relate to the true value of services provided by Deutsche Post DHL. This is the only way that all potential efficiency enhancement programs and their impact can be illustrated.

The customer and product footprint are calculated from the total emissions allocated to a customer or product. If cost allocation rules have been installed, they can be used. Otherwise, the emissions are allocated based on the actual service provided for a product or customer. The emissions per customer can also be shown as the total number of products the customer has bought. This is a commonly used method in relation to standard products that are always calculated the same way. With customer-specific shipments, the emissions are allocated directly to the customer and not first of all to a specific product.

At the highest report level, the CO_2 footprint of the entire Group and the efficiency index value are reported. The total emissions are calculated by adding them up across all management levels, customers or products. The efficiency index value is calculated from the individual indices for the divisions. As they each have different reference values, the annual index value should only be viewed as a measure for improvement or deterioration but not as the emission value for each unit of output.

The difficulties and different interpretation possibilities for allocating emissions can best be illustrated using example 1, which you are already familiar with.

The CO_2 footprint, calculated above, of a shipment that is transported from Madrid to Rome is to be compared with different reference values depending on the addressee. For the manager responsible for this trade lane and its emissions, the representation of the footprint is not sufficient. Rather he needs the efficiency of this trade lane in order to be able to manage savings measures. As such, the great circle distance (GCD) discussed above is important as the length of the direct distance between Madrid and Rome. The customer is only commissioning Deutsche Post DHL to cover this distance. This route also needs to be based on the trade lane Madrid to Rome in order to obtain the efficiency value “emissions per RTK [CO_2/tkm]”. It may seem unusual at first glance that, for the efficiency view, it is not the actual route flown via Leipzig, but the route commissioned by the customer that is used as a basis. However, it is only this so-called product view that reflects any network optimization or even a change of mode of transport.

$$\text{Efficiency of the shipment from Madrid to Rome} = \frac{\text{footprint of the shipment}}{\text{creditable weight} \times \text{GCD}}$$

$$= \frac{16.52\ \text{kg}\ CO_2}{0.007\ \text{t} \times 1{,}300\ \text{km}} = \frac{1.82\ \text{kg}\ CO_2}{\text{RTK}}$$

If the actual distance flown was used in the denominator, a measure that involves network optimization and minimizes routes would lead to a higher index value or would be deducted via the decreasing footprint of the shipment. The denominator needs to be a fixed reference value. The logistics service provider selected the minimum RTK value possible that is made up of the weight and the minimum distance between two points, the great circle distance. The impact of optimization measures is now displayed via the changed footprint.

Other efficiency-enhancing measures can also be displayed in this model. Upgrading the fleet used with more efficient aircraft leads to a reduction in the consumption of kerosene, which is taken into account in the footprint of the shipment. This effect can, of course, only be observed if the emissions are also determined using actual consumption data. If an industry average that is not impacted by changes to a company’s fleet is used, the success of the measure is not displayed. The footprint of the shipment can also be reduced by using alternative fuels or more environmentally-friendly modes of transport, for instance, by shifting to rail transport. Likewise, increasing the utilization of capacity, which should be achieved as part of ordinary network optimization aimed at reducing costs, results in a lower CO_2 footprint for the shipment. These management measures therefore have consequences for all addressees: they lower the customer and product footprint, while increasing the efficiency of the trade lane and hence of the group.

This example clearly shows not only that the emissions need to be allocated to the individual, selective parties responsible for generating them but that the network needs to be displayed. This is a time-consuming and costly task for a group operating on a global scale. The more stations a shipment passes through and the more stations are allocated to a management unit, the more complex it becomes to display the process and subsequently complete the relevant calculations. Calculation systems have already been developed for some divisions that link the data from existing systems, making it possible to calculate the emissions generated by each product. However, it is only the footprint and not the efficiency that is calculated. In the future, not only the extraction of data from subsystems but also the calculation of efficiency indices should run automatically once the allocation rules have been specified. This would mean that the measures could be managed on an ongoing basis.

At Deutsche Post DHL, the above-mentioned method of calculating the index is referred to as the “product view”. The calculation of the footprint for an individual shipment or the efficiency of an individual operational unit, disregarding its importance in the network, is referred to as the “production view”. An additional example will later show that both views have their justification.

4.3 Calculating the great circle distance (GCD) and central provision of data

The GCD serves as the basis for calculating the efficiency index of an entire network. It is defined as the shortest distance between two points A and B measured along a path on the surface of the sphere. Hence, the GCD does not describe the mathematically shortest distance as it describes the shortest path on the Earth’s surface but not through the Earth’s core. The GCD is calculated from the product of the earth’s radius *r* and the angle ψ between the two points A and B.

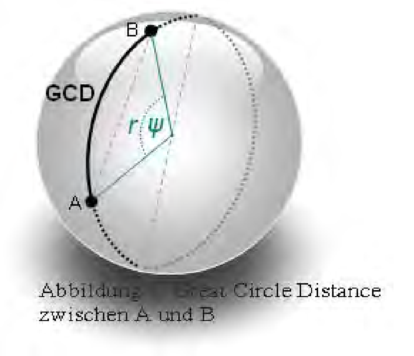


Figure 7: Great circle distance between A and B

In order to determine the angle, the coordinates in the form of the longitude and latitude of points A and B are needed. Once these two coordinates are known, any point on earth can be clearly defined. If φ_A and φ_B indicate the latitudes of points A and B, in other words, their positions south or north of the equator converted into angles, and λ_A and λ_B indicate the corresponding longitudes and δ the difference in each case, the angle ψ can be calculated using the following formula:

$$\psi = \arctan\left(\frac{\sqrt{(\cos\varphi_B \sin\partial\lambda)^2 + (\cos\varphi_A \sin\varphi_B - \sin\varphi_A \cos\varphi_B \cos\partial\lambda)^2}}{\sin\varphi_A \sin\varphi_B + \cos\varphi_A \cos\varphi_B \cos\delta\lambda}\right)$$

In order to calculate the GDC, it is therefore imperative to know the values for the longitude and latitude of the starting point and destination of any potential shipment. The coordinates must also be available for all of the stations within the network that a shipment passes through on its route. Once the values are known, it is easy to calculate the GCD automatically.

The complexity of recording the information on the longitude and latitude of the starting point, the destination and the points in-between varies depending on the mode of transport used and the location of the stations. In addition, the data is fed into a system in standardized form. The majority of international airports are identified by a three-digit code. Sea ports have a five-digit code, which can be used to clearly identify individual ports and their locations. Railway stations and larger terminals tend not to have an internationally valid code. The coordinates can be allocated to these fixed network points on the basis of their official address. As there is only a limited number of them available, they hardly ever change and some already have internationally valid and clear identification codes, on the one hand, it is a time-consuming task to record the data but, on the other, it is a task that can certainly be solved. It is far more complicated to determine the clear addresses and hence the longitudes and latitudes of end customers. Transport runs are carried out to almost two billion stations globally for the pick-up and delivery of shipments. The fact that these transport runs are allocated to subcontractors makes it more difficult to record the data as Deutsche Post DHL does not know the starting point or the destination. The points Deutsche Post DHL stops at change constantly as it gains new customers and ceases catering for others.

The availability of the stations' exact addresses also depends on the countries in which they are located. In Europe and North America, nearly all addresses are recorded on maps, which means that longitudes and latitudes can be allocated to them. The rest of the world has not been fully mapped, although the bulk of Deutsche Post DHL's business is in Europe.

If average values are calculated for each shipment in traditional mail and parcel network operations using the top-down approach to calculate the index, the GCD plays a secondary role as the emissions are related to the number of shipments transported in order to calculate the index.

In future, the allocation of addresses to coordinates and the calculation of the GCD should occur in an automated system. A database is available for this purpose that stores all of the data on longitudes and latitudes centrally and can be centrally accessed. This ensures standardized measurement of the GCD. When the starting address and the destination address are entered, the GCD is automatically determined via the stored coordinates, using standard distances between two points. As this system is accessed by users from different countries – at best even by users from different companies – it should identify addresses even in entries made in different languages or incorrect entries as well as provide specifications on the use of longitude and latitude (e.g. what values apply to an airport, the runway or a particular terminal?).

As outlined above, it is necessary to create this database in order to determine the GCD and hence the efficiency index for the network. Group-wide and globally uniform values can only be calculated and used for all interpretation purposes if data is supplied centrally. Data should also be supplied centrally across companies.

4.4 Example 2: Differences in calculating the index from the product and the production perspective

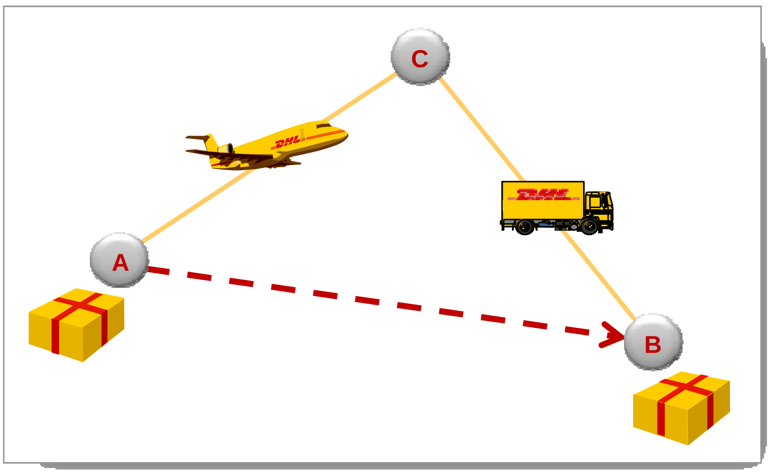


Figure 8: Shipment from A to B (customer request), which is transported via C on account of the network structure.

A customer dispatches his parcel from point A to point B. This parcel is not transported alone on a direct route, it is consolidated with other shipments and is flown to a network node C. The parcel is subsequently transported by road from point C to point B.

The only issue that is of interest to the customer is the CO_2 footprint of his shipment. How and via which network the parcel is dispatched is only important to the manager responsible at the logistics service provider. However, both parties feel the impact of network optimization: The customer via a decreasing product footprint, the trade lane manager via a higher efficiency index value.

An efficiency index can also be calculated for each individual station in the trade lane. This shows local management its efficiency although it does not display pure network optimization. The view of the individual production steps leads to the following indices:

$$\text{Index}_{Air} = \frac{\text{CO}_2\,(A\,to\,B)}{\text{weight of the shipment} \times \text{GCD}_{A\,to\,B}}$$

$$\text{Index}_{Road} = \frac{\text{CO}_2(B\,to\,C)}{\text{weight of the shipment} \times \text{GCD}_{B\,\text{to}\,C}}$$

$$\text{Index}_{Facility} = \frac{\text{CO}_2(A)}{\text{weight of the shipment}}$$

If one of the shipments is handled by a subcontractor, this significantly increases the complexity of the index calculation – to simplify matters, we assume that both shipments generate direct emissions only. At each production step, the manager responsible can achieve his efficiency by implementing various measures, such as increasing the utilization of capacity, improving the fleet or facilities and by encouraging his staff to embrace energy-saving behavior. Here, too, the denominator is a constant as the weight of the shipment and the distance via the great circle distance do not change. The impact of measures leads to a higher index value owing to reduced CO_2 emissions. This display enables modes of transport and their CO_2 efficiency to be compared. However, the impact of shifting to a different mode of transport is only shown clearly in the production perspective.

To this end, the total emissions are related to the shortest distance paid for by the customer as in the example above.

$$\text{Index}_{\text{Pr}oduct} = \frac{\sum \text{CO}_2(air) + \text{CO}_2(road) + \text{CO}_2(building)}{\text{weight of the shipment} \times \text{GCD}_{A\,to\,B}}$$

This index value is also influenced by network optimization and a change in the mode of transport although the individual index values of the production steps do not reflect this change.

4.5 Example 3: Use of the great circle distance to display efficiency improvements

Let us assume that the delivery of a shipment from A to B by truck, initially over a distance of 500 kilometers, could subsequently be carried out over a distance of 350 kilometers following optimization. The GCD between the two points is 270 kilometers.

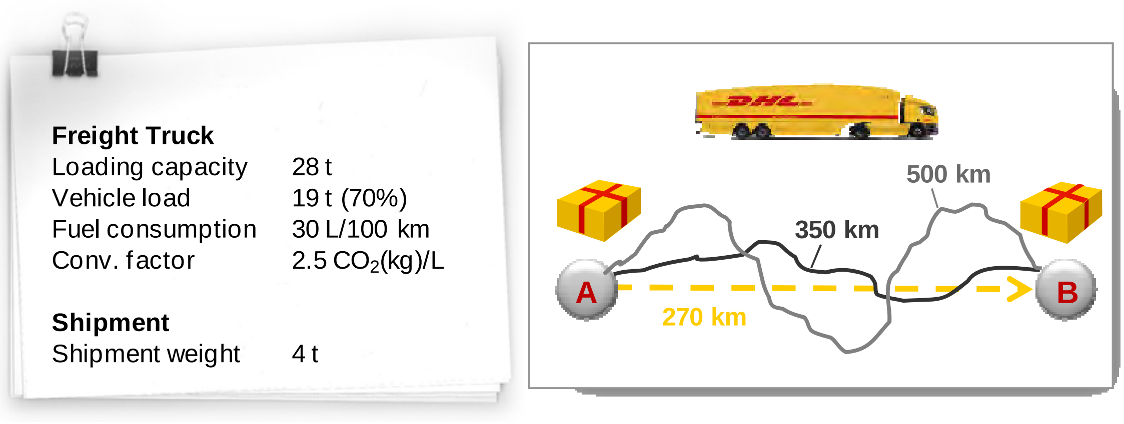


Figure 9: Different distances covered when transporting a shipment from A to B.

If the sample values indicated are now used to calculate the numerator of the CO_2 efficiency index, a higher CO_2 value (79 kg) is obtained owing to the different fuel consumption for the longer route in absolute terms.

Carbon footprint of the shipment

- **500 km:**

$$\frac{30\ \text{L}}{100\ \text{km}} \times 2.5\ \frac{\text{kg } CO_2}{\text{L}} \times 500\ \text{km} \times \frac{4\ \text{t}}{19\ \text{t}} = \mathbf{79\ kg\ CO_2}$$

- **350 km (optimized network):**

$$\frac{30\ \text{L}}{100\ \text{km}} \times 2.5\ \frac{\text{kg } CO_2}{\text{L}} \times 350\ \text{km} \times \frac{4\ \text{t}}{19\ \text{t}} = \mathbf{55\ kg\ CO_2}$$

Figure 10: CO_2 emissions on a route of 500 km and 350 km, respectively

If the CO_2 efficiency is now calculated on the basis of the distance actually driven (500 km and 350 km), an identical CO_2 efficiency index of 39.5 g of CO_2 per ton kilometer is obtained – despite route optimization. A reduction in fuel consumption for this shipment of around 30 percent is ultimately not visible in the efficiency index if the kilometers actually driven are used as the basis. The kilometers actually driven to transport a shipment are therefore of no use for tracking energy efficiency improvements.

- **500 km:**

$$\text{Efficiency of shipment from A to B} = \frac{CO_2\ \text{Footprint}}{\text{Actual Weight x Actual Distance}_{\textbf{A to B}}} = \frac{79\ \text{kg}\ CO_2}{4\ \text{t x}\ 500\ \text{km}} = \mathbf{39.5}\ \frac{\mathbf{g\ CO_2}}{\mathbf{tkm}^{1)}}$$

- **350 km (optimized network):**

$$\text{Efficiency of shipment from A to B} = \frac{CO_2\ \text{Footprint}}{\text{Actual Weight x Actual Distance}_{\textbf{A to B}}} = \frac{55\ \text{kg}\ CO_2}{4\ \text{t x}\ 350\ \text{km}} = \mathbf{39.5}\ \frac{\mathbf{g\ CO_2}}{\mathbf{tkm}}$$

Figure 11: Calculating the CO_2 efficiency index on the basis of the kilometres actually driven.

However, if the GCD is used as the reference value in the denominator, the efficiency improvement becomes visible. The GCD is therefore suitable as a tool for reflecting changes in the network or even the mode of transport. The efficiency improvement of 30 percent is visible in the index.

- **500 km:**

$$\text{Efficiency of shipment from A to B} = \frac{CO_2\ \text{Footprint}}{\text{Actual Weight x GCD}_{\textbf{A to B}}} = \frac{79\ \text{kg}\ CO_2}{4\ \text{t x}\ 270\ \text{km}} = \mathbf{73}\ \frac{\mathbf{g\ CO_2}}{\mathbf{tkm}}$$

- **350 km (optimized network):**

$$\text{Efficiency of shipment from A to B} = \frac{CO_2\ \text{Footprint}}{\text{Actual Weight x GCD}_{\textbf{A to B}}} = \frac{55\ \text{kg}\ CO_2}{4\ \text{t x}\ 270\ \text{km}} = \mathbf{51}\ \frac{\mathbf{g\ CO_2}}{\mathbf{tkm}}$$

Figure 12: Calculating the CO_2 efficiency index on the basis of the great circle distance (GCD).

5. CONCLUSION

- CO_2 emissions are in proportional relation to energy consumption. Reducing energy consumption has the immediate impact of reducing CO_2 emissions. This means reducing energy consumption has an immediate impact on costs.
- In order to enable local management to control energy consumption efficiently, there will be a growing need in the future to record primary energy sources and utilization of capacity directly in order to calculate the CO_2 value per shipment. Using indirect emission factors from industry averages to approximate CO_2 emissions is a step in the right direction, although it obscures the strengths and weaknesses of companies' own fleets.
- Accurate carbon accounting that deals with the recording of primary energy data must be followed by targeted controlling. In order to be able to initiate efficiency-enhancing measures effectively, the correct measurements need to be implemented.
- The method of calculation and the selection of key performance indicators need to be such that all the levers for improving efficiency can be displayed.
- A singular view of CO_2 emissions is too little for successful management of CO_2 where it is generated.
- The definition of units of output is the key factor for showing efficiency improvements in the product view. Customers, in particular, are interested in the product view and in the efficiency indices calculated for their products. The great circle distance (GCD) is an important component in this regard.
- Accurate and centralized calculation of the great circle distance (GCD) for each product or production is hence an essential basis for achieving efficiency improvements in the transport sector.
- Correct recording of the Scope 3 footprints and the units of output for subcontractors via an international, independent platform that is managed and audited by third parties is a key success factor for efficiency improvements in logistics. From the product perspective, direct emissions cannot be separated from indirect emissions and are hence an mandatory component of reporting.

6. Abbreviations

ATK	Available Ton Kilometer, maximum loading capacity in tons multiplied by kilometers flown/driven
DEFRA	Department for Environment, Food and Rural Affairs, UK, http://www.defra.gov.uk
EPA	U.S. Environmental Protection Agency, http://www.epa.gov
GCD	Great circle distance
IATA	International Air Transport Association, http://www.iata.org
ICAO	International Civil Aviation Organization, http://www.icao.int
RTK	Revenue Ton Kilometer, one ton of load (passengers and/or cargo) carried for one kilometer (relevant to revenue)
WBCSD	World Business Council for Sustainable Development, http://www.wbcsd.org
WRI	World Resources Institute, http://www.wri.org

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