Global Logistics Emissions Council Framework

Smart Freight Centre

BUILT ON GHG PROTOCOL

GLEC Global Logistics Emissions Council

For logistics Emissions Accounting and Reporting

V3.1

Foreword

Freight transportation and logistics activities currently contribute 8% of global greenhouse gas (GHG) emissions, and demand for freight transport is expected to roughly double by 2050, according to the International Transport Forum.[1] To meet the Climate Targets of the United Nations' Paris Agreement, it is crucial to improve the efficiency of freight transport and reduce transport-related emissions. A concerted global effort is necessary to achieve goals. The GLEC Framework v3 supports you in your efforts and contribution to reaching these goals.

The next few years are decisive in this regard. Failure to reach climate targets could have massive economic impacts, and the expected cost of an increase of 2.0°C is already 11% of the world's GDP, not to mention the other dramatic changes expected, such as increasing extreme weather conditions, loss of agricultural land, etc.[2] However, there is still time to take action, and we must take it jointly and immediately.

One of the crucial steps needed is to change the way we organize our supply chains and logistics. We must avoid unnecessary transport and empty trips, and optimize the use of existing capacity, as well as make use of the most sustainable transport solutions available. Transparency on the sources of emissions in our transport system is vital to achieving this outcome.

To enable this transparency, the Global Logistics Emissions Council (GLEC) has developed the GLEC Framework, which provides guidance on the calculation and reporting of freight transport systems, chains and operations. This framework, first published in 2016, brings together in one place concepts and learning from the world's leading approaches for calculating greenhouse gas emissions arising from freight transport.

In response to industry requests, work on an ISO standard using the GLEC Framework as a basis began in 2019, with the objective of providing an internationally accepted and established format for the calculation and reporting of transport related GHG emissions.

Over three years, experts from all over the world collaborated on the development of ISO 14083, which was published in 2023 under the title of:

Greenhouse gases — Quantification and reporting of greenhouse gas emissions arising from transport chain operations.

Following its publication, we have integrated the provisions of ISO 14083:2023 back into the GLEC Framework. The outcome, GLEC Framework v3, is now in front of you. From the GLEC Framework v1 & v2 to the GLEC Framework v3 – this document brings together the accessibility of the GLEC Framework and the requirements of ISO 14083 (see Figure 1 on next page).

The GLEC Framework v3 guides and supports companies in implementing transparency on the efficiency of their supply chains and logistics. It offers an easy-to-use approach to an ISO 14083-compliant calculation of GHG emissions from transport, covering the transport itself as well as logistics hubs and the emissions from the energy supply to them both. Throughout the GLEC Framework you will find the relevant references to ISO 14083. Third party assurance of emission reports is crucial for building trust and credibility, while also highlighting the efficiency and sustainability effort of companies that engage in transport improvements. Using the GLEC Framework will ensure your GHG Emissions Report is ready to be verified by an assurance provider.

Foreword

Many companies have made huge efforts in recent years to reduce their carbon footprint and improve the efficiency and sustainability of their transport chains. Their efforts are most valuable and important, and the GLEC industry partners have incorporated their insights into the GLEC Framework v3. We thank all those who have contributed their expertise and experience. You have made this journey possible.

For a further acceleration of changes, it is now important that all companies analyze the efficiency of their transport and logistics and take any possible and necessary steps to optimize their transport system's efficiency. In particular, multinationals hold the key to reaching climate targets, especially those with global brands and supply chains. As buyers or suppliers of freight services, they have the power to change the way we organize logistics and supply chains. They can act as leaders through reporting carbon emissions, setting climate targets, and collaborating with partners to achieve them.

For those of you who have used the GLEC Framework before, you will find a separate chapter on the key changes implemented in the GLEC Framework v3 compared to the - GLEC Framework v2. For everyone else, we hope that this document opens the door to the next chapter for your company, enabling you to improve your efficiency and supporting you in your contribution to reaching climate targets.

If you have any questions or suggestions, please let us know. And if you are looking for a platform to exchange experiences in emission accounting, reporting and reduction, come and join Smart Freight Centre's (SFC's) GLEC program. We can only reach the necessary low emission freight transport system in cooperation with your active participation.

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Figure 1
The development of GLEC Framework v3

Acknowledgements

The third version of the GLEC Framework is based on the GLEC Framework v2 and incorporates the freight transport related methodologies of ISO 14083 Greenhouse gases — Quantification and reporting of greenhouse gas emissions arising from transport chain operations.

It was made possible thanks to the SFC team around the globe and the contribution of numerous GLEC members since the formation of the GLEC in 2014.

The authors wish to thank the many contributors who offered their insights and perspectives on this work, in particular Jan-Philipp Jarmer and Kerstin Dobers from the Fraunhofer Institute for Material Flow and Logistics (IML) for their work on logistics sites, Giacomo Lozzi for his work on the transport modes and reporting, Noelle Fröhlich of DHL Group, Adrian Wojnowski and Patric Pütz of Smart Freight Centre, and Sophie Punte of the SFC Board of Directors for reviewing the document and supporting the work with their expertise and technical advice.

A particular thank you also goes to Suzanne Greene, who authored the GLEC Framework v2 jointly with Alan Lewis. The GLEC Framework v2 constituted a key input for the ISO 14083, and several parts of the GLEC Framework v2, as well as the basic structure, are to be found again in the GLEC Framework v3.

Furthermore, we would like to recognize the valuable work of the team of experts around the globe who worked on the development of ISO 14083. A thank you also to the DIN team in Berlin, in particular Angelina Patel, Mayan Rapaport, Lina Molitor and Wiebke Meister who were the secretariat of the ISO working group.

About the GLEC

www.smartfreightcentre.org/en/global-logistics-emissions-council

A Smart Freight Centre program, the GLEC was established in 2014. GLEC is our community of organizations and NGOs dedicated to driving widespread, transparent, and consistent calculation and reporting of logistics GHG emissions. GLEC works to identify common problems, remove barriers and, above all, share a conviction that emission reduction in freight is urgent.

About SFC

www.smartfreightcentre.org

Smart Freight Centre (SFC) is a globally active non-profit organization for climate action in the freight sector. SFC`s goal is to mobilize the global logistics ecosystem, in particular our members and partners, in tracking and reducing its greenhouse gas emissions. SFC accelerates the reduction of logistics emissions to achieve a zero-emission global logistics sector by 2050 or earlier, consistent with 1.5° pathways.

150+

Leading multinationals have committed to implementing the GLEC Framework through joining the SFC community.

Learn more about the SFC community and our GLEC participants.

Structure of the document

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Click on each panel to go straight to the section.

Introduction to Logistics Emission Accounting Freight Transport's Climate Impact

Transport demand is expected to double by 2050, driven largely by Asia, Africa and Latin America. Even in its most optimistic scenario, the International Transport Forum expects a doubling of transport demand to over 270,000 billion tkm for all transport modes combined by 2050. In its highest scenario, levels of almost 350,000 billion tkm are expected.[3]

Without intervention, freight transport emissions will more than double by 2050.

Logistics' climate impact is large and growing

The logistics sector plays a vital role in the supply chains which lie at the heart of the global economy. The maritime and rail sectors are critical enablers of the flow of energy resources such as oil and natural gas, as well as commodities such as steel, fertilizers and containerized consumer goods. The aviation sector plays an important role in moving time-sensitive products and high-value consumer goods. At the base, there is road transport – the most ubiquitous form of freight transportation to points of consumption around the world. All these modes are linked by various types of transport hub where goods are stored, repacked and distributed.

The climate impact of logistics and the transport sector accounts for around 60% of global oil demand. The reduction in transport activity during the COVID-19 pandemic resulted in a massive temporary reduction of GHG emissions as road transport and aviation transport demand were drastically reduced. The International Energy Agency estimates that the reduced road transport demand can be linked to a reduction of 50% in global oil demand and the reduced aviation transport to a reduction of 36% during the pandemic. At the same time, the demand for low-carbon technologies, including solar photovoltaic (PV) and wind energy, increased to unprecedented levels, raising their share in the global energy mix to over 20%.[4] In fact until 2021, transport related oil demand levels were below pre-pandemic levels, resulting in a reduced annual emission of 600 Mt CO_2 emissions compared to 2019 levels. The trend of growth in transport demand, with the related GHG emissions has returned since then and is continuing[5]. Further action is therefore needed to reach climate targets.[6]

It doesn't have to be that way

Growth in the logistics sector does not necessarily have to mean growth in emissions. Indeed, to meet global climate goals – limiting global temperature increase to 1.5°C from pre-industrial levels – governments, the logistics sector and its many customers will need to make a concerted effort to decarbonize freight transportation.

More efficient operational practices like load consolidation, modal switch, and energy-efficient driving have the potential to decrease emissions without the need for capital investments. Zero and low-emission freight technologies are also increasingly available and have strong potential for reducing carbon emissions, most notably the adoption of renewable energy for transportation and logistics sites. Ambitious decarbonization policies can enhance industry actions and drive further reductions. Committing to tracking and reporting our carbon emissions is essential to determine whether we are on track to achieve our goal.

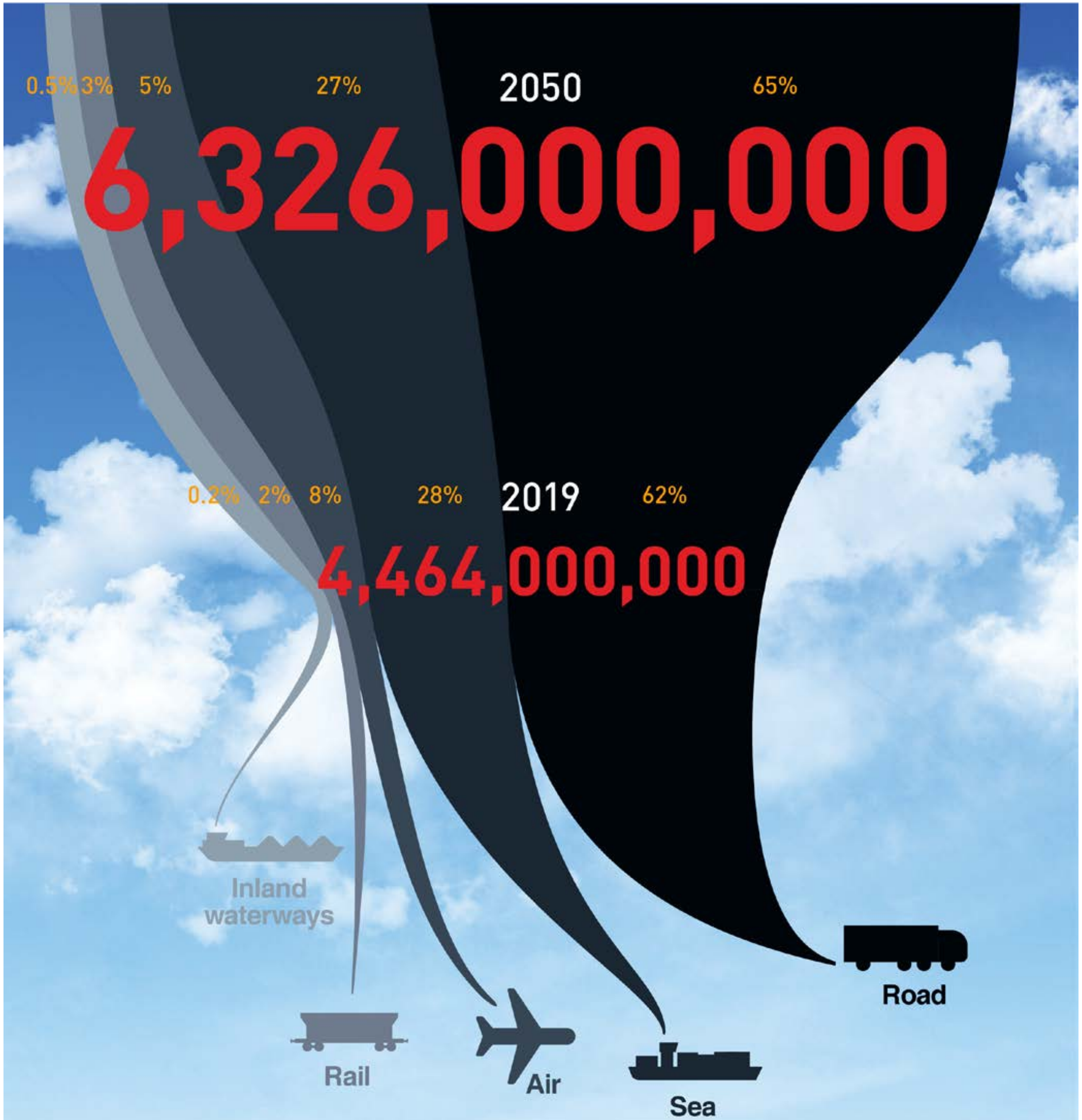


Figure 3
Each mode of transport contributes to logistics emissions, to varying degrees.

Logistics emissions are set to increase 36% but they need to be close to net zero by 2050!

Tonnes CO_2

Source: International Transport Forum Outlook 2023

Why companies use the GLEC Framework

GHG emissions have become the default metric for communicating climate sustainability between buyers, suppliers, investors, customers and governments and beyond. Tracking GHG emissions over time allows companies to use both total emissions and emission intensity as key performance indicators (KPIs) in operational and supply chain planning and target-setting.

Despite this, carbon accounting for logistics is still a relatively new practice. The complexity of the sector requires a simple and practical approach that companies of all sizes and institutional capacities can apply – the GLEC Framework offers such an approach.

Here are some ways the GLEC Framework streamlines GHG emission accounting across supply chains and geographies:

The Framework works with Industry Standards
The GLEC Framework aligns with ISO 14083 and is recognized by the Greenhouse Gas Protocol. It is the recommended method for reporting logistics emissions to the Carbon Disclosure Project (CDP) and for setting targets in line with the Science-Based Targets initiative (SBTi).

The Framework works for all transport stakeholders
Covering the entire transport chain, the Framework works for carriers, logistics service providers (LSPs) and shippers as well as other end-users of emissions information, such as governments, investors and green freight programs. It works for companies just beginning to account for their transport emissions through to those that have full visibility of emissions in their operations and supply chain – and provides an accessible and realistic pathway for the former to progress and achieve the latter. With its global applicability, it can also provide guidance to policymakers who are looking to implement carbon accounting regulations for transport.

The Framework works for decision-making
GHG accounting can be used in investment, procurement and sales strategies to assess the impact of different scenarios, predict the carbon return on investment and track progress toward climate goals following implementation. This leads to improved efficiency and bottom-line financial savings, alongside reduced climate and health impacts.

The Framework works with green freight programs
Green freight programs play a critical role in connecting shippers and carriers around the globe. Accounting and reporting freight activity are part of the broader process of supply chain efficiency and sustainability efforts that green freight programs help to support.

The GLEC's partnerships with global green freight programs, such as the United States Environmental Protection Agency (US EPA) SmartWay, Clean Cargo, Lean & Green, Clean Air Transport, Sea Cargo Charter, Smart Freight Alliance China and Programa de Logística Verde, are essential for streamlining carbon accounting and emission reduction on a global scale.

How to use the GLEC Framework

The GLEC Framework offers clear guidance while leaving enough space for adaptability to the specific needs of your situation. It provides information on the requirements toward the definition of boundaries and data sourcing throughout the entire transport chain, from sender to receiver. Different levels of granularity in the detailing of transport chain analysis can be realized with it. It also maps out reporting requirements from the basic "must-have" to very advanced levels of detailed information to ensure that you can gain the best insights possible into the improvement potential within your transport and logistics services.

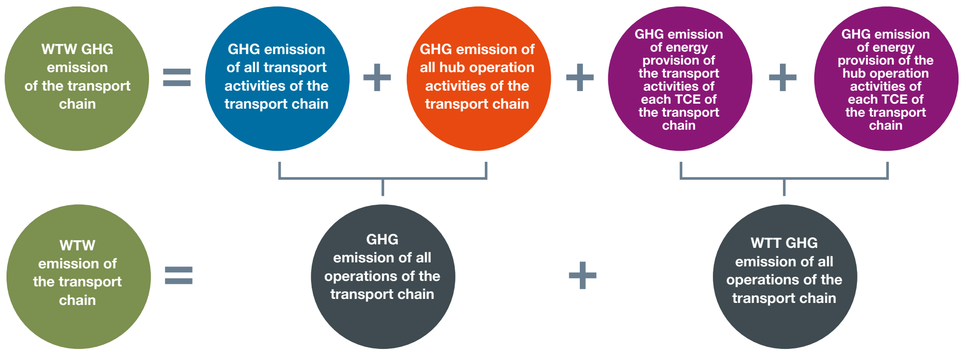
The GLEC Framework introduces the concept of operation categories, transport operation categories (TOC) and hub operation categories (HOC). These are groups of operations that share similar characteristics. Such an identification of TOCs and HOCs provides a tool to structure your transport services – those provided and used – and to identify relevant emission intensities, according to the specific situation of your organization. (More details are to be found in Section 1 chapter 2 Calculation Steps: Establishing of the relevant TOC or HOC). The Framework in the presented form focuses on the most common situations to keep it easy to use. To make the application even more accessible, example cases and company-specific use cases are to be found in Module 4. Therefore, you can use the document to familiarize yourself with GHG emission accounting and reporting. At the same time, advanced users of emission accounting tools will find all necessary information on the concept and requirements of ISO 14083. For ease of orientation, the end of each paragraph references the related ISO chapters.

Changes introduced in Framework v3 in comparison to v2

The GLEC Framework v3 has the transport chain and its transport chain elements (TCEs) as its starting point, just like its predecessor. However, the perspective of analysis and reporting have evolved slightly.

The GLEC Framework v2 classified logistics emissions into three scopes, following the principles of accounting put forward by the Greenhouse Gas Protocol. Scope 1 includes direct emissions from assets owned or controlled by the reporting company, Scope 2 includes indirect emissions from the production and distribution of electricity, heat and steam purchased by the reporting company and Scope 3 includes indirect emissions from the reporting company's supply chain, such as transportation emissions and product use. The GLEC Framework v3, in line with ISO 14083, divides the overall GHG emissions into emissions related to the energy use for the operation of transport or hub activities and the emissions related to the provision of this energy. Whereas the emissions of the transport operations – hub and transport activity – constiute the tank-to-wheel (TTW) (also referred to as "tank-to-wake" where appropriate) emissions, the energy provision emissions for energy used for transport activity or hub operations make up the well-to-tank (WTT) emissions. With the v3.1 update, minor changes have been implemented, primarily data sources used in Module 3. A detailed overview of the tracked version can be found in the Glossary on page 171.

Figure 4
GHG emissions well-to-wheel (WTW)



How to use the GLEC Framework

So, where does this leave Scope 1, Scope 2 and Scope 3 emissions. See also Figure 5: Scopes of accounting.

The ownership of the vehicle or equipment carrying out the transport or hub operation is not decisive for the calculation of emissions. It is the position of the reporting organization within the value chain that determines which scope category the emissions fall into. The link between transport operation providers and users is provided via reporting between supply chain partners. Traditional Scope 3 users of transport services will need to be provided with information on the activity carried out and the related emission intensities, or with the readily calculated emissions of their transport chains from Scope 1 and Scope 2 providers of transport services. (For further details, see also Section 2 Chapter 1 Reporting Emissions).

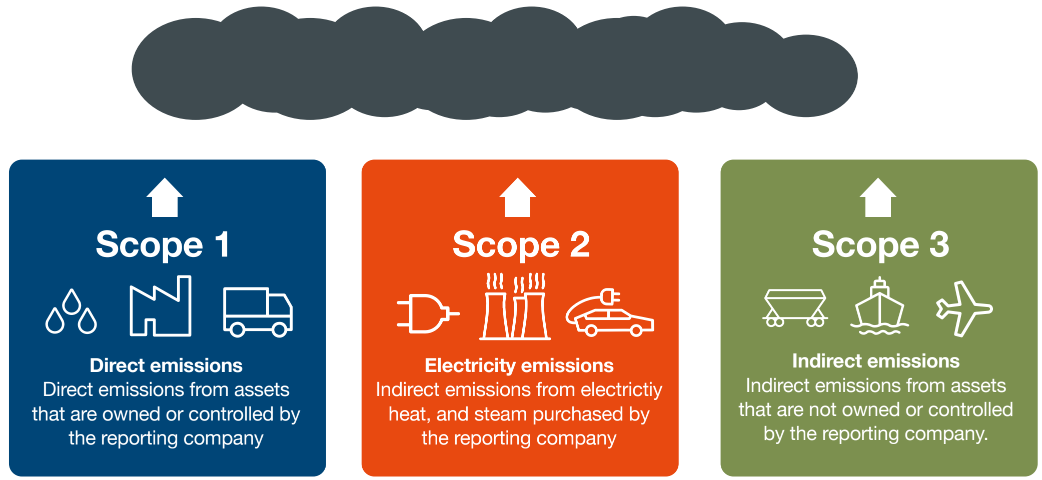
The concept of TOC and HOC has been updated and given additional prominence. Previously referred to as Transport Service Categories (TSCs), TOCs and HOCs serve two major purposes: providing the boundary for the calculation of emission intensity values, and the allocation of emission intensity values for specific TCEs. These TOCs and HOCs are clusters of transport or hub activities of similar character and emission intensity. There are guidelines for the clustering of transport or hub services into categories, which can be found in Section 1 Chapter 4, Information and Requirements for the Individual Transport Modes. Each organization providing transport services must build the TOC and HOC clusters in line with its specific situation, ideally aligned with the information needs of its key customers. (For more information on TOCs and HOCs, see Chapter 3 Steps for establishing the emission intensity factors of a TOC or a HOC).

Further changes are the inclusion of:
- additional modes of transport (pipelines and cable cars)
- processes of hub equipment energy provision
- construction and dismantling of energy infrastructure (to be embedded within emission factors)
- start-up and idling of vehicles, pipelines, transshipment and (de)boarding equipment
- cleaning/flushing operations for pipelines
- combustion and/or leakage of energy carriers at vehicle or hub equipment level
- leakage of refrigerants used by vehicles and hubs
- amendments to reporting requirements

Figure 5

Scopes of accounting

The GHG protocol classifies emissions into three categories, Scope 1, 2 and 3. ISO 14083 avoids this distinction, as these scope differentiations are considered commercially driven distinctions. Instead, ISO 14083 distinguishes between direct and indirect emissions.

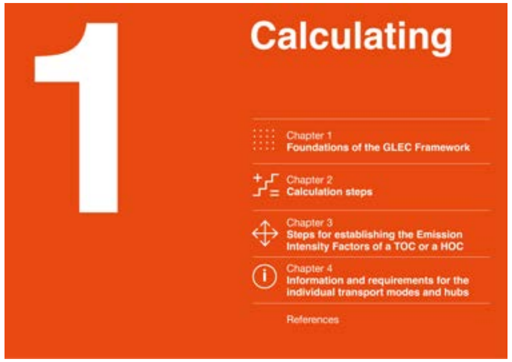


Scope 1 emissions include the direct emissions from assets that are owned or controlled by the reporting company. This includes the combustion of solid or liquid fuels purchased to produce energy, heat or steam for use in stationary or mobile equipment (e.g. vehicles, vessels, aircraft, locomotives, generators) and/or buildings associated with logistics sites (e.g. warehouses).

Scope 2 emissions are indirect emissions from the production and distribution of electricity, heat and steam purchased by the reporting company for use in its own logistics sites, electric vehicles or other owned asset requiring electricity.

Scope 3 emissions include the indirect emissions from assets that are not owned or controlled by the reporting company. This includes the transportation emissions required to move goods from suppliers to the reporting company and from the reporting company to the end customer; when these operations are not carried out by the reporting company. Scope 3 also covers the production and distribution of fuels burned in Scope 1, transport emissions embedded within purchased goods and services, product use and end-of-life.

How the Framework is organized



This document is divided into three primary sections. **Section 1** covers the calculations themselves. It is divided into Chapter 1, which provides an overview of the foundations and principles of the GLEC Framework; Chapter 2, which guides you through the steps in emissions accounting and Chapter 3, which explains how the emission intensity factors for TOCs and HOCs are established. Chapter 4 then provides additional information specific to each transportation mode and logistics hubs.

In **Section 2**, information on how to report and use calculation results is detailed. Chapter 1 of Section 2 provides information on reporting and disclosure, and Chapter 2 of Section 2 discusses ways in which carbon emissions can be used in decision-making and target-setting.

Chapter 3 gives an overview on the next developments targeted for further advancing freight transport emission calculation and reporting.

These first two sections are followed by **Section 3**, which holds all additional information for the data sourcing and calculation of GHG emissions, including real-life examples. Section 3 is divided into modules, with Module 1 listing Fuel Emission Factors, Module 2 Default Energy Efficiency and CO_2e Intensity Factors, Module 3 Refrigerant Emission Factors and Module 4 the Calculation Examples.

Information on references can be found at the end of each section. In **Section 4** you find Module 5, the guidance on "Calculating GHG transport and logistics emissions for the European Chemical Industry", as well as further information on units and conversion factors, a glossary and an overview on abbreviations used.

In practice, we know logistics accounting isn't always a linear process. You may find yourself going back and forth between sections to learn more about a certain mode, check the glossary or find data collection guidance. As new data becomes available, you may return to the Framework to refine calculations.

In any case, we hope the information you are looking for is here and, if not, we encourage you to get in touch and ask questions at www.smartfreightcentre.org

1

Calculating

Click on each icon to go straight to the chapter

Click here to go back to ***Structure of the document*** *page*

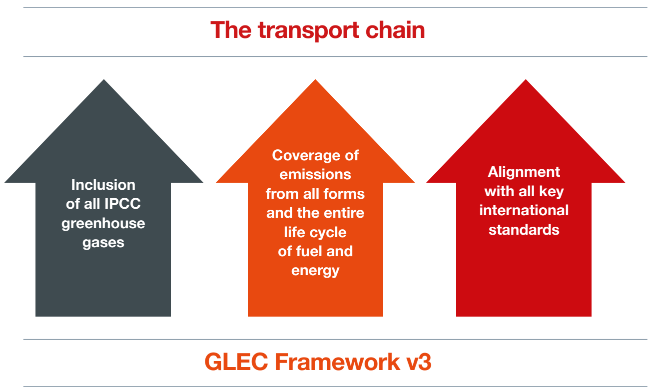
1 Chapter 1 Foundations of the GLEC Framework

Click here to go back to **Section 1** *contents page*

The foundations of the GLEC Framework are
1. Coverage of all operations in the transport chain
2. Inclusion of all Intergovernmental Panel on Climate Change (IPCC) greenhouse gases and climate pollutants (status spring 2023)
3. Coverage of emissions of all forms and the entire life cycle of fuel and energy
4. Alignment with all key international standards and emission reporting programs

Application of the GLEC Framework ensures an alignment with the basic foundations of logistics emissions accounting. The following chapter sets the foundation of the Framework, establishing the guiding principles and boundaries of the method.

Figure 1
The foundations of GLEC Framework v3



1. Coverage of all operations in the transport chain

The GLEC Framework aims to cover all freight transport and hub operations along the transport chain. It covers transport operations from national to international levels, anywhere in the world. Transshipment points along a journey, such as ports or warehouses where goods are transferred, stored or repackaged are also included. They are classed together as hubs. Furthermore, in line with the scope of ISO 14083, freight transport using pipelines and cable cars is added to this new GLEC Framework.

An organization's emission footprint from its freight transport and hub operations is the sum of emissions of all transport chains, taking into consideration emissions from the organization's own operations, purchased energy and subcontracted operations (Scope 1, 2 and 3) as well as emissions across the full fuel/energy life cycle. This applies to organizations that are transport providers as well as to their customers. The GLEC Framework v3 covers all of these.

Figure 2
Modes covered by GLEC Framework v3

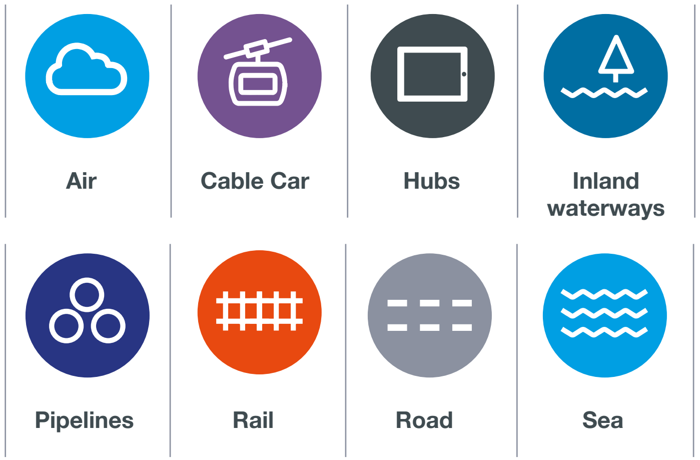
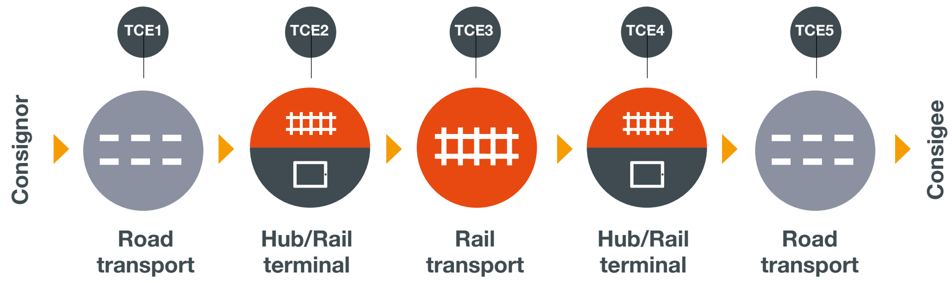


Figure 3
Example of a transport chain and its TCEs



Calculating emissions of transport chains based on TCEs' emissions

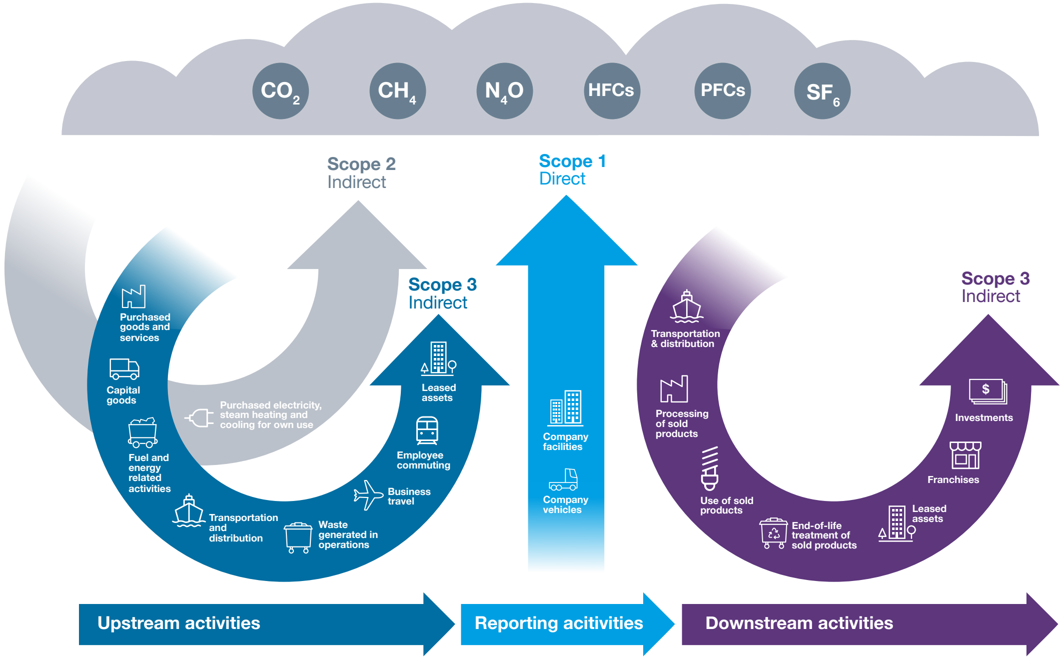
The starting point for the calculation of GHG emissions from transport operations is the identification of "transport chains." A transport chain always begins at the point where an item of freight is leaving a consignor, i.e. the point of departure of a shipment, which is often the sender or shipper. It ends when the item reaches its consignee, i.e. usually the receiver of the shipment, also defined as the point where the first non-transport related operation is carried out on the freight. Both consignor and consignee, can also be e.g. wholesalers, retailers or intermediaries.

The GLEC Framework, in line with ISO 14083, calculates emissions per transport chain. To ensure the consideration of empty operations and the accounting of the related emissions, the use of vehicles in transport chains is based on a round trip approach, both for calculation of emission intensities and for the allocation of emissions to consignments in shared transport. Therefore, the necessary return of a vehicle is included, even though freight is usually moved from consignor to consignee in one direction only. This ensures that all emissions related to a transport operation are included.

Once a transport chain is identified, it is subdivided intoTCEs. A TCE is defined by freight being carried by a single vehicle or transiting through a single hub. So, each change of vehicle or hub requires the identification of a separate TCE and therefore a separate calculation of its GHG emissions.

The GHG emissions calculated for each TCE are added to calculate the emissions of the entire transport chain (see Figure 3). Finally, the emissions from all transport chains within an organization's logistics supply chain are added to give the organization's total freight and logistics emissions.

Figure 4
Scope 1, 2, and 3 according to the GHG protocol[7]



Calculating emission for three scopes of an organization

The GHG Protocol also has as a key objective the consideration of all emissions from one organization, direct as well as indirect (see also Introduction to Logistics Emission Accounting, Info box Scopes of Accounting). For this purpose, it distinguishes between the organization's directly owned emissions (Scope 1), indirectly owned emissions (Scope 2), and indirect, not-owned emissions (Scope 3).

Emissions of an organization, e.g. an LSP or shipper, are calculated by adding up all emissions from transport chains that are used by the organization as well as its subcontractors. What is considered as Scope 1 or 3 depends on the organization's perspective. For a carrier or hauler, transport-related emissions are considered Scope 1, but for their customer (and LSP or shipper) these emissions are included in Scope 3.

ISO References: 1. Introduction and 3. Definitions, in particular 3.1.25 Transport Chain (TC), and 3.1.26 Transport Chain Element (TCE)

2. Inclusion of all IPCC greenhouse gases and climate pollutants

We are continuously learning about the relevance of new gases on the climate. The list of GHGs is therefore regularly updated. The GLEC Framework v3 is fully aligned with the current list of GHGs included in ISO 14083, the GHG protocol, the SBTi and the United Nations IPCC.[8] These GHG emissions are quantified in CO_2 equivalents (CO_2e). The reason for this is that carbon dioxide comprises the majority of GHG emissions for logistics operations and is thus the standard reference by which emissions are quantified. CO_2e is the common unit used to represent the global warming impact of the various GHGs according to their Global Warming Potential (GWP). Therefore, CO_2e is used as such throughout the GLEC Framework in line with ISO 14083.

GHGs included in ISO 14083 and the GLEC Framework v3 are:
- CO_2 Carbon Dioxide
- CH_4 Methane
- CFCs Chlorofluorocarbons
- HFCs Hydrofluorocarbons
- NF_3 Nitrogen trifluoride
- N_2O Nitrous oxide
- PFCs Perfluorocarbon
- SF_6 Sulphur hexafluoride
- SO_2F_2 Sulfuryl fluoride

Black carbon

Black carbon is the term used for particulate matter emitted from partial combustion of complex hydrocarbon fuels. As such, it is prevalent in freight transport which often relies on such fuels. It is a short-lived climate pollutant with potent global warming potential and a negative effect on human health. The GLEC Framework provides a separate approach to calculate emissions from black carbon in "The Black Carbon Methodology for the Logistics Sector." This approach for the calculation of black carbon was developed by the Smart Freight Centre, the UN Climate and Clean Air Coalition, the International Council on Clean Transportation and the US Environmental Protection Agency's SmartWay team as an optional element to the GLEC Framework v2 and is also included as an optional ("informative") Annex to ISO 14083.[9]

The Black Carbon Methodology provides a way to calculate emissions from black carbon following the same principles as the GLEC Framework.

Learn more at https://www.ccacoalition.org/en/resources/black-carbon-methodology-logistics-sector

3. Coverage of emissions from all forms of fuel and energy sources

The GLEC Framework accounts for all relevant logistics emissions from transport operations, as well as the emissions resulting from the energy or fuel provision related to these operations. It includes the energy consumption of all transport operation related processes, regardless of whether this energy consumption is caused by combustion, by fuel leakage or by refrigerant leakage. For hub operational processes, all handling, on-site transportation and transshipment as well as (dis)embarking equipment and facilities, including heating and temperature control are considered. Covered by the GLEC Framework v3 are therefore:

- processes of vehicle operations;
- processes of hub equipment operation (including operations of forklifts, pallet trucks, etc.);
- processes of vehicle energy provision;
- processes of hub equipment energy provision;*
- any loaded and empty trips made by vehicles, including diversionary and/or out-of-route distance;
- construction and dismantling of energy infrastructure;*
- start-up and idling of vehicles, pipelines, transshipment and (de)boarding equipment;*
- cleaning/flushing operations for pipelines;*
- combustion and/or leakage of energy carriers at vehicle or hub equipment level;*
- leakage of refrigerants used by vehicles and hubs;*

* = new additions since GLEC Framework v2

As the GLEC Framework v3 includes all modes of transport, as well as any hubs which are part of the transport chain, energy consumptions of contractors and any form of subcontractors, as well as their combustion and leakages, are included, independent of who is carrying out these operations.

Ensuring energy provision emission inclusion

To ensure the best emission calculation result for the available energy consumption data, the best accessible or recommended (e.g. nationally prescribed) GHG emission factors are to be used. This ensures the inclusion of GHG emissions resulting from upstream processes and those of the energy carriers. The following activities are to be included for the respective energy-carrier:

- For solid, liquid and gaseous energy carriers: the production and dismantling of the infrastructure of the energy source; extraction or cultivation of primary energy; chemical processing; transport and distribution (including pipeline) of energy at all steps of the production of the energy carrier.
- For electricity: extraction, processing and transport of primary energy; power generation; power generation infrastructure, e.g. solar panel or wind turbine manufacture; and grid losses associated with transmission and distribution of electricity.

Should the recommended or best available GHG emission factors not include the production and dismantling of the infrastructure of the energy source, it is important to note this in the emission reporting. Omission of any processes from the calculation of emissions is not permitted. Where any omissions are made despite this general rule, these must be stated and justified in the report (see Section 2 Chapter 1 Reporting Emissions).

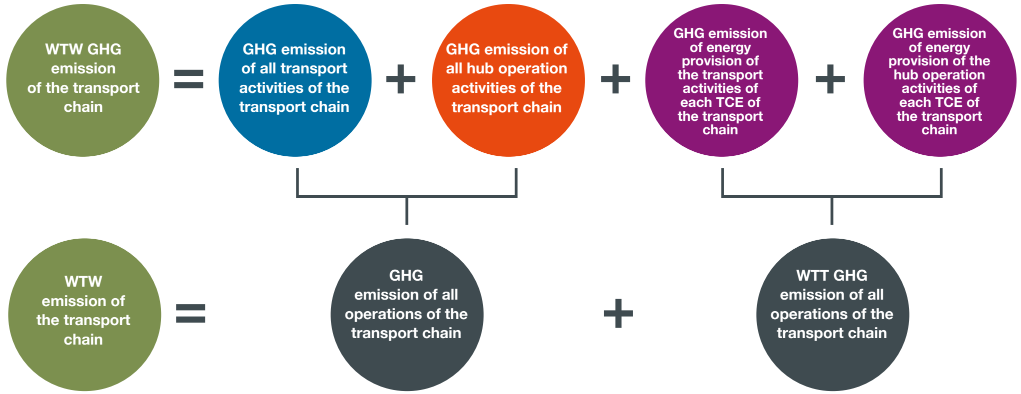
Figure 5

Calculating WTW emissions of a transport chain

WTT emissions within the GLEC Framework v3 and ISO 14083 are referred to as energy provision emissions. WTT refers to a "method used to calculate the energy consumed and GHG emitted from the moment of production of a transport fuel (petrol, diesel, electricity, natural gas) to the moment of fuel supply (at the recharging or refueling station.)"[9]

TTW emissions, also referred to as "tank-to-wake" emissions, are referred to as transport operations activity emissions within the GLEC Framework v3 and include also hub operation activity emissions. TTW refers to a method used to calculate the energy consumed and GHG emitted from the point of transmission of transport fuel to the vehicle (at the recharging or refueling station) to the moment of its discharge (consumption of the fuel or electricity, while on the move.)"[9]

WTW or "well-to-wake" emissions are the sum of WTT and TTW emissions. Together they comprise the total emissions of a TCE. The GLEC Framework v3, like the ISO 14083, is based on the WTW concept, i.e. the inclusion of the total emissions of a transport chain and its elements.



Calculating emissions across the fuel/energy life cycle

ISO 14083 and the GLEC Framework v3 require that calculating emissions of a transport chain covers the full fuel/energy life cycle. This includes both emissions from energy and fuel consumption TTW as well as their provision WTT, which combined are WTW emissions (see Figure 10 Calculating WTW emissions of a transport chain). Consequently, an organization that is using the GLEC Framework v3 needs to include WTW emissions from fuel/energy used in emission calculation for all transport chains so that both emissions from transport operations and related energy provision are taken into consideration.

Special considerations for alternative energy sources

To cover the entire emissions of a transport or hub operation activity, energy provision (WTT) emissions need to be included. For alternative energy sources this can be challenging.
It is particularly relevant where GHGs are emitted in the WTT phase (e.g. from hydrogen and electricity) or where CO_2 emitted in combustion is considered to be balanced by carbon sequestration of CO_2 in the feedstock production phase (biofuels.)

For this reason, as biofuels and renewable energy sources gain a larger market share, ISO 14083 gives guidelines for the inclusion of energy provision emissions.

Biofuel

Because biofuel production methods vary more widely than conventional fuels due to different feedstock and associated processes, there is no single standard recognized emission intensity value for the energy provision (WTT). Biofuel providers will be able to provide this value directly; other sources may be life cycle databases, government agencies and green freight programs. Annex J of ISO 14083 sets out the elements to be considered in the calculation of the upstream processes and emission relevant activities.

Biofuel in Conventional Fuels

Conventional fuels often include a small percentage of biofuel; this can be reflected within the GLEC Framework emission calculations with relatively low uncertainty.

Electricity

When calculating the emissions from electricity consumption, the source of energy used to create the electricity has to be considered. Therefore, specific emission factors are used to convert electricity use to CO_2e, based on the source(s) of energy used to generate the electricity used. Emission factors are expressed as mass of CO_2e released per kilowatt hours (kWh).

The electrification of transport systems with renewable energy sources is seen as a key strategy for a successful and meaningful decarbonization of the transport sector. To track emissions from electrified operations, companies must gather electricity emission factors for countries or regions.

Growing investment in renewable energy technologies means that electricity emission factors in some countries are changing rapidly. Therefore, organizations' databases should be updated regularly.

The International Energy Agency (IEA) compiles and publishes annually updated lists of national electricity emission factors, and we recommend companies use this as a source of information. The factors are available for purchase from the IEA website.

IEA electricity emissions factors include data for the following items:

- gCO_2/kWh produced during electricity generation
- gCO_2e/kWh contribution from CH_4 produced during electricity generation
- gCO_2e/kWh contribution from N_2O produced during electricity generation
- Correction for transmission and distribution losses induced emissions (gCO_2/kWh)
- Correction for trade induced emissions (gCO_2/kWh)

To ensure a full WTW approach, all these elements must be included in the national electricity emission values. (ISO 14083 Annex J.3 gives detailed guidance on the application of electricity emission factors, especially on location-based vs. market-based factors.)

Hydrogen Fuel Cells

At the time of publication, there is no widely accepted value for hydrogen fuel cell WTT emissions. Please refer to the producer for more information about hydrogen production and distribution.

4. Alignment with key international standards and base methodologies

At the core of the GLEC Framework is the alignment of global efforts in carbon accounting for logistics operations. It builds on international standards and harmonizes practices and guidelines for green freight programs developed by industry, experts, practitioners and governments around the world. This improves compatibility and comparability of results, while streamlining data collection and reporting efforts.

The following table gives an overview of the key international standards and methodologies with which the GLEC Framework v3 is aligned (Table 1).

Exclusions from the GLEC Framework

Not included in the calculation of GHG emissions are:
- the production and supply processes of refrigerants;
- waste produced;
- processes at the administrative (overhead) level of the organizations involved in the transport services;
- processes for the construction of vehicles and transport or transshipment devices (e.g. embedded GHG emissions associated with vehicle production);
- maintenance of vehicles or transshipment and (de)boarding equipment and the scrapping of these;
- processes of construction, service, maintenance and dismantling of transport infrastructure used by vehicles, e.g. roads, inland waterways or rail infrastructure, or transshipment and (de)boarding infrastructure;
- businesses co-located within a hub such as retail and hospitality services, whose functions are severable and incidental to the transportation operation of the hub.

Attention: the outcomes of any form of carbon offsetting actions or GHG emissions trading are excluded. These are not part of the transport chain GHG emission calculation or eligible for tracking progress against science-based targets for the transport sector, although they can be included in the subsequent environmental reporting and claims of an organization depending on the basis upon which the claims are being made.

ISO References: 5.2 System boundaries, in particular 5.2.2 Processes included, 5.2.3 Application of cut-off criteria, 5.2.4 Processes not included, 5.2.5 Optional processes, Annex J (normative) Additional requirements and guidance for GHG emission factors.

Table 1
Overview of emissions accounting and reporting methods which are harmonized in the GLEC Framework

Alignment level	Norm/Standard/Protocol
High-level alignment over entire GLEC Framework v3	ISO 14083
	Greenhouse Gas Protocol v1 • Corporate Accounting and Reporting Standard • Scope 2 Guidance, and Corporate • Value Chain (Scope 3) Accounting and Reporting Standard
	IPCC Good Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC Guidance)
	SBTi
Air	International Air Transport Association Recommended Practice 1678 (updated 2022)[10] and RP 1726 2022[11]
	SmartWay Air Cargo Tool[12]
Cable Cars	ISO 14083
Hubs	Guide for Greenhouse Gas Emissions Accounting at Logistics Hubs v2[13]
	Guidance for Greenhouse Gas Emission Footprinting for Container Terminals[14]
	SmartWay Barge Carrier Tool[15]
Inland Waterways	GHG Emission Factors for Inland Waterways Transport[16]
	International Maritime Organization Ship Energy Efficiency Operation Index[17]
Pipelines	ISO 14083
Rail	EcoTransIT World: Environmental Methodology and Data Update 2024[18]
	SmartWay Rail Carrier Tool[19]
Road	4.2 2022 (Europe[20]), SmartWay Road Carrier Tool[21]
Sea	International Maritime Organization Ship Energy Efficiency Operation Index[17]
	Clean Cargo Carbon Emissions Accounting Methodology[22] (Currently applies to container shipping only)

Chapter 2
Calculation steps

Click here to go back to **Section 1** *contents page*

An organization's freight and logistics emissions are the sum of emissions from transport chains, which in turn consists of multiple TCEs. The GLEC Framework v3 takes a bottom-up approach and starts with TCEs. This chapter explains the calculation steps for emissions for each TCE.

The calculation of GHG Emissions is carried out in three steps:
1. Calculate the transport activity of the TCE.
2. Identify the applicable emission intensity of this TCE by establishing the relevant TOC or HOC applicable.
3. Calculate the TCE's emissions by multiplying the transport activity with the emission intensity value.

Figure 1
Calculation steps

Calculation of the activity of the TCE

↓

Identification of the applicable emission intensity for the TCE

↓

Calculation of the TCE's emission

These steps are explained in detail on the next page

Calculation of the activity of the TCE

Calculation of transport activities

Transport activity of a TCE is expressed in tonne-kilometers (tonne-km or tkm). Therefore, to calculate the transport activity of a TCE, you need to establish the freight mass that is transported as well as the distance. Freight mass is quantified in metric tons (1 metric ton = 1000 kg) or in kg. If other units of weight are used, these must be clearly stated and communicated, including in the reporting. In some cases, different approaches can be necessary:

- If the weight of the transported freight is known in Twenty-foot Equivalent Units (TEUs) only and not in kg or metric tons, an average weight of 10 tonnes per TEU can be assumed. If the containers are light, then 6 tonnes can be used as approximation, and if they are heavy, an average weight of 14.5 tonnes can be assumed.
- For special transports, e.g. parcel and post operations or other containerized special freight, different weight units can be applied. Such different approaches will need to be clearly documented. (See ISO 14083 chapter 5.4.2 for details.)

The distance of transport activities is quantified in km and stretches from consignor to consignee. The use of different units for distance is also possible here if these are clearly stated and communicated, including in the reporting. The transport activity distance is either the shortest feasible distance (SFD), or the Great Circle Distance (GCD) (see text box on distances).

The resulting value is expressed in tonne-kilometers. One tonne-kilometer represents one tonne of cargo moving for one kilometer. The tonne-kilometer provides a useful and consistent “common denominator” to express efficiency for freight transportation just as distance does in a simple fuel efficiency metric such as a “miles per gallon” or “liters per 100km” figure.

Capturing shipment mass and distance in an accurate and consistent manner can be surprisingly difficult to achieve, largely because it is a concept that is not yet widespread at the organization level. Shippers may not be able to acquire this information from their carriers, and carriers may struggle to correlate their transport activity with actual energy consumption. The following paragraphs give guidance on how to establish the shipment weight and transport distance.

Capturing shipment mass data

In the GLEC Framework, the basis for quantifying the amount of goods being transported or handled is the actual shipment mass (often colloquially referred to as weight). Mass weight can be consistently applied across the supply chain, as this approach is in line with the key approaches for transport operation emission calculation. Volume, density and other metrics may be used by companies for analysis and, in some cases, reporting, but mass should be communicated alongside these metrics to ensure consistency along the multimodal supply chain.

The mass calculations must include the product and the packaging provided for transport by the shipper. However, calculations must not include additional packaging or handling equipment used by the carrier or LSP, such as pallets of the containers used by the transport operator and specific for the transport operation. Mass information may be found on invoices or bills of loading within a Transport Management System (TMS), etc.

ISO References: 5.4.2 Freight Transport

Different approaches and considerations apply when establishing the activity of transport of hub operations.

Calculation of the activity of the TCE

↓

Identification of the applicable emission intensity for the TCE

↓

Calculation of the TCE’s emission

Figure 2
Calculating the transport activity of a TCE

Transport Activity of a TCE in tkm = [Mass of shipment 1 in tonnes X Transport Activity Distance of shipment 1 in km] + [Mass of shipment 2 in tonnes X Transport Activity Distance of shipment 2 in km] +...+ [Mass of shipment n in tonnes X Transport Activity Distance of shipment n in km]

Capturing transport distance data

While it may seem simple to establish the distance of transport operations, especially considering developments in GPS and telematics systems, quantifying distance consistently and accurately is part of what makes logistics emissions accounting a complicated endeavor.

Many shipments are moved via multiple transport legs and modes, and some are handled by multiple carriers. Sometimes there are intermediate stopovers in locations that reflect a carrier's transport network rather than the most direct route; sometimes routes are modified due to weather, tides, construction or traffic conditions, information that may or may not be known to other parties.

This is further complicated by goods traveling on shared transport assets, where shipments are consolidated to increase vehicle loading and hence efficiency but may lead to longer distances being traveled than would be the most direct route for an individual shipment.

The GLEC Framework is based on the concept of transport chains and TCEs (see also Section 1 Chapter 1 The Transport Chain). The distance of a transport chain is measured from the point where the shipper hands goods over to the carrier, so when leaving the consignor, and ends with the hand-over of the shipment to another carrier or the consignee. The distance of a transport TCE is defined by freight being carried by a single vehicle (hub TCEs are associated with zero distance), with each change of vehicle or hub requiring the identification and calculation of a separate TCE. Distance information must be collected for each TCE, either through direct measurement or estimation. Three common approaches to establishing distance are used within the GLEC Framework: SFD, GCD and actual distance corrected by a Distance Adjustment Factor (DAF).

Guidance for distance calculation for each mode is provided in the mode specifications in Section 1 Chapter 4.

Once mass and distance are established per TCE, the transport activity can be calculated, preferably in in tonne-kilometers. This is done by multiplying the mass of a consignment, quantified in tonnes, by the transport activity distance of this specific consignment, measured in kilometers. The resulting tonne-kilometer brings together weight and distance as the metric for freight transport activity. It is important to calculate the transport activity per shipment of each TCE separately. In line with ISO 14083 a shipment is defined as an "identifiable collection of one or more freight items (available to be) transported together from the original shipper to the ultimate consignee."[9] For establishing the tonne-kilometer for an entire TCE, the tonne-kilometer of each shipment is then added in a next step.

Distances

SFD
SFD represents the shortest practical route between two places taking into account the real operating conditions, such as the physical restrictions of a vehicle (e.g. weight and height), road type, topography and congestion and is typically found using route planning software. For most situations, it is the recommended approach. (It is important to keep in mind that SFD does not reflect the shortest distance if you are willing to risk shortcuts that might be unsuitable for your vehicle type or congestion typical of a city center.)

GCD
Also known as direct distance or "as the crow flies," GCD is an approach to distance measurement that is currently focused on air transport. It is the shortest distance between two points by crow-line, including the curving of the earth. While this is a compelling option for harmonizing distance measurement across multimodal supply chains, it is currently not widely known or accepted outside of the aviation industry.

Actual distance corrected by a DAF
Where neither SFD nor GCD are available, the actual distance in combination with a DAF can be used. Based on odometer readings or knowledge of the actual route, the true actual distance is generally only known by the carrier. In most cases, a shipper or LSP does not have access to the actual distances traveled by its subcontracted carriers. The application of the DAF enables compatibility between different elements of the GHG emission calculations – specifically if an emission intensity is calculated based on actual distance, whilst the end user only has access to transport activity based on the SFD.

ISO References: 1. Introduction and 3. Definitions, in particular 3.1.27 Transport distance and 3.3.4 Distance adjustment factor

Calculation of hub operation activities

Hub operation activity is quantified based on the tonnes throughput of shipments leaving the center, i.e. outbound freight.

Inclusion of packaging into the freight's weight

It is important, that you always include the mass of the packaging provided by the consignor when establishing the weight of the freight.

Instead, the weight of packaging necessary for transport or hub operations, such as the mass of pallets or of containers, are not to be included. Be aware though, that, when empty containers are transported, they are considered as the freight. In these cases, the empty container's weight equals the mass of the transported and handled freight.

Identification of the applicable emission intensity for the TCE

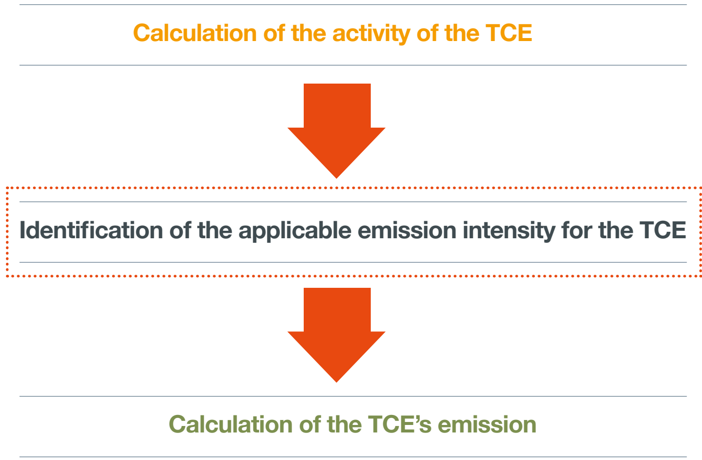
In order to identify the emission intensity applicable for a specific TCE, it must be established to which TOC or HOC this TCE can be linked. A TOC is a group of transport operations that share similar characteristics and a HOC is a group of hub operations that share similar characteristics, in a defined period, which is typically one calendar year unless specified otherwise and explained in the related reporting.

These shared characteristics can be based on various criteria, such as the mode of transport, journey type, type of cargo being transported, temperature-controlled transport, specific trade lanes, the nature of freight carried, or the nature of the contractual agreement. (Further suggestions for the characteristics which can be used to establish TOCs can be found in the transport mode specific chapters of Section 1 Chapter 4). Transport is rarely carried out in isolation for each piece of freight or shipment. Instead, it is usually bundled to optimize space and time. The identification of TOCs and HOCs also contributes to avoiding the need for calculating emission intensity for each and every individual transport.

Both TOCs and HOCs, can have different levels of granularity, depending on the analysis needed and the data available (see also Info box Granularity of TOCs and HOCs). ISO 14083 suggests as examples (see also Info box Recommendations Regarding Granularity of TOCs and HOCs):

- TOC of a single vehicle on a single journey
- TOC of a single vehicle in multiple schedules
- TOC of a specific vehicle type in a single journey
- TOC of a specific vehicle type in multiple schedules
- TOC of a specified group of vehicles in a single schedule
- TOC of a specified group of vehicles in multiple schedules
- Hubs or terminals with transshipment and/or warehousing as relevant services, etc.

Based on this emission intensity value of the relevant TOC or HOC, the emissions of an individual transport chain element can then be calculated.



Demonstration of tonne-kilometer (tkm) calculation approaches

Shipment	Tonnes	Kilometer	Tonne-kilometer
1	10	1,000	10,000
2	40	400	16,000
3	400	300	120,000
4	10	700	7,000
5	60	1,200	72,000
Total tkm			225,000

These TOC or HOC specific emission intensities can either be calculated using primary data or they can be modeled, or default values can be applied, depending on which data is available (see Info box Data Categories). It is important to remember that only good quality primary and modeled data are representative of actual conditions of the analyzed transport operations and transport chains. Default factors are just best-case approximations to the actual situation. Using default factors limits the ability to use carbon emissions as a KPI to evaluate carriers, routes and other operational differences.

Recommendations regarding the granularity of TOCs and HOCs

Consider fleet compositions.

• If a carrier specialized in temperature-controlled services runs a fleet of 40-tonne trucks, it is possible that there is not much differentiation within the services offered. In this case the carrier can establish and use a single emission intensity for the whole fleet, i.e. the whole fleet represents one TOC ("TOC of a specific vehicle type in multiple schedules.")

• If a carrier fleet consists of different vehicle sizes offering different service types, the fleet specification needs to be adjusted accordingly ("TOC of a specified group of vehicles in multiple schedules"). Such vehicle groups may be split into further clusters, e.g. linehaul and last mile delivery, which still contain multiple schedules but each with similar emission intensities. If the services are not comparable and have different emission intensities, a further differentiation into separate TOCs is needed, such as local vs. regional, densely populated urban vs rural areas, etc.

Align TOC and HOC definitions with those of the main stakeholders of the offered transport services. If a customer needs to add up emissions from different providers, the customer may need to use TOCs and HOCs which all providers apply in a comparable and consistent way.

Separate clusters for some customers. If a customer wants to know the impact on the emissions of the change of the energy source used for a transport service, the concerned group of vehicles in the specific (group of) schedule(s) needs to be clustered separately into a TOC (or HOC respectively). Then information about those specific transport services can be generated to understand the impact of such a change. (This would be particularly important for insetting projects.)

Distance clusters in air transport. There is no linear dependency of carbon intensity and the distance of a flight. Take-off and landing have a strong impact on aviation emissions and, therefore, TOCs must take into consideration distance clusters (short- and long-haul flights). The aircraft size (capacity) and type (freighter vs. passenger aircraft) are also relevant and therefore need to be considered as well. Finally, if Sustainable Aviation Fuel use is related to specified port pairs (chartered flights), the granularity level of the related TOC needs to be considered ("a specific vehicle type in a specific schedule.")

Transport operations can never be split between two different TOCs, as each transport operation must be allocated to one specific TOC. On the other hand, a TOC can include different energy carriers for propulsion, or also different types of activity with different transport requirements, e.g. diesel and LNG vehicle operations can be combined. To facilitate transparency, the following types of TOC exist, and each TOC must be identified as one of them:

- TOC of freight only (general case)
- TOC of freight only with multi-temperature vehicles
- TOC of vehicles with passenger vehicles and freight (e.g. ferries)
- TOC of any other case

TOCs should reflect entire round trips made by the vehicles. The round trip does not require an immediate return to the point of origin, and it can include a group of sequential journeys that start and end at the same point.

- Include all loaded as well as empty trips which are part of the round trip to balance out GHG emissions within asymmetric transport flows.
- Where empty containers or pallets are transported on behalf of a transport service purchaser, e.g. for relocation purposes, they become a consignment in their own right.
- An exception is when a vehicle or vessel is chartered for a one-way journey, which can be specifically identified within the transport operator's network as well as in the transport purchaser's system.
- Pipelines are exempt from the round-trip concept, due to the nature of their use and infrastructure.

HOC factors. For the identification of a HOC, the factors that affect the scale, composition and characteristics of the operations carried out need to be taken into consideration, e.g.:

- Number and type of hub operations contributing to the HOC, e.g. handling of freight, (un)loading, (de)boarding, transport on-site;
- Nature and consistency of the hub operations included in the HOC, e.g. electrified or non-electrified;
- Inbound and outbound transport mode and relevance of intermodal change;
- Any processes essential for maintaining the condition of the freight or ensuring passenger health and safety;
- Nature of freight handled (e.g. palletized, containerized, piece good);
- Additional, energy consuming and emission-causing activities related to the operations, e.g. temperature control, repackaging, etc.

Hub operations can never be split between two different HOCs, as each hub operation must be allocated to one specific HOC. A hub may perform hub operations that form part of a different HOC. (Further suggestions for the characteristics which can be used to establish HOCs can be found in Section 1 Chapter 4 "Information and Requirements for the Individual Transport Modes and Hubs")

ISO References: 7. Quantification Actions, in particular 7.1 General, 6.3 Transport operation categories (TOCs) and hub operation categories (HOCs)6.3.2.1 Categorization of transport operations into TOCs and 6.3.3.1 Categorization of hub operations into HOCs

Data categories and quality

The type of data used has a direct influence on the accuracy of the results, and therefore on the degree to which results can be used, to inform, analyze the efficiency of transport operations, track emission reduction actions, etc. It is therefore important to gather high-quality, consistent data, and to specify the type of data and calculation approach used. Specific guidance on collecting high-quality data for transportation is provided by US EPA SmartWay.[23]

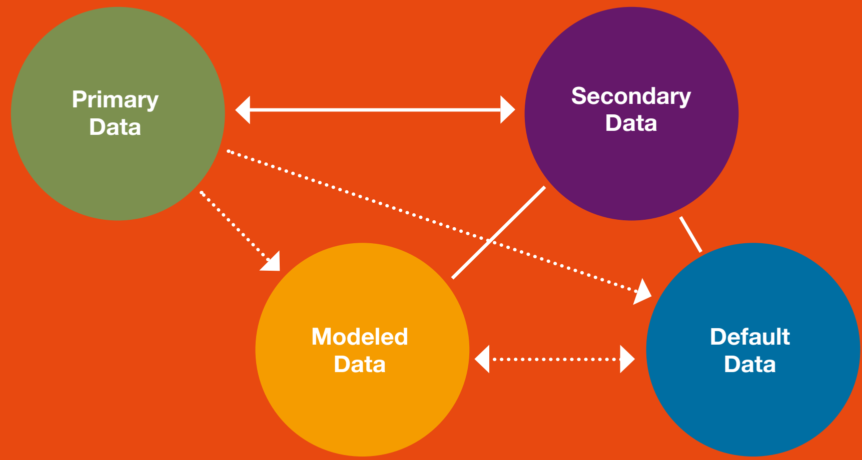
In line with ISO 14083, the following data categories are distinguished:
- Primary data
- Secondary data
  - Modeled data
  - Default data

Primary data. Primary data is the "quantified value of a process or an activity from a direct measurement or a calculation based on direct measurements."[9] Good quality primary (actual) data is what should be used by a transport or logistics site operator to calculate its Scope 1 GHG emissions. It is also the type of data transport buyers should aim to collect from carriers for their Scope 3 emissions accounting. Primary data can range from highly precise information, such as from fuel receipts or annual energy consumption spend, to aggregated values that reflect energy consumption or emission intensity for a year's worth of vehicle movements.

Secondary data. Secondary data is all data that is not primary data. It can be differentiated into modeled data and default data.

Modeled data Modeled data is data which is established using a model "that takes into account primary data and/or GHG emission relevant parameters of a transport operation or hub operation."[10] Companies and tool providers model energy consumption and emissions using available information on types of goods consignment sizes, journey origin, destination and intermediate handling locations, and any information about the vehicles used, load factors, etc. The accuracy of the model's outputs will depend on the level of detail that is available about the transport operation and the assumptions made, as well as the model's algorithms. In general, assumptions that are made that rely on default data, rather than primary data, will increase the uncertainty of the output. It is important to ensure that the methods embedded into tools for modeling data are aligned with the GLEC Framework.

Default data. If no other data is available, the last resort is to use default data representative of average industry operating practices. Default data can provide a general indication of emissions, illuminating hotspots, and can offer a structure for prioritizing further data collection to improve accuracy. To help companies that are starting out on a journey to high quality logistics emissions calculations, Section 3 Module 2 of the Framework presents a wide range of default data with varying levels of precision that provides a general indication of emissions. Communication with suppliers can help to better understand the actual conditions to pick the most appropriate default factors. Specific information about the vehicle fleet, energy type, temperature control, topography, etc. can improve accuracy. The source of any default data used must be clearly specified.



The GLEC Framework is intended to align methodological aspects as far as is possible. GHG emission calculations rely not only upon a sound methodology but also good quality input data. The type of data used can influence the accuracy of the results, and the degree to which results can be used to inform and track emission reduction actions. Thus, it is important to specify the type of data and calculation approach used.

It is recommended that companies consider appointing appropriately qualified, independent third-party entities to conduct assurance of the input data and any assumptions embedded within the calculation process. Though not required, third party assurance provides an independent assessment with the aim of establishing confidence or trust around a process and/or declared output.

To support this process, SFC has worked with GLEC members and consultees to develop an assurance scheme to accompany the GLEC Framework and ISO 14083. The purpose is to provide a common framework for transport operators, their customers and assurance providers to assess claims made about the adoption and implementation of and calculation outputs from the GLEC Framework. Details are available online at www.smartfreightcentre.org.

ISO References: 3.3.3 Data categories

Calculation of the TCE emissions

Calculation of the activity of the TCE

Identification of the applicable emission intensity for the TCE

Calculation of the TCE's emission

To calculate the emissions of an individual TCE, you multiply the transport activity or hub operation activity by the GHG emission intensity of the related TOC or HOC respectively:

The approaches for transport activities and hub operation activities in this last step vary slightly, since the calculation of emissions of transport operation TCEs often requires a correction by a DAF. This DAF is needed when a different distance type is used for the distance of the quantification of the TCE's transport activity and for the quantification of the emission intensity of the related TOC.

For transport activity TCEs:

GHG emission of the transport activity of this TCE = Transport activity in tkm X GHG emission intensity of the related TOC X DAF between transport distance type used for the TCE and TOC

For hub operation activities TCEs:

GHG emission of a specific hub operation activity of the TCE = Specific hub operation activity of the TCE X GHG emission intensity of the related TOC

The GHG emissions of transport operations have two components: an energy provision component and an operation component. This allows the operation and energy provision emissions to be calculated separately. To obtain the total GHG emissions of the TCE, the GHG emissions of the transport operation and the GHG emission of the energy provision are added together.

ISO References: 10 Calculation of GHG emission for a transport TCE and 11 Calculation of GHG emission for a hub TCE

For transport activity TCEs:

Total GHG emissions of the transport activity TCE = **GHG emission of the transport activity** of this TCE + **GHG emission of the energy provision for the transport activity** of this TCE

For hub operation activities TCEs:

Total GHG emissions of the hub operation TCE = **GHG emission of a specific hub operation activity** of this TCE + **GHG emission of the energy provision for the operation activity** of this TCE

Colour and shape codes

Blues - Transport related calculations and values
Oranges - Hub-related calculations and values
Yellows - Energy-provision related values
Green - Transport chain related values
Greys - All other: grey or white

☐ Sums and multiplication products of your calculations
○ Values to be sourced

Adding up of transport chains to networks and transport use of organizations

A transport chain's total GHG emissions are calculated by adding the GHG emissions for each of the TCEs that comprise it. The GHG emissions of the vehicle operations, the vehicle energy provision allocated to each TCE, the hub equipment operations and the hub equipment energy provision allocated to the TCEs of the specific transport chain are added up to give the total.

Similarly, if you want to calculate the emissions of an entire organization, you add all transport chains that constitute your network.

Calculations such as these can be used for corporate reporting or for a defined subset of your business, by aggregating different transport chains and the relevant elements (i.e. transport and hub TCEs.) What is important, is that GHG emissions for each TCE are calculated individually first.

ISO References: 12 Results, including 12.1 For one transport chain and 12.2 For a set of transport chains

GHG emissions of a transport chain = **GHG emissions of the transport activities** of the transport chain + **GHG emissions of all hub operation activities** of the transport chain + **GHG emissions of the energy provision of each transport activity** of the transport chain + **GHG emissions of the energy provision of all hub operation activities** of the transport chain

= **Total GHG emissions of all the transport activities of all consistuting TCEs** + **Total GHG emissions of all the hub operation activities of all consituting TCEs**

1 Chapter 3 **Steps for establishing the emission intensity of a TOC or a HOC**

A TOC is a group of transport operations that share similar characteristics and a HOC is a group of hub operations that share similar characteristics, in a defined period, which is typically one calendar year unless specified otherwise and explained in the related reporting. Establishing the emission intensity for TOCs and HOCs therefore contributes to improving the transparency of the efficiency of your transport operations.

General considerations regarding the establishing of emission intensity for a TOC or a HOC

For calculating a TCE's GHG emissions, you need to establish the related TOC or HOC emission intensity (see also Chapter 3 "Establishing the relevant TOC or HOC").

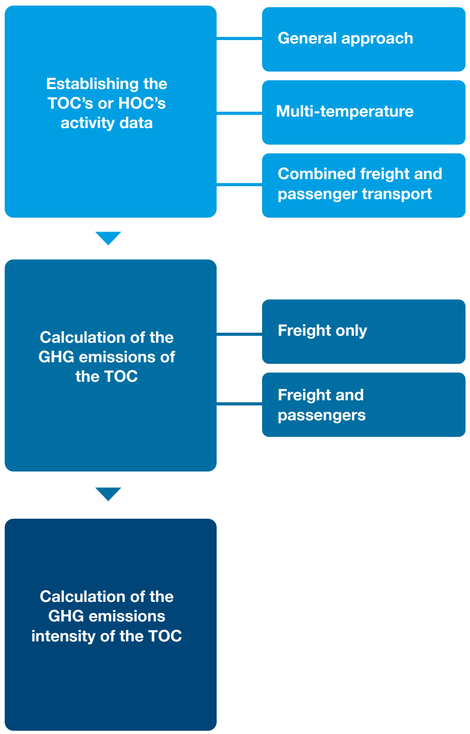
The GHG emission intensity relates GHG emissions to the transport or hub operation activities that caused them. It can be expressed as:

- CO_2e per tonne-kilometer (or equivalent units) for transport
- CO_2e per tonne throughput (or equivalent units) for freight hub throughput

The following steps are required to establish a TOC's or HOC's emission intensity:

1. Establish the TOC's or HOC's activity data.
2. Establish the energy use, related emission factors and calculation of the GHG emissions of the TOC or HOC.
3. Calculate the emission intensity of the TOC or a HOC

Click here to go back to ***Section 1*** *contents page*



You can use the following forms of data for establishing the emission intensity of a TOC or HOC (see also Chapter 2: Info box Data Categories and Quality):
A. Using primary data
B. Calculating data with a model
C. Selecting a value from a database of default values
D. Collecting a value from a contracted operator that has used primary data (A) or modeled data (B)

For transparency and to obtain results that reflect the specific efficiency and emissions of a TOC or HOC, you should use primary data (option A) whenever possible. Especially as a transport or hub operator you should use primary data to maximize transparency on your operations. Where primary data is not available, modeled data (option B Calculating data with a model) should be prioritized over default values (option C Selecting a value from a database of default values). It is very common that a combination of the different types of data is needed as primary data is not always available. In all cases it is important that the data is representative and of the highest possible accuracy for the TOC or HOC and the purpose for which it is used.

Data sources for calculating emission intensities

A. Using primary data
When using primary data, the following steps must be carried out:
1. All transport and hub operations that are performed and are related to the GHG emission quantification need to be identified.
2. The TOCs and HOCs for these operations must be established.
3. For each TOC and HOC the GHG activity data from each GHG source (quantity of energy consumed, refrigerant leakage, etc.) must be identified, quantified and converted to GHG emissions; the sum of all the GHG sources equals the GHG emissions for the TOC or HOC. Then the corresponding transport or hub operation activity for the TOC or HOC are calculated, and finally the GHG emission intensity for the TOC or HOC. For a detailed description of the mode-specific quantification actions at TOC or HOC level see Section 1 Chapter 4 "Information and Requirements for Individual Transport Modes and Hubs."

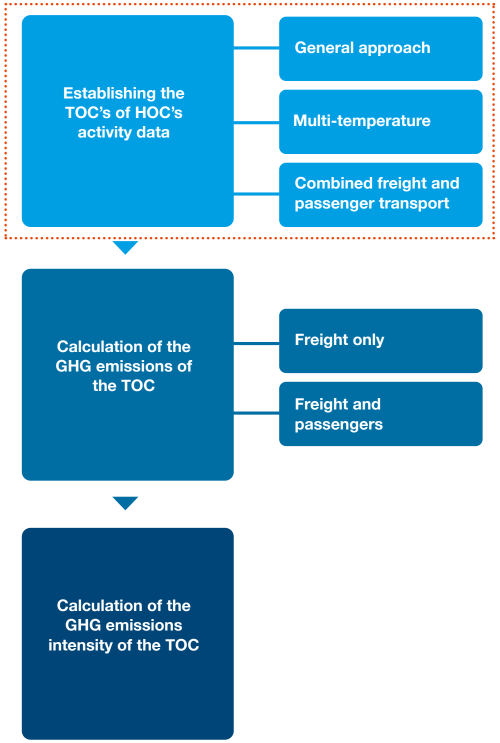
B. Calculating data with a model
You can find detailed information on calculating GHG emission intensities by means of a model in Section 3 Module 2 "Default Energy Efficiency and CO_2e Intensity."

C. Selecting a value from a database of default values
Where default data needs to be used, the data chosen must have the closest match between the default GHG emission classification and the characteristics of the TOC or HOC concerned. If no clear match can be identified, the sources used to fill the gap and the reasons for their choice must be fully documented (Section 2 Chapter 1 "Reporting Emissions.")

D. Collecting a value from a contracted operator that has used primary data (A) or modeled data (B)
GHG emission intensity values may also be collected from contracted operators that have applied option A Using primary data preferably or alternatively option B Calculating data with a model.

ISO References: 7.2 Establishment of GHG emission intensity of a TOC or HOC, in particular 7.2.3 Calculation with primary data, 7.2.4 Calculation with a mode, 7.2.5 Selection of a value from a database of default values and 7.2.6 Collection of a value from a contracted operator

Establishing a TOC's or HOC's activity data



Establishing the transport activity for a TOC – general approach

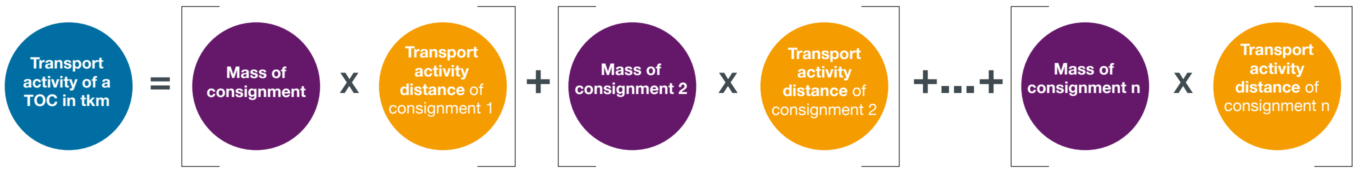
To establish the emission intensity of a TOC for a given period (usually one calendar year), first, you need to identify the transport activity of this TOC. The second step is to generate the emission intensity. Generally, the freight transport activity of a TOC is calculated by:

- multiplying the mass of each consignment with its specific transport activity distance
- adding up all the results of above multiplication for each shipment of the TOC during a given period (usually one calendar year).

(see also Info box "Demonstration of tonne-kilometer (tkm) calculation approaches".)

Establishing the transport activity for a TOC for multi-temperature vehicles

Where a TOC has different temperature zones, even within one vehicle, you must calculate a freight transport activity for each temperature condition separately. Therefore, the freight transport activity per temperature condition is calculated first, before adding the transport activities of the different temperature conditions to build the transport activity of the specific TOC.



Establishing transport activity for a TOC for combined passenger and freight transport

In the case of a TOC of vehicles or vessels that combine passenger and freight transport, whether they include passenger vehicles or not, the calculation of the transport activity can be done in the following steps:
1. Each relevant type of sub-category to the TOC needs to be identified, e.g. passengers with their luggage, cars, motorcycles, empty trailers, loaded trailers.
2. If possible, also here you should use primary data in the form of actual mass of passengers and vehicles. Where this is not possible, you can apply the conventionally used equivalent of 100kg per passenger, including baggage. Similarly, default values for different vehicles can be used where their specific mass is not available. (For more detail see Section 1 Chapter 4 “Information and Requirements for the Individual Transport Modes and Hubs.”)
3. For each sub-category identified, the transport activity distance needs to be multiplied by the number of entities of that specific type, e.g. number of passengers multiplied by number of the related transport activity data. The result equals the transport activity of this specific type of entity.
4. Finally, the transport activities of all types of entity are added and comprises the transport activity of the combined transport.

ISO References: 8.4 Calculation of transport activity for the TOC, in particular 8.4.4. Transport activity of a TOC of freight – General case, 8.4.6 Transport activity of a TOC of Freight with multi-temperature vehicles, 8.4.7 Transport activity of a TOC with passengers and freight (whether including passenger vehicles or not)

Total transport activity of a specific entity of a combined passenger and freight transport = Transport activity per single unit of a specific entity x Quantity of units of the specific entity

Total transport activity of all entities of a combined passenger and freight transport = Total transport activity of entity A of a combined passenger and freight transport + Total transport activity of entity B of a combined passenger and freight transport + ... + Total transport activity of entity n of a combined passenger and freight transport

Establishing the operation activity for a HOC

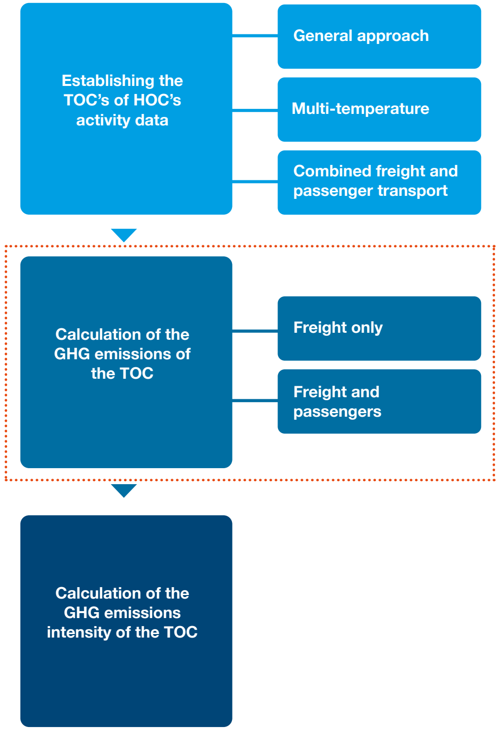
When establishing the emission intensity of a HOC, the approach is similar to the one described for TOCs. It is particularly important to include the total consumption of each energy carrier and refrigerant. In the case of different hub operation activities that generate GHG emissions, activity data for each of these hub operation activities must be quantified separately. Once you have established the activity data of the individual hub operations, their sum comprises the activity data of the entire HOC.

Similarly, where hub operations are not homogeneous and different sub-categories of hub operations can be distinguished, e.g. due to different temperatures in temperature-controlled operations or due to combined freight or passengers operations within a HOC, a two-step process is needed. First you need to establish the corresponding hub operation activity data per specific sub-category of the operation, then calculate individual emission intensify for each of these activities.
Section 1 Chapter 4 “Information and Requirements for the Individual Transport Modes and Hubs” gives guidance for allocating GHG activity data for a HOC.

Attention: Refrigerant refills at vehicle or load unit level (e.g. reefer containers) are not part of hub emissions, as these are considered as a form of GHG activity for the corresponding TOC.

ISO References: 9.2 Quantification of the GHG activity data of a HOC

Calculation of the GHG emissions of a TOC or a HOC



Calculation of the GHG emissions of a TOC

For the calculation of GHG emissions for a TOC, it must be identified as fitting into one of two categories:

- The transport operations carried out are near identical or at least show similar characteristics for all consignments and no passenger transport is included in the TOC
- The transport operations carried out to the consignments differ and/or passenger transport is part of the TOC.

In the first case, where the transport operations applied show similar characteristics for all consignments, you can calculate the GHG emissions for all operations of the TOC jointly. In the second case, where different transport operations are carried out on the consignments and/or passenger transport within the TOC, you need to calculate the emissions for each specific transport activity, i.e. for each sub-category, separately.

For example, if a transport includes temperature-controlled operations and non-temperature-controlled operations, which in all other respects are similar, you must calculate two different GHG emissions for the TOC, as well as two different transport activity energy provision GHG emissions: one for the non-temperature-controlled vehicle operations of the TOC and one for the temperature-controlled vehicle operations. Similarly, for a ferry, you must establish the emissions for passengers and freight separately.

ISO References: 8.3 Calculation of GHG emissions of a TOC

You calculate the GHG emissions of a specific transport operation of a TOC by multiplying that transport activity and the related emission factor of the TOC.

GHG emissions of a TOC for a specific activity = **Quantitiy of the specific transport activity of the TOC in tkm** x **GHG emission factor for the specific transport activity of the TOC**

You calculate the emissions of the energy provision of a specific transport activity of a TOC by multiplying the transport activity and the energy provision GHG emission factor for the specific activity of the TOC:

GHG emissions of the energy provision for a specific transport activity of a TOC = **Quantitiy of the specific transport activity of the TOC in tkm** x **GHG emission factor of the energy provision for the specific transport activity of the TOC**

Once the GHG emissions of all transport activities of the TOC have been calculated and the GHG emissions of all energy provisions for the transport activities of the TOC are established, the sum of them constitutes the total GHG emissions of the TOC:

Total GHG emissions of the TOC = **Sum of all GHG emissions of the transport activities of the TOC** + **Sum of all GHG emissions of the energy provisions for the transport activities of the TOC**

Calculation of the GHG emissions of a HOC

Similarly, for the calculation of GHG emissions for a HOC, it must be identified as fitting into one of two categories:

- The hub operations carried out are near identical or at least show similar characteristics for all consignments and no passenger transport is included in the HOC
- The hub operations carried out to the consignments differ (e.g. different temperature conditions apply) and/or passenger transport is part of the TOC

In the first case, if the operations carried out within the HOC are homogeneous, you can calculate the emissions of the HOC for all operations jointly. In the second case, you must differentiate individual types of activities and calculate the emissions for the operations applied to the freight and for the operations applied to the passengers separately. For hub operations with different temperature conditions, you must establish GHG emissions and GHG emission intensities separately for each temperature condition.

You calculate GHG emissions for the hub operation activities by multiplying the quantity of the specific hub operation activity by the related GHG emission factor for the specific hub operation.

GHG emissions of a TOC for a specific hub operation activity = Quantitiy of a specific HOC hub operation activity x GHG emission factor for the specific HOC hub operation activity

To establish the GHG emissions related to the energy provision of specific hub operation activities of a HOC, you multiply the specific hub operation activity by the related energy provision GHG emission factor:

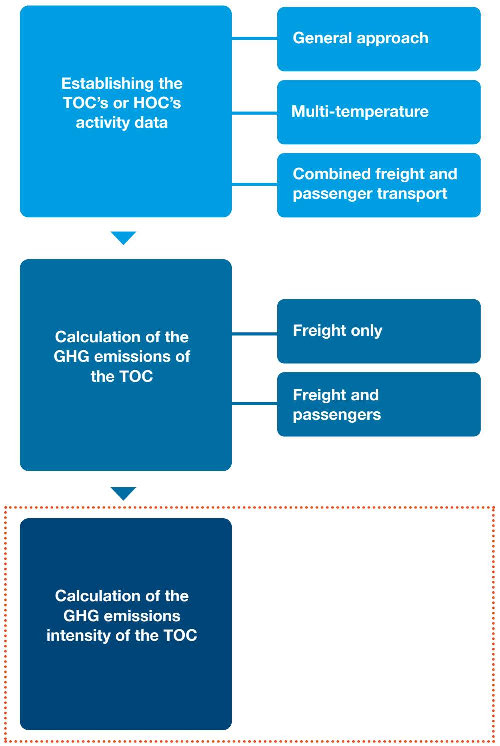
GHG emissions of the energy provision of a specific hub operation activity of a HOC = Quantity of a specific hub operation activity of the HOC x GHG emission factor of the energy provision for the specific hub operation activity of the HOC

Once the GHG emissions of all hub operation activities of the HOC have been calculated and the GHG emissions of the energy provision of all these hub operation activities of the HOC are established, the sum of them constitutes the total GHG emissions of the HOC:

Total GHG emissions of the HOC = Sum of all GHG emissions of the hub operation activities of the HOC + Sum of all GHG emissions of the energy provision for the hub operation activities of the HOC

ISO References: 9.3 Calculation of emissions of a HOC

Calculating GHG emission intensity of a TOC or a HOC



Calculating the GHG emission intensity of a TOC

To establish the GHG emission intensity of a TOC, you divide the total GHG emissions of the TOC by the total transport activity of the TOC:

$$\text{GHG emissions intensity of a TOC} = \frac{\text{Total GHG emissions of the TOC}}{\text{Transport activity of the specific TOC in tkm}}$$

As with the calculation of transport activity distance for multi-temperature vehicles, you must establish the GHG emission intensities separately for each temperature condition:

ISO References: 8.5 Calculation of GHG emission intensity for the TOC

$$\text{GHG emissions intensity of a TOC} = \underbrace{\frac{\text{Total GHG emission of the TOC of this temperature zone}}{\text{Transport activity of this temperature zone}}}_{\text{Temperature zone 1}} + \underbrace{\frac{\text{Total GHG emission of the TOC of this temperature zone}}{\text{Transport activity of this temperature zone}}}_{\text{Temperature zone 2}} + \ldots + \underbrace{\frac{\text{Total GHG emission of the TOC of this temperature zone}}{\text{Transport activity of this temperature zone}}}_{\text{Temperature zone n}}$$

Calculating the GHG emission intensity of a HOC

For establishing the GHG emission intensity of a HOC, you divide the total GHG emissions of the HOC by the total hub operation activity of the HOC.

The result of this calculation is expressed in CO_2e per hub operation activity.

ISO References: 9.5 Calculation of GHG emission intensity for the HOC

$$\text{GHG emissions intensity of a HOC} = \frac{\text{Total GHG emissions of the HOC}}{\text{Total of the hub operation activities of the HOC}}$$

Chapter 4
Information and requirements for the individual transport modes and hubs

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Air

Global impact

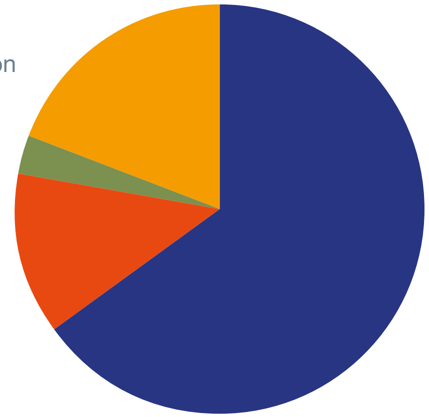
Global aviation, encompassing both domestic and international operations for both passenger and freight transport, contributes to approximately 1.9% of total GHG emissions.[24] Air transport has a unique interaction with the climate because the majority of emissions occur at cruising altitudes of 8-12 km.[25] The IPCC notes that high altitude deposition of not only CO_2, but also NOx, methane, water vapor and ozone, contributes a climate warming impact, and can also seed clouds that trap heat from the earth's surface (radiative forcing).[26]

Aviation is the most emission-intensive mode of transportation. Most aviation emissions come from passenger transport, with freight comprising around 19% of total aviation related emissions.[27] That said, aviation is expected to be one of the fastest growing modes of transport in the coming years, with a projected annual growth rate of around 3% until 2040.[28] Between 2009 and 2017 the energy efficiency of aviation improved by 17%.[29]

Our strategy towards net zero

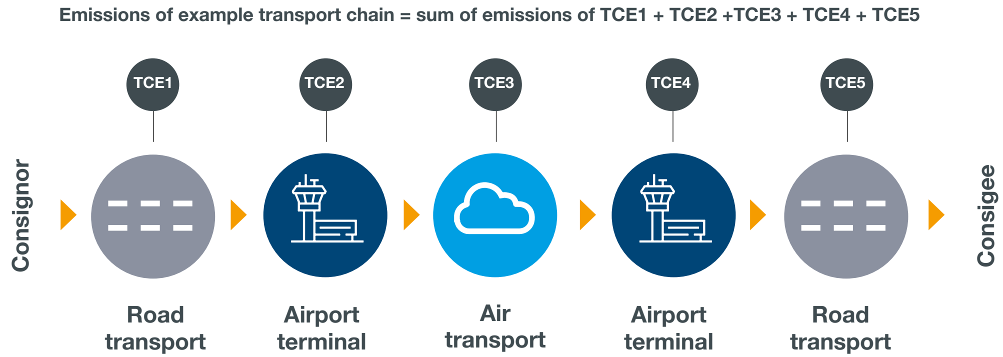
Achieving net zero by 2025 will require a combination of maximum elimination of emissions at the source, offsetting and carbon capture technologies.

- **65%** Sustainable Aviation Fuel (SAF)
- **13%** New technology, electric and hydrogen
- **3%** infrastructure and operational efficiencies
- **19%** Offsets and carbon capture



https://www.iata.org/en/programs/environment/flynetzero/

Figure 1
Emission calculation for an air transport chain, including an air transport TCE (TCE 3)



Reductions in air freight emissions are possible through more efficient aircraft concepts and engines, use of renewable fuels with a lower lifecycle impact (often referred to as SAFs), improved air traffic management and other optimization measures.[30,31] However, achieving aviation decarbonization will be a challenge without a radical new aircraft engine technology. The lack of ready technologies has led the International Civil Aviation Organization (ICAO) to put forth the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), which uses carbon offsets to mitigate climate impacts until new technologies are available.[32]

Scope

The GLEC Framework covers freight transport by any type of aircraft, including freighters and passenger aircraft carrying cargo in their hold ("belly cargo or freight.") When assessing the emissions generated by air freight, the GLEC Framework takes into account the complete flight cycle of both cargo and passenger aircraft. This includes considering various activities such as taxiing, take-off, cruising and landing, as well as any other movements associated with the loading and unloading of freight. Neither the embedded emissions of producing the aircraft themselves, nor the emissions related to airline or airport staff, are included in the GHG emission calculation for air freight transport. Also currently excluded are any additional global warming impacts from the combustion of aviation fuels at high altitude.

The services provided by the air terminal (e.g., loading, unloading, cleaning, block power) are classified under logistics sites.

Transport Operations Categories (TOCs)

In air freight transport chains, the air transport usually is the mainhaul (see Figure 1).
For air transport, suitable factors to structure TOCs include distance, which can be categorized as short (< 1 500 km) or long (> 1 500 km), and plane configuration, which can be a dedicated freight aircraft or a passenger aircraft with belly freight. Finer granularity levels for defining air transport TOCs can be:

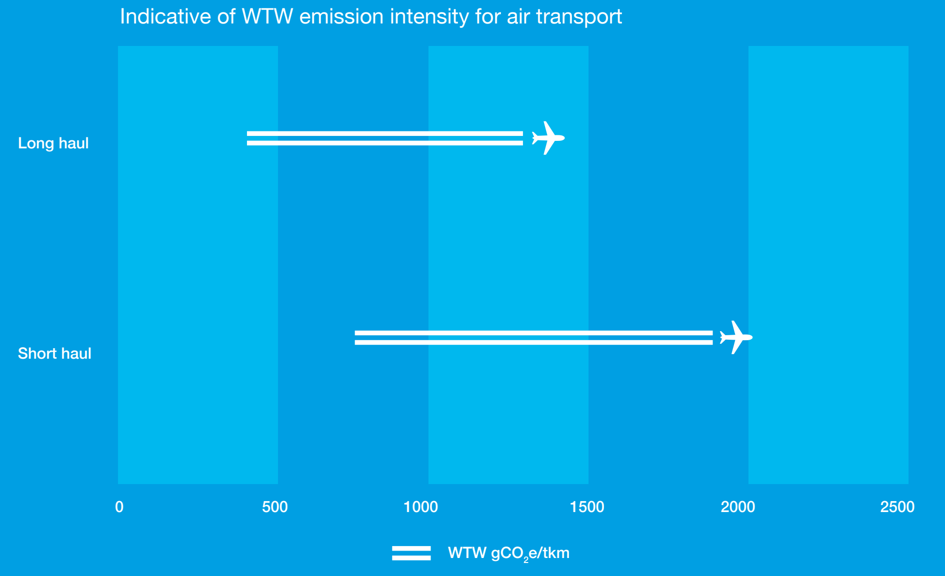
- A single aircraft or aircraft type on a single schedule: e.g., a B777-F flying FRA – NYK – FRA
- A single aircraft or aircraft type in a multiple schedule: e.g., a (group of) B777-F flying destinations between Europe and North America
- A group of aircrafts (same aircraft type, mixed aircraft types) in a single schedule: e.g., all freighters or all aircrafts flying FRA – NYK - FRA
- A group of aircrafts (same aircraft type, mixed aircraft types) in multiple schedules: e.g., all freighter or all aircrafts flying destinations between Europe and North America

Methodology alignment

The GLEC Framework's approach of allocating freight emissions of air transport by mass is fully compatible with the International Air Transport Association's (IATA) Recommended Practice 1678, the US EPA's 2018 SmartWay Air Carrier Partner Tool15 and ICAO's CORSIA program.

Figure 2

Examples of WTW emission intensity for air transport



IATA RP1678[33] and RP1726[34]

- IATA has updated its emission calculation Guideline IATA RP1678 for freight and added a "Passenger CO_2 Standard Methodology" in 2022 (IATA RP1726).
- IATA's network-based approach is in line with the transport operation category approach.
- IATA allows emissions to be calculated on a weight or volume basis; for alignment with the GLEC Framework, weight should be used.
- The allocation rule between passenger and belly freight (IATA RP1726) is in line with ISO 14083 and only mass balanced.

CORSIA[32]

- The Monitoring, Reporting and Verification (MRV) procedures for CORSIA include the WTW approach for calculating emissions from aviation fuel. This requires airlines to report the carbon intensity of their aviation fuel.
- The "CORSIA Methodology for Calculating Actual Life Cycle Emissions Values" provides for all greenhouse gases (CO_2e) related to biogenic and fossil energy sources.
- CORSIA requires airlines to report their emissions based on a standard methodology for calculating CO_2e emissions from aviation fuel. This methodology is based on the ICAO Carbon Emissions Calculator,[35] which takes into account factors such as energy source, aircraft type and flight distance.
- CORSIA values must be scaled from CO_2 to CO_2e.
- CORSIA does not specify use of fuel life cycle for fossil kerosene.

Under CORSIA, airlines are required to offset any emissions above the 2020 baseline through the purchase of carbon credits from approved emission reduction projects. The scheme is being phased in since 2021, with a voluntary phase from 2021 to 2026, followed by a mandatory phase from 2027 to 2035 for most countries.[36]

For emission factors you can refer to Section 3 Module 1 indicated factors for Jet A/A1 fuel in the regions North America and Europe.

Requirements for air transport calculations

Consignment mass

Use the actual consignment mass, not proxies like chargeable weight.

Distance

- Distance is measured as the GCD between the origin and destination airport for each flight leg.
- If the actual distance is used in the calculation, you need to apply a DAF to prevent underreporting. The DAF must be calculated on best available data regarding maneuvering, taxiing and other deviations, and needs to be disclosed alongside the provided values in the reporting. In case the specific information for the DAF is not available, you use the ratio of (GCD + 95km) / GCD
  In this case, the 95km represent the difference between the actual distance and the transport activity distance due to maneuvering etc.;
- The latitude and longitude of the origin and destination can be taken either from aerodrome data published in the national Aeronautic Information Publication or from a source using such data (e.g., ICAO).
- If intermediate stops are made, distance and associated emissions should be calculated separately, because each leg in the overall journey counts as a TCE, and then added to give the totals.
- For Scope 3 calculations, it can be difficult to know whether there were any intermediate stops on the flight path. If distance is taken between origin and destination, not including intermediate stops, this will lead to systemic underestimation of distance and emissions. Therefore, you should aim to obtain the flight numbers for each journey, as this is the most reliable approach, even if getting this information can be complex.

Default factors

- The GLEC Framework provides the following air transport energy efficiency and emission intensity (see Section 3 Module 2 Default Energy Efficiency and CO_2e Intensity Factors for more information):
- The overall IATA industry average.
- A matrix showing notional short- and long-haul values for passenger planes and freighters, as well as an average value that can be used when the nature of the air transport is unknown.
- If flights include intermediate stops, you should apply the appropriate default factor for each flight leg's origin and destination points.

Energy source

- Jet fuel A (kerosene) is the assumed energy source for air transport.
- Aviation gas is also used in some cases, such as for aircraft with piston engines.
- If there is reason to believe another energy source is used, i.e., through detailed knowledge of aircraft type, select the appropriate CO_2e emission factor and document the change.

Transport activity for passenger aircraft with belly freight

- In the case of TOCs in which the main function is passenger transportation with belly freight, apply the ISO provisions on combined transport of freight and passengers for calculation of transport activity (see also Chapter 3 Calculation Steps "Establishing transport activity for a TOC for combined passenger and freight transport".)
- To consider freight and passenger transport together, two options are available:
  - The first option is based on mass and uses the total passenger mass, including baggage, and actual freight mass for both allocation and calculation of GHG emission intensity.
  - The second option is only for use in situations when data needed for the first option is not available. In this case you convert the cargo mass into passenger equivalents using a conversion value of 100kg = 1 passenger equivalent and then allocate the emissions according to proportional share the total number of share of passengers and passenger equivalents. The emission intensity can then be calculated using the known cargo mass combined with the transport activity distance.
- The mass of passengers encompasses every individual passenger and their accompanying baggage; the mass of freight comprises the mass of the freight itself and the mass of packaging provided by the organization sending the shipment. Any additional transport packaging, pallets, or containers used specifically for the transport operation is excluded.

Cable Cars

Global impact

Cable cars are transportation systems for people, freight or both combined. Cable cars exist in the form of suspended air ropeways or surface bound ropeways. Whereas air ropeways usually have cabins or buckets for the transport of passenger and freight suspended from a cable, surface ropeways are funiculars or bucket systems equipped with either wheels or rails.

In all cable cars, the movement is generated by a cable or rope that pulls the transporting unit. The cables are typically powered by an electric motor, and the gondolas or buckets can either be fixed to the cables or detachable, depending on the system. They are often used in mountainous or difficult-to-access terrain. In urban areas, cable car systems for both freight and passenger transport are used with positive environmental and social impacts (e.g., Medellin, Columbia or Graz, Austria).[37] The dual use of the system as used in e.g., Graz generates synergies such as the bundling of traffic and avoidance of unnecessary journeys and displacement effects. Cable car stations can serve as multifunctional operating points for both freight logistics and passenger traffic.

The GHG emissions of cable cars vary depending on several factors, such as the type of cable car system, the energy source used to power the system, and the volume and weight of the materials being transported. If a cable car system is powered by electricity generated from renewable sources such as hydroelectric, wind or solar power, the GHG emissions will be significantly lower than if the system is powered by fossil-fuel energy.

Currently, there is a scarcity of studies focusing specifically on the GHG emissions of cable cars, in particular cable cars used for freight or combined transport. Therefore, the environmental impact of cable cars needs to be evaluated on a case-by-case basis, taking into account the specific context, energy source and conditions of each system.

Scope

The content of this section is applicable to all cable car systems that consume energy and are primarily used for the transportation of freight. Regardless of whether the cable car system consists of multiple vehicles or a single wagon only, it must be viewed as a unified transport system, including its infrastructure. Vehicles that move on cables, but without the transmission of movement through at least one cable, do not fall under the definition of cable cars. Similarly, vertical elevators are excluded from the definition of cable cars.

Transport Operation Categories (TOCs)

Aerial cable cars can be further divided into three types:
1. Unidirectional Monocable: this system uses a single cable to transport goods in one direction. The cable is supported by towers and driven by a motor located at one end of the cable car line. Goods are loaded onto fixed-grip or detachable-grip buckets that travel along the cable.
2. Unidirectional bi-cable: this system uses two cables, with the cabins or containers attached to one of the cables by means of a grip or carrier. The cables are driven by motors at opposite ends of the cable car route, and the cabins or containers move in one direction along the cables. This system can be further divided into the variations Material 2S and Material 3S, differing in how the cabins or containers are attached to the cables and the configuration of the cables themselves.
3. Reversible bi-cable (Jigback): this system uses two separate cables that run parallel to each other. The cabins or containers are attached to the cables by means of detachable carriers, and the cables are driven by motors at opposite ends of the cable car route.

Methodology alignment

When evaluating the GHG emissions of cable cars used for freight transport, it is possible to use either primary measured data or secondary modeled data. Often, a combination of the two is necessary and used.

Requirements for cable car transport calculations

Distance

- The transport activity distance should be based on the SFD and usually no DAF is required, as the route of the cabins or buckets is defined by the ropes of their system and deviations are impossible.
- If two or more cable cars are linked to each other to one transport system, each of the constituting sections shall be considered as one cable car, even if they ensure the continuity of the travel of the vehicle they connect.

Hubs

Global impact

Hubs are locations where passengers and/or freight is handled from one vehicle or transport mode to another before, after or between different transport operations of a transport chain.[9] Hubs for freight, also known as "logistics hubs", are a vital backbone to supply chains. Logistics hubs are where freight is stored and processed, and where myriad forms of transport intersect. Logistics hubs are often close to populations, emphasizing the importance of both the climate and health impacts of their activities. Given their integral role in the booming logistics sector, their impact is only expected to grow in the coming years. Thus, it will be all the more important in the future to align other phases of the life cycle of logistics hubs with sustainability topics in addition to operation.[38]

Logistics hubs are a diverse group of facilities scattered around the globe; their collective impact is not well-understood. The World Economic Forum estimated that warehouse and sorting facilities alone can comprise up to 13% of supply chain emissions.[39]

Country-specific evaluations have shown that warehouse emissions account for around 20% of the transport emissions in the United States, while in the UK, it is assumed that they account for 11% to 30%.[40] For Germany, about 15% of transport emissions were assigned to logistics hubs.[41]

A company's use of logistics hubs, and the subsequent emissions arising from operation, will vary based on the modes of transport, refrigeration needs and region. Therefore, the relative impact of emissions from logistics hubs will vary by company and product and should be assessed accordingly in order to create transparency about the performance of logistics hubs in a first step and to understand other overarching interdependencies in subsequent steps. This includes, for example, the continuous evaluation of measures that can reduce the environmental impact of hubs.

Scope

Logistics hubs are the nodes, sites, facilities, centers and depots that connect transport legs (within and between corresponding transport modes) or are the start or end point of a transport chain.[42] Examples for logistics hubs are facilities such as warehouses, consolidation/fulfilment centers, distribution centers, and cross-docking sites or micro depots/city hubs as well terminals at maritime or inland ports, freight and intermodal terminals or cargo terminals at airports. Logistics hubs consist of own transport chain elements (TCE). So the boundary for emissions from logistics hubs begins when the consignment is unloaded from the inbound vehicle or vessel, and ends when the freight is either handed over to the recipient or reloaded onto the outbound vehicle or vessel.

While the consideration of transshipment processes according to ISO 14083 is mandatory, the consideration of storage or repacking of cargo is optional, as are emissions related to information and communications technology (ICT) equipment and data servers provided by external server providers. If any of these processes (warehousing, (re)packing, external server providers) are taken into account, this shall be noted accordingly.[9]

The GLEC Framework considers emissions from logistics hubs as those emitted by the fuel and electricity used to unload/load or move freight at the hub, and direct losses of refrigerants used in temperature control equipment. This includes energy used for onsite vehicles, technical equipment for handling freight, lighting, heating/cooling (for facilities and reefers), weigh stations, onsite server rooms and administrative facilities related to freight movement at the hub, and other freight-related activities. Emissions linked to energy supply for onsite vehicles and machinery such as cranes, reach stackers, fork-lift trucks, shuttles that transport employees onsite, diesel generators and shore power to vessels are included. The energy and refrigerant use of inbound and outbound transport to or from the hub is not included in the logistics hubs' emissions, those are covered by the corresponding transport TCE. The upstream emissions related to infrastructure, vehicles and material handling equipment are not included, nor are Scope 3 emissions resulting from employee commuting and business travel. Emissions related to self-driving cargo, e.g. in roll on, roll off (RoRo) terminals are not included in logistics hubs' emissions.

In order to manage this variety, structuring can be made using so-called HOCs categories

(HOCs), which take into account different levels of granularity on the one hand, e.g. HOC of a single hub or specific hub types in the network, and factors that affect the scale, composition and characteristics of the operations carried out on the other. Thus, any single hub operation shall always be considered in the context of the overall system in which it takes place. Finally, a HOC is the summary of hub operations with similar characteristics in a defined time period (up to one year).

HOCs

Recommended clusters for HOC are based on[9]

- Processes: freight transshipment only, passenger transfer only, combined passenger/freight transfer, freight transshipment and storage
- freight types: average/mixed, containerized or swap bodies, palletized, break bulk/ piece goods, dry bulk, liquid bulk, vehicle transport, other and
- conditions: ambient, temperature controlled

Methodology alignment

The Fraunhofer IML "Guide for Greenhouse Gas Emissions Accounting at Logistics Hubs" provides detailed instructions on accounting for logistics hubs.[40] The method was developed jointly in collaboration with SFC and EcoTransIT World, adapted to ISO 14083 and informed this version of the Framework.

Requirements for logistics hubs calculations

Shipment mass

Activity data for logistics hubs is calculated based on the cumulative annual tonnes throughput of shipments leaving the center, i.e. outbound freight. It may be useful to also track the number of tonnes requiring special treatment, such as temperature control (e.g. cooling or heating). Such differentiation allows you to allocate emissions accordingly.
Hubs dealing primarily with containerized cargo may need to convert TEU to tonnes if shipment mass is not available. An average value of 10 tonnes per TEU can be used. Alternatively, a value of 6 tonnes per TEU may be used for lightweight cargo or 14.5 tonnes per TEU for heavyweight cargo if the use of these categories can be justified.

For post and parcel operations, where knowledge of individual items' mass is limited, the quantity of freight may be the number of items.

Allocation

Wherever possible, allocation should be avoided by more detailed data gathering. You might not have access to detailed hub operations activity in cases when multiple services with different characteristics are fulfilled by a hub. In those cases, you can allocate GHG emissions considering specific characteristics. When handling involves ambient and refrigerated freight at a hub, the energy consumption for cooling, and the leakage of refrigerants, allocate overall emissions between these two characteristics. In some cases, it may be difficult to split electricity and fuel consumption for freight and non-freight related activities. In these cases, logistics hub operators are encouraged to make these calculations based on the best available information and transparently record any potential anomalies when reporting.
For logistics hubs that are operated jointly by more than one operator, allocation of emissions should be based on the throughput tonnage by each operator separately.

Further allocation may be necessary if corresponding separate data acquisition is not possible.

The selected allocation principles shall remain constant over time and shall be documented transparently, e.g. using the amount of freight to allocate electricity consumption for lighting to specific functional areas.

Time period

The operational data for hubs should be aggregated over periods of up to one year. This is to remove seasonal fluctuations resulting e.g. from heating or lighting, or any transient impact on long-term trends.

Default values

Still a developing area, default values for logistics hubs have been historically difficult to obtain. Furthermore, logistics hubs are extremely diverse in their nature. Container terminals are very different from transshipment hubs, but even within each category of logistics hubs very different services can be found.[38] Fraunhofer IML has advanced the understanding of average logistics hub emission intensity values through extensive industry research and data collection with the help of the REff Tool®.[43] This version of the Framework benefits from their research, offering a set of default values for transshipment sites, warehouses and terminals considering ambient freight as well as temperature controlled handling. The default values are included in Module 2.

For these values, electricity, heating energy, or other fuels and refrigerants are already converted to CO_2e using corresponding regional emission factors where available and are aggregated on a global level. While data on terminals originate from various regions worldwide, the main source for warehouses and transshipment sites is currently Europe.

Inland waterways

Global impact

Freight transport by inland waterways comprises a relatively small share of the logistics sector. With approximately 50% lower energy consumption per tonne-kilometer of freight compared to road transport, it is on a par with rail transport in terms of energy efficiency. Due to its relatively low carbon emission intensity and role in reducing road congestion, inland waterways are seen as a beneficial option. Furthermore, inland waterways guarantee a high level of safety, particularly when it comes to the delivery of dangerous goods. Despite these benefits, inland waterway transport has experienced less growth and infrastructure investment than other modes, especially in developing countries.[44] A boost to the investment in technologies for inland waterway operations could come about in the coming years, as the European Union has set a goal of increasing transport by inland waterways and short sea shipping by 25% by 2030 and by 50% by 2050, compared to 2015.[45]

Energy use and emissions information for inland waterway transportation is often grouped with other modes of water transport in statistical publications, making it hard to isolate trends.[46] Nevertheless, the GLEC Framework default values suggest that, depending on the vehicle or vessel used, inland waterways can offer a low energy, low emission alternative particularly for medium and long-distance transport.

Further improvements of efficiency of inland waterway transport can be gained through slow-steaming and optimized logistics operations. Energy-efficient power and propulsion systems, streamlined hulls and superstructures, and alternative energy sources, such as biodiesel, electricity or hydrogen, present practical near-term solutions.[47] A few cutting-edge propulsion technologies, such as fuel cell hybrid drive systems, may also soon be on the market.[48]

Scope

Inland waterway transport refers to freight movement along stretches of water that are not part of the sea, such as rivers, lakes, canals and estuaries.[49] The GLEC Framework v3 includes, like ISO 14083, all types of inland waterway vessels including barges, coupled convoys, pushed convoys, tankers and container vessels. Freight types considered are dry and bulk, containerized freight, and mass and volume-limited general freight.

Emissions to be considered are linked to the consumption of energy for the propulsion of the vessel, as well as maintenance of freight in the condition and at the temperatures required by the owner of the goods. All emissions related to the movement of freight, including empty backhauls and repositioning, should be included. Moreover, any energy that is supplied from shore, including in particular electrical energy, should be included in the vessel operator's activity data.

Emissions related to buildings and equipment used to load or unload cargo are classified under logistics sites and included in the HOC emissions.

TOCs

To cluster transport services with similar emission intensities, it is recommended to structure the TOCs based on a suitable combination of influencing factors for inland waterway freight transport, based on factors such as vessel size category, vessel size category and configuration, condition and waterway type:[9]

Freight type
- Dry bulk
- Liquid bulk
- Containerized
- Mass-limited, general freight
- Volume-limited, general freight

Vessel size category
- < 50 m
- 50 m to 80 m
- 80 m to 110 m
- 110 m to 135 m
- >135 m

Vessel configuration
- Individual vessel
- Pushed convoy

Condition
- Ambient
- Temperature-controlled

Waterway type
- Canal
- River
- Lake

Methodology alignment

In general, inland waterway emissions accounting follows the principles developed by the maritime sector. The GLEC Framework is in alignment with the principles of the International Maritime Organization (IMO) Energy Efficiency Operation Index (EEOI) guidelines and the US EPA SmartWay Barge Carrier Tool.

IMO EEOI[17]

- IMO EEOI emission results are expressed as TTW, CO_2; therefore, the WTT emissions must be added and the result must be scaled to a CO_2e basis for alignment with the GLEC Framework.

- SmartWay Barge Carrier Tool[15]
- SmartWay emission results are expressed as TTW, CO_2; therefore, the WTT emissions must be added and the result must be scaled to a CO_2e basis for alignment with the GLEC Framework.
- Carrier-specific values are available for a small set of companies operating in North America.
- SmartWay intensity values are reported as CO_2/ton-mile – the energy consumption is already converted to CO_2 using standard emission factors supplied by SmartWay.
- Conversion from US tons to metric tons may be needed to ensure consistency of reporting.

Requirements for inland waterway transport calculations

Shipment mass

- Use actual mass of freight.
- For containerized transport, an alternative parameter such as TEU may be used in place of the mass of freight (See also SECTION 1 Chapter 2 Calculation Steps).

Distance

- The ideal distance data is taken from the vessel's log book.
- Other options may include distance planning software, telematics data or other sources of network distance data.
- In cases where actual distance is not available, distance for inland waterway transport should be either the SFD, taking into account the inland waterway network, or the GCD.
- The limited number of route options available within the inland waterway network leads to little opportunity for deviation between the actual distance and the SFD. Therefore, you do not have to apply a DAF.
- Appropriate distance calculators can be used to help identify inland waterway distances as accurately as possible.
- Convert (nautical) miles to kilometers using factors in Annex 4 Unit Conversions.

Default factors

- Smart Freight Centre and STC-Nestra worked collaboratively with GLEC members to develop a new set of industry-reviewed default factors that accurately represent today's inland waterway sector.[16]
- Whilst we would always encourage you to use carrier-specific values, the default values in Module 2 provide a significant step forward in terms of collecting and sharing consistent data for a wide range of inland waterway vessel types.

Energy sources

- Marine diesel oil is the assumed energy source for inland waterway transport operations.
- Other potential energy sources include other diesel oils, liquefied natural gas (LNG) and biodiesel.
- If there is reason to believe another energy source is used, i.e., through knowledge of operations, select the appropriate CO_2e emissions factor and document the deviation.

Water current effects

- For inland waterway transport operations, water direction (i.e., whether with or against the current) can have an important impact on energy consumption.
- Any calculation of emissions shall be applied on a round-trip basis to average this impact across the transport operations.

Pipelines

Global impact

Pipeline transport involves the movement of a medium, such as liquid, gas, liquefied gas or slurry, through a system of pipes from one location to another. Pipelines provide an important mode of transportation for specific elements of the freight transport industry and are composed of long tubes made of steel or plastic and are used for transporting liquids or gases over long distances with high efficiency and low environmental impact. Pipelines can be either underground or above ground, and their diameter can vary from a few centimeters to several meters, depending on the volume of the product being transported.

Pipelines can transport large volumes over very long distances, which makes them ideal for products such as oil, gas and water. Pipelines are used extensively in the oil and gas industry, where they are used to transport crude oil, refined petroleum products and natural gas from the production site to refineries and distribution centers. In addition to the oil and gas industry, pipelines are also used in the chemical industry to transport chemicals such as chlorine and ammonia.

There are two aspects to consider when assessing the environmental impacts of pipelines: construction and operation. Studies have shown that the construction phase has a greater impact on the ecology of the affected area.[50] This is because building a pipeline causes disruption to the area, including clearing away plants, digging, compressing soil and other activities. Moreover, since pipelines are usually constructed in a straight line, they can affect different natural and climatic zones with diverse geological and hydrological features.

However, the operation of pipelines is not without its challenges either. One of the main challenges is to ensure the safety of the pipeline, which requires regular maintenance and inspection to prevent leaks and other accidents. As per the US EPA, methane leaks from gas pipelines were responsible for emitting approximately 21 million metric tons of CO_2 equivalent in 2020.[51] Additionally, the cost of building and maintaining pipelines can be high, which may limit their use in some areas.

Scope

- When calculating GHG emissions from pipeline operations, the operational calculation is based on the energy used by the equipment within the pipeline network to move the product and maintain the relevant pressure level. Furthermore, direct fugitive GHG emissions from delivery systems, such as flanges, valves, unions and threaded connections, must also be taken into account.
- When comparing pipeline transport with other modes of transport, you should include the differential compression, cooling or heating processes, and their energy use and related GHG emissions in the comparison.
- The initial compression of the medium and pumping needed for feeding the pipeline, located at the production site or at transshipment point/terminal within the transport chain, should be excluded from the GHG emissions calculation of pipeline transport and allocated to the hub via the HOC calculation.
- When considering a TCE that involves pipeline transport, it is recommended that you define the TOC for pipelines based on the activity of the relevant pipeline section or network for all operations and mediums transported over the course of one year.
- The system boundaries of ISO 14083 require that multiple operational processes which contribute to GHG emissions through combustion or leakage, such as the vehicle and hub operational processes, as well as the processes involved in providing energy to the vehicles and hub equipment, are considered when quantifying GHG emissions for a transportation chain. The implication of this for pipeline transportation is that you also need to include additional processes such as start-up and idling of pipelines and cleaning and flushing operations required for pipeline maintenance.
- In the case of slurry pipelines, the allocation or assignment of freight mass should not include the weight of the transport medium, such as water.

Requirements for pipeline transport calculations

Mass

In addition to the quantity of freight expressed in mass, you can use other parameters, e.g., volume.

Distance

- The transport activity distance should be based on the SFD, considering the pipeline network, or the GCD.
- A DAF is not required in the case of pipelines, as the limited number of route options available within the pipeline network leads to little opportunity for deviation between the actual distance and the SFD.

Rail

Global impact

The rail freight sector has a relatively low impact on global emissions compared to other modes of transportation. In 2018, rail freight contributed only 1% of transport GHG emissions, while passenger rail accounted for 4%.[52] The use of electric rail transport, which makes up about 80% of passenger rail and half of freight movements, does not release operational CO_2 emissions. As for the overall final energy mix of rail, diesel consumption plays a more prominent role in freight rail, accounting for approximately two-thirds of its total energy consumption worldwide in 2021.[53]

To enhance efficiency and sustainability, the rail freight industry is embracing new technologies and operational practices, with several countries allocating funding for these initiatives.[53] Electrification plays a significant role in reducing emissions by eliminating direct emissions from rail operations. The use of sustainable fuels such as biofuels is also increasing. The expansion of rail networks, including the establishment of high-speed rail links, track modernization and digitalization of signaling systems, improves efficiency and attractiveness of the system.[54]

The rail freight sector is expected to experience growth in the coming years. The US Federal Railroad Administration is committed to decreasing the carbon footprint of rail transportation by various strategies such as promoting the expansion of electrification and the use of sustainable fuels. Furthermore, they aim to expand the rail network to enhance efficiency for both passengers and goods shipments, and to implement measures to reduce GHG emissions from rail operations, maintenance and construction.[55] The European Union has set ambitious goals of 50% growth of rail freight by 2030 and doubling by 2050, aiming to reduce GHG emissions and alleviate congestion on major road networks.[55]

However, the rail freight market, particularly in the EU, may be directly impacted by a substantial increase in energy prices. Rail freight operators who haven't secured sufficient energy purchases for 2022 and 2023 could face significantly higher costs in the future. This cost burden might potentially force operators to exit the market, posing a threat to the progress made in shifting freight to rail.[57]

Scope

For rail transport, emissions are associated with the energy and/or electricity used to power the trains or haul cargo using other rail vehicles. This includes energy used for train propulsion supplied by hub operators' systems. The GLEC Framework v3 also accounts for electricity transmission losses (already factored into electricity GHG emission factors) and energy resulting from brake-energy-regeneration re-injected into the grid. Emissions resulting from any internal movements within a hub's boundaries are also accounted for; they are classified as logistics site emissions and therefore are part of a HOC.

TOCs

TOCs for rail transport should be structured based on a suitable combination of the influencing factors given in the list below.

Operation type:
- Long-distance freight transport:
  - block train
  - single wagon
  - intermodal wagon
- Short-distance freight transport (feeder services)

Freight type:
- Average/mixed
- Containerized/swap bodies
- Dry bulk
- Liquid bulk
- Vehicle transport
- Semi-trailers
- Other

Condition:
- Ambient
- Temperature controlled

Propulsion:
- Electric motor:
- fixed electricity supply system (catenary, third rail)
- on-train battery energy storage
- fuel cell energy storage
- Combustion engine
- Other

Methodology alignment

In addition to ISO 14083, the GLEC Framework v3 is compatible with the EcoTransIT World Methodology, recommended by the Union Internationale des Chemins de Fer (UIC). In the US, the US EPA, SmartWay Rail Carrier Tool and the information collected and published at federal level by the US Surface Transportation Board provide alternative sources of information in compatible format.

EcoTransIT World[58]
- The EcoTransIT World tool aligns with the WTW GHG emissions, and the scopes outlined in the GHG Protocol Corporate Value Chain Accounting and Reporting Standard.
- EcoTransIT allows for reporting emissions as both CO_2/CO_2e and TTW/WTW. Be sure to always use the values that include WTW and CO_2e
- EcoTransIT divides geographies by region to model the level of electrification vs diesel locomotives, considering the challenge of finding electrification data on a country level.

SmartWay Rail Carrier Tool[59]
- Carrier-specific CO_2e intensity factors are not available from SmartWay; however, an annual average value representing the emission intensity of North American rail companies is provided and may be useful for benchmarking.

Requirements for rail transport calculations

Shipment mass

- For calculation of the transport activity, actual mass in tonnes is to be used. If this is not available, estimated weight based on the mass of the cargo can be applied. For containerized transport, the weight can be estimated based TEU.
- GHG activity data should be calculated at the consignment level for the freight transport chain using standard freight transport rules.
- Average load factors for default values, where no measured data is available, are not well-established for rail transport. EcoTransIT estimates load factors based on net and gross tonne-kilometers (or revenue and non-revenue tonne-kilometers) for some cargo types, plus standard factors for wagon weights and payload capacity.[19] SmartWay provides average railcar capacity data for North America.[59]

Distance

- Rail transport activity should be calculated based on the SFD, based on the start and end point of the journey.
- If you use the actual distance for the calculation of the transport activity, further analysis into any possible deviation is needed to establish the right DAF, given that rail transport is very limited in the routing options and any deviation from the planned route is most probably due to specific reasons.
- Rail distance can be difficult to identify. Some rail carriers and GHG emission calculation tools offer a rail distance calculator to their customers. EcoTransIT's online tool can also be used to calculate rail distance at no cost.

Considerations regarding locomotives and energy sources

- The most important differentiator for rail transport is whether the locomotive uses electricity or diesel as its energy source. In North America diesel is the most common, and hence assumed, energy source if actual conditions are unknown.
- Information on train length (and hence unladen weight and capacity) can be helpful for improving accuracy.
- Other potential energy sources are electricity, diesel oils, LNG and biodiesel.
- The extent of electrification varies by region, being particularly common in mainland Europe, but can be difficult to determine if carrier data is not available.
- Information on regional electrification can be found in RAIL Information System and Analyses (RAILISA) UIC Statistics for the rail sector.[60]
- EcoTransIT models regional electrification values within its tool.[58]
- If the train is electrified, choose the appropriate emission factor for the original energy source (if known) and/or electricity grid factor.

Road

Global impact

In terms of global transport emissions, the road sector is by far the biggest emitter, with passenger and freight road transport contributing nearly three-quarters of overall transport emissions.[61] In 2021, European road freight transport increased by 6.5 % compared to 2020.[62] However, the majority of global road freight transport growth is expected to come from non-OECD countries.[63]

The vast majority of road freight transport is powered by diesel and a widespread transition to electrified road transport is considered as essential to meet global climate targets.[64] Electrification of short-distance road transport is becoming a common option, whereas electric long-distance transport is still in its infancy, with gradual commitments being made to scale up fleet investment.

Efficiency measures show great promise for reducing emissions from road transport. Optimized fleet assignments and routing as well as efficient driving behavior are powerful, easy-to implement changes which improve energy efficiency.[64] Collaboration with supply chain partners can increase efficiency further through optimized ordering patterns and consolidated loads.

The road freight sector is highly fragmented. In the European Union, over 90% of road haulage companies have fewer than 10 employees, and around 85% of road freight companies have fewer than five trucks.[65] Similarly, in the United States, the majority of carriers (about 91%) operate six or fewer trucks.[66]

Multinational shippers and LSPs may need to contract with hundreds, even thousands, of road carriers in order to meet their global logistics needs. This renders the efficiency optimization and thus emission reduction of road transportation and its networks difficult, although green freight programs can help to streamline data exchange processes.

Scope

Road transport refers to any freight moved using a road vehicle over a road network between a place of loading and unloading. Road vehicles are any vehicles for use on roads.[67] Road transport emissions under the GLEC Framework pertain only to the fuel and/or electricity used to operate road freight vehicles and their onboard systems (e.g., for cooling). The emissions related to the production of road vehicles, hubs or road infrastructure are not included.[67]

TOCs

TOCs for road freight transport should be structured based on a suitable combination of the influencing factors given in the list below:

Freight type
- Dry bulk
- Liquid bulk
- Containerized
- Palletized
- Vehicle transport
- Mass-limited, general freight (heavy cargo)
- Volume-limited, general freight (light cargo)

Condition
- Ambient
- Temperature-controlled

Journey type
- Point-to-point long-haul
- Collection and delivery

Contract type
- Shared transport
- Dedicated contract (charter)

Additional factors can be relevant for defining a highly specific TOC, e.g., topography, road type (highway vs urban vs rural), vehicle mass category, wagon/trailer body type.

When computing the emissions of a hub and spoke network, different TOCs have to be identified for the different elements of the network, e.g., one TOC for the transport from origin to initial hub, another TOC for the transport from final hub to point of delivery (i.e., the “spokes”) and another one for the line-haul transport from hub to hub.

Methodology alignment

In addition to ISO 14083, the GLEC Framework is compatible with the US EPA's SmartWay Truck Carrier Tool. EPA SmartWay collects and shares emissions data on thousands of North American road carriers, which can be used with the GLEC Framework.

SmartWay Truck Carrier Tool[9]

- SmartWay emission results are expressed as TTW, CO_2; therefore, the WTT emissions must be added and the result must be scaled to a CO_2e basis for alignment with the GLEC Framework.
- Carrier data is reported as the average CO_2/ton-mile for the carrier's fleet. Carrier emission factors can be used with the proper conversions.
- Conversion from US tons to metric tons may be needed to ensure consistency of reporting.
- Carrier data is reported in SmartWay using actual distance. See the tips below for information on converting actual to planned distance.

Requirements for road transport calculations

Shipment mass and transport activity

- For calculation of the transport activity, actual mass in tonnes is to be used. If this is not available, estimated mass of the cargo can be applied.
- For containerized transport, the mass can be estimated based on (TEU using standard conversion factors.

Distance

- Road transport activity should be calculated based on the SFD, considering the road network or GCD. Values for the SFD based on the road network can usually be sourced from route planning software or maps.
- If actual distance is used as an alternative to SFD or GCD, e.g., to avoid toll roads or to reach rest points, the transport operator needs to inform the transport user accordingly and ideally also add this information to the reporting.
- When actual distance is used to calculate GHG emission intensity, a DAF must be applied in the final emission calculation to compensate for any deviation. This DAF should be based on the most accurate information available regarding the distance deviation and should be relevant to the context of the transportation. If such information is not available, a general estimated value for the DAF may be used instead.
- When shifting from transportation that uses energy to transportation that does not use any energy, such as using foot or bicycle delivery instead of vans/trucks for mail and parcel delivery, the full distance of the transport activity still needs to be considered when calculating the transport chain's transport activity.

Time period

- To allow for seasonal impacts, the operational data for regular transport operations should be aggregated over one calendar year. In this way seasonal fluctuations and temporary impacts are removed and a long-term trend is identified.
- Deviations from the general rule of annual aggregation are permitted but must be noted and reported. Shorter aggregation periods may be more relevant for road transport operations due to their short duration and high frequency. An example of where an alternative time period can be appropriate is when a transport service is only provided during a specific time of year.

Energy sources

- Diesel is the assumed energy source type for the majority of road freight transport and the majority of default emission intensities provided in Module 2 are calculated on this basis.
- It is important to reflect the typical national biofuel blend in the emission calculation.
- Other potential energy sources include biodiesel, electricity, hydrogen, compressed natural gas (CNG), LNG and gasoline.

Consideration of collection and delivery rounds

Many road transport operations fall under **"collection and delivery rounds"** which involve shared transports with multiple stops and changing load factors. For these forms of transport, which are particularly common in urban deliveries, it is important that you ensure that the total energy and GHG emissions for each consignment are calculated based on its share of the transport activity. You can use a notional transport activity to calculate the individual consignment's share of the overall transport activity of the entire collection and delivery round, based on loading and unloading points independent of the actual routing, which can vary day to day.

Post and parcel services

Post and parcel services require a different approach. Apart from tracked systems that are used for high value individual items, it is common for mail items and small parcels not to be tracked in such bulk distribution systems; where that is the case, a per-item emission calculation is a more practical approach. Again, it is important that you specify which approach was used in the reporting and explain any deviations from the commonly used method.

Sea

Global impact

Maritime transportation accounts for 80-90% of global trade[68] and is responsible for about 30% of the global logistics sector's emissions. As the demand for sea transport continues to rise, there is a significant increase in GHG emissions, which grew by 10.1% between 2012 and 2018, reaching a staggering 1,076 million tonnes.[69] Despite facing a temporary setback during the COVID-19 pandemic, sea transport has resumed its growth trajectory, experiencing a further 4.7% increase between 2020 and 2021,[71] with most of the increase coming from container ships, dry bulk carriers and general cargo vessels.[69]

The increasing average age of the global fleet is a growing concern, as older ships tend to have higher levels of pollution. Currently, the average age of the fleet is 21.9 years based on the number of ships and 11.5 years based on carrying capacity. The reluctance of shipowners to invest in new equipment is attributed to uncertainty regarding future technological advancements, the most cost-efficient fuels, changing regulations and carbon pricing.[68] Consequently, there is a pressing need for a new generation of ships that can use the most efficient fuels and seamlessly integrate with intelligent digital systems.

Innovative energy sources for sea transport, such as electric, hydrogen fuel cell, innovative sail systems, ammonia and biofuel technologies, are currently under development. These emerging technologies appear promising for reducing emissions and fostering sustainability in maritime transportation. Nevertheless, shipbuilding volumes remain low, and one of the most successful approaches to emission reduction at present is the operational practice of slow steaming. By reducing a ship's speed by 10%, emissions can be decreased by 27%.[71, 72]

The global containerized trade is heavily dominated by the top 10 container lines, which collectively control more than 85% of the market.[73] Unlike industries with fragmented players like the road sector, collective actions from a few key players in the maritime industry has the potential to drive substantial changes and initiatives that can effectively reduce emissions and promote sustainability within the industry.

Scope

Sea transport is the movement of goods on seagoing vessels either wholly or partly at sea.[74] Seagoing vessels include floating marine structures with one or more surface displacement hulls. Cargo ships are responsible for transporting general goods, while tankers are specialized in carrying liquid cargo such as oil and gas. Container ships are designed to transport standardized containers. Bulk carriers handle the transportation of commodities like grains, coal and iron-ore.[73]

All forms of sea transportation that consume energy for the primary purpose of transporting freight are captured in emission accounting under this guidance, in line with ISO 14083. These include emissions linked to energy consumption for both propulsion of the vessel and the maintenance of the freight in specific conditions (e.g., cooled or temperature controlled).

Whenever the vessel is in port or any other location where freight transfer occurs, GHG emissions that are related to the vessel's activity should be calculated and reported as part of the sea TCE. This means that any energy, particularly electrical energy, received from the shore that is stored and subsequently used for propulsion or to maintain the cargo in the required condition, must be incorporated as part of the vessel operator's GHG activity data.

Additionally, GHG impact linked to refrigerant leakage that is then replenished during a port call needs to be included in the calculation of the sea transport's GHG emissions. On the other hand, shore power ("cold ironing") is to be included in the calculation of the logistics hub, unless otherwise agreed with the shipping company.

TOCs

To cluster transport services with similar emission intensities, it is recommended to structure the TOCs for sea transport based on a suitable combination of the influencing factors as follows:

Sea freight TOC characteristics:

Vessel types:
- Bulk carrier
- Chemical tanker
- General cargo Ro-Ro
- Liquefied gas tanker
- Oil tanker
- Other liquid tanker
- Container
- Vehicle carrier

Freight conditions:
- Ambient temperature-controlled
- Mixed ambient and temperature-controlled

Service type:
- Scheduled (by origin and destination pairs)
- Tramp (unscheduled)

Mixed sea freight/passenger TOC characteristics:

Vessel types:
- Ro-Pax ferry (mixture of roll-on roll-off freight and passengers)

Vessel size:
- Varies by vessel type (refer to Table G.4 of ISO 14083)[9]

Service type:
- Scheduled (by origin and destination pairs)
- Chartered

Methodology alignment

In line with ISO 14083 we distinguish two ways to categorize vessels or services for the purpose of calculating GHG emissions: vessel-based categorization and service-based categorization.[9]

Vessel-based categorization

Based on the IMO's Fourth GHG Study, parameters such as freight type, vessel type, vessel size categories and freight condition (for fully temperature-controlled ships) can be combined into generally applicable TOCs for a vessel-based categorization. This vessel-based categorization method is particularly useful for charter services, where the vessel and its characteristics are known to both charter parties as they are fixed in the contract. As primary data is usually accessible in such a case, its use for calculating the GHG emissions of the sea transport is to be preferred. In all other cases, modeled or default data for the specific TOC can be used.

Service-based categorization

In cases where the specific vessel is not known to the transport service user, the service-based categorization can be used. This is often the case for container services, Ro-Ro services or Ro-Pax services. In such cases, the transport operator can usually provide information in the form of aggregated values that are representative for the specific transport service, based on the schedules in place.

In addition to ISO 14083, the GLEC Framework aligns with the following methodologies, with modifications as indicated.

Energy sources

IMO Energy Efficiency Operational Indicator[17]
- The IMO covers all forms of maritime transport and freight and provides default factors for various ships and energy sources.
- IMO values must be scaled from CO_2 to CO_2e.
- IMO does not specify use of fuel life cycle.

Clean Cargo Carbon Accounting Methodology[22]
- Clean Cargo covers only container ships though additional guidance may be offered in future.
- Operator-specific data per trade lane is available to Clean Cargo members.
- Specific guidance is available for calculating reefer energy consumption.

Requirements for sea transport calculations

Vessel

There is a unique opportunity for sea transport to improve the accuracy of emission calculations by finding more specific vessel information. Unlike the fragmented road sector, where millions of trucks carry goods, ships are well-catalogued and tracked, and public information on each vessel is available via the IMO's Global Integrated Shipping Information System.[75]

Continuing advances in digitization and data sharing within the maritime supply chain create more visibility on the actual vessel used to carry freight. This holds the potential to improve transparency in the supply chain and could build towards improved supply chain planning for shippers and LSPs, as refined vessel values based on carrier and/or vessel specific information will be key for tracking progress towards emission-reduction goals in the maritime sector. If a company invests more advanced shipping technology or using low sulfur energy sources and slow-steaming practices, the company wants its numbers to reflect it.

Shipment mass

For containerized transport, the number of TEU slots available onboard is the primary limiting factor and the unit used for booking. Therefore, TEU is a common unit used instead of mass or weight. For example, Clean Cargo trade lane emission intensity values are expressed as CO_2e per TEU. Conversion from TEU to tonnes is possible.

If the actual cargo mass per TEU is not known, a standard conversion factor of 10 tonnes per TEU may be used for a typical container; a conversion factor of 6 tonnes per TEU for lightweight cargo, and a conversion factor of 14.5 tonnes per TEU for heavyweight cargo can be applied with justification (see also Section 1 Chapter 2 Calculation Steps, The Calculation in an Overview).

Distance

- Calculation of transport activity distance for sea transport should be done using SFD or GCD, depending on available information.
- Specific sea transport distance calculators are available for accurate results. SFD can be estimated e.g., using online port-to-port calculators or via the Centre d'Études et de Recherches sur le Développement International (CERDI) Sea Distance Database.[76]
- Actual distance can be found in ship logbooks. Where this actual distance is used to calculate the emission intensity, a DAF needs to be applied in the subsequent calculation of GHG emisisons.
- The DAF should be based on the best available information and should be relevant to the transportation context. In the absence of a specific operational DAF, a default global value can be used. Clean Cargo recommends using a DAF of 1.15 since actual sea container transport distances were found to be on average 15% greater than the shortest feasible port-to-port route. Convert nautical miles to kilometers using factors in Annex Unit Conversions.

Mode-specific considerations

- As each TCE must be calculated separately before aggregation to a transport chain, for journeys with multiple legs you must also calculate the GHG emissions for each leg or element individually, before aggregation.
- For high frequency, regular, repeatable or short duration transport, it is common for the operator to aggregate a year's worth of operational data for transportation operations that occur during that time period.
- For charter operations in bulk shipping, quantify and report for specific journeys, as the data is identifiable for the individual journeys.
- When transporting freight with mixed temperature-controlled consignments, treat it as a single TOC and allocate GHG emissions between the ambient and temperature-controlled consignments based on the share of energy required to move the freight and the energy used to maintain the temperature-controlled freight within the required range.
- Treat mixed passenger and freight operations, typically for Ro-Pax ferries, as a single TOC and use passenger equivalents (peq) to estimate the allocation of emissions. These peqs are based on a combination of mass- and volume-based equivalents to provide balanced results.

Refer to the peq values reflecting the characteristics of TOCs as follows:[9]

Passenger transport:
- Individual passenger (including luggage): peq = 1.0
- Passenger car: peq = 1.3
- Bus/coach: peq = 10.0
- Caravan, small: peq = 1.1
- Caravan, medium: peq = 2.3
- Caravan, large: peq = 3.5
- Mobile home: peq = 3.5
- Motorcycle: peq = 0.3

Freight transport:
- Small van: peq = 1.3
- Large van: peq = 3.5
- Rigid truck: peq = 10
- Articulated truck: peq = 18
- Unaccompanied trailer: peq = 14

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2

Using emission results

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2 Chapter 1 Reporting emissions

Equally important as the calculation of GHG emissions, is their reporting. It is the tool with which an organization communicates its efforts and results of GHG emission reduction. It is therefore the purpose of GHG emission reporting to provide transparent and accurate information. Reporting also helps stakeholders, including investors, customers and regulators, to understand the organization's environmental impact and sustainability performance.

1. An overview of the basic principles

The guide "End-to-End GHG Reporting of Logistics Operations" published by the Smart Freight Centre (SFC) and the Global Logistics Emission Council (GLEC) jointly with the World Business Council for Sustainable Development (WBCSD) and the Partnership for Carbon Transparency (PACT), considers in detail opportunities, requirements and approaches for transparent and meaningful emission reporting.[1] It includes insights and needs identified in the years of cooperation between the SFC and its partner organizations.

Section 2 of the GLEC Framework provides companies with recommendations for standardized reporting of emissions in line with ISO 14083 in a more condensed form.[2] Companies that want to conform with the GLEC Framework must report at least the minimum elements listed in this chapter. However, if companies have more information about their GHG emissions that they are willing to share, they can refer to other reporting frameworks such as the afore mentioned End-to-End guide, the GHG protocol[3] CDP[4], and Science-Based Targets initiative (SBTi[5]) guidelines. The reporting requirements mapped out in the following sections refer to the external reporting of GHG emissions. Internal reporting for managerial purposes will usually require the inclusion of further details and specifications.

Please note that, while carbon offsets may be purchased as part of an organization's overall corporate social responsibility (CSR) strategy, they are not part of the GHG emission calculation and reporting under the GLEC Framework v3. Offsetting is a theoretical compensation for emissions but not part of the emissions caused by an organization and therefore not included in ISO 14083.

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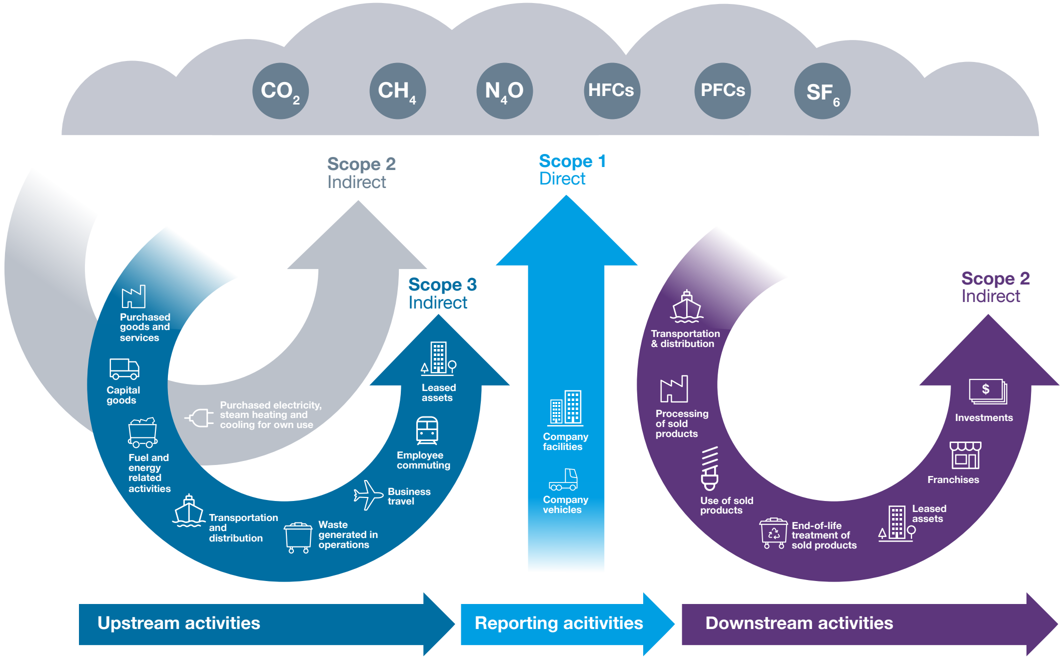
Figure 1
Scope 1, 2, and 3 according to the GHG protocol[3]



Reporting: the basics

Emissions should be reported using two key performance indicators (KPIs) in conjunction with each other:

- a total GHG emission value, which shows the scale of the overall impact as an absolute value, and
- a GHG emission intensity value, which links the emissions to the transport activity (for transport operators or service providers), or amount of product (e.g., for manufacturers or retailers), by setting these values in relation to one another.

If Paris Agreement targets for the transport sector are to be reached, a step-change reduction in both total emissions and emission intensity is needed.

Total emissions

Total emissions are important for reporting and tracking an organization's overall emissions from year to year. Total, or absolute, emissions, are often expressed as kg or tonnes CO_2e over a defined timeframe.

Emissions can be differentiated into:

- well-to-tank (WTT) emissions; referred to as **energy provision GHG emissions** within the GLEC Framework v3 and the ISO 14083, and
- tank-to-wheel emissions (TTW), also called tank-to-wake emissions; referred to as **operational GHG emissions** within the GLEC Framework v3 and the ISO 14083

Jointly, these two add up to the well-to-wheel, also called well-to-wake (WTW) emissions and they build the emissions of an entire transport chain element (TCE).

The GLEC Framework v3, like the ISO 14083, is based on the WTW concept, i.e., the inclusion of the entire emissions of a transport chain and its elements (see also Section 1 Chapter 1).

When calculating and reporting GHG emissions, there is another approach that is often linked to the reporting unit's scope, which includes Scope 1, Scope 2, and Scope 3 emissions. This is a fundamental concept that the GHG Protocol uses to categorize emissions (see also Introduction and Section 1 Chapter 1.

The GHG emissions accounted for in the GLEC Framework v3 and ISO 14083 are also included in the scopes of the GHG Protocol. However, there are differences in where the emissions are represented, depending on an organization's place in the value chain, so a direct comparison is not possible. The GHG Protocol considers all organization-related emissions from different stakeholders, distinguishing between an organization's direct owned emissions (Scope 1), indirect owned emissions (Scope 2), and indirect, value chain emissions (Scope 3).[3]

From a logistics service provider's (LSP) perspective, emissions from their own operated transportation assets and hubs are classed as Scope 1, for operational fuel-related emissions, or Scope 2, for electricity-related emissions. Related energy provision emissions are included in Scope 3, category 3 (Fuel- and energy-related activities), whereas operational and energy provision emissions for outsourced transportation are included in Scope 3, category 4 (Upstream transportation and distribution). From a customer's perspective all of these emissions are included in Scope 3, category 4.

Emission Intensity

Emission intensity is an important KPI to gain insight into the efficiency of transport and transport operations. Emission intensity metrics provide a numerical value to track, analyze and strategize emissions reduction. They also provide a pathway for companies to showcase efficiency in the face of business growth; e.g. an expanding business might show an increase in total emissions while reducing emission intensity.

Generally, reporting a KPI combination of total emissions and emission intensity values is always the best way to understand how far an improvement of transport efficiency and sustainability is achieved, e.g., by reporting a tonne-kilometer-based emission intensity KPI alongside total emissions.

Emission intensity values provide a numerical basis for carriers to communicate to customers and stakeholders their progress towards meeting emissions reduction targets over time. For example, if an operator invests in new electric trucks or consolidates its shipments to reduce partial loads, the energy efficiency will go up and the CO_2e intensity will go down.

Figure 2
Calculating emission intensity of transport operation categories (TOCs)

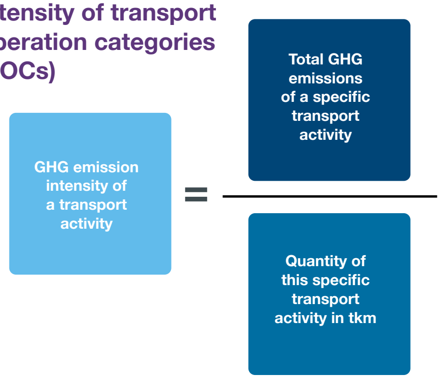
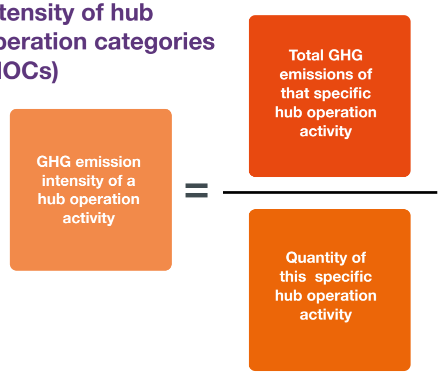


Figure 3
Calculating emission intensity of hub operation categories (HOCs)



Granularity

In the context of reporting GHG emissions, granularity refers to the level of detail at which data is reported or analyzed. It is the extent to which data is broken down into smaller or more specific components.

For example, in the case of reporting GHG emissions for transport and hubs, granularity may refer to the level of detail at which emissions are reported for different modes of transport, types of hubs, or specific transport or hub services. A high level of granularity would mean that emissions are reported in very specific detail, while a low level of granularity would mean that emissions are reported in more general terms.

The level of granularity chosen will depend on the goals of the reporting entity and the level of detail needed to support decision-making or communicate with stakeholders. In general, higher granularity can provide more detailed insights and support more precise decision-making, while lower granularity can make reporting and analysis more manageable and easier to communicate.

2. Basic reporting requirements

The basic requirements of reporting are necessary to ensure that the information provided is accurate, transparent and of high quality, as well as comparable and compatible between different actors. They therefore must be met when publishing reports or data.

Accordance with ISO 14083

It is of central relevance that all calculations and reporting are carried out in complete accordance with the GLEC Framework v3. If conformity with ISO 14083 is aimed for, reports need to mention explicitly the sentence "These calculation results have been established in accordance with ISO 14083:2023"[2].

Differences in or omissions or deviations from the calculation procedures as specified in ISO 14083 and the GLEC Framework v3 are to be avoided. Where they are unavoidable, they must be highlighted and justified, and their implications must be described in the report.

Transparency requirements

It is important to make sure that the reported GHG emission data is reliable and useful, and providing supporting information is essential to achieve this. This supporting information must be easy to access and understand for all users of the report. It should include a clear explanation of how the GHG emissions were calculated, and any GHG sources or transport and hub operations that were left out should be mentioned with an explanation of why they were omitted.

You also need to describe in detail how transport and hub operations were implemented, along with any other information necessary to understand the method.

Accuracy and data quality

To ensure transparency, an emission report should be clearly structured, and the data sourcing and calculation must be explained. ISO 14083 requires transparent reporting of modeled data or default GHG emission intensities used in calculations.[2] Each report should specify the quality of data used by indicating the share of primary and secondary data applied in the calculation of GHG emissions. For secondary data, the report should distinguish between the share of modeled and default data.[2]

If modeled data is used, the report must specify the type of model used and the parameters applied. If the share of primary and secondary data used for different TOC parameters (such as vehicle size category, filling rate and street category/topography) differs as input to a model, the report should indicate what the balance of data type is for each parameter. Furthermore, for each model it should be stated, which of the following parameters are included or not:[2]

- use of energy or activity-based model
- vehicle related: vehicle class and fleet profile, energy consumption profile, vehicle configuration (body type and empty vehicle mass, engine type, engine emission class, energy carrier used in vehicle, share of energy carrier)
- operational: freight type (freight requirements/characteristics, use of specific container types, load factor of average load expressed in tonnes, service type such as full truck load, less than truck load etc., extent of empty trips)
- journey characteristics: routing including locations of intermediate stops (route characteristics, location characteristics, direct/via locations/multiple collection and delivery), drive cycle (road type, urban/mixed/long-haul, frequency of stops, speed profile, topography), geographic region of applicability, currents/flowrate, head, cross or tail wind and windspeed, any additional parameters

When using default emission intensities, the report must specify the source of the default data and justify its use.

Frequency and format of reporting

Reports should be produced at least annually and more frequently when deemed necessary and relevant, such as during change processes or to evaluate different development scenarios. The report must specify the exact period covered.

There are different reporting formats that an organization can use, depending on its objectives and audience. The basic reporting format recommended by ISO 14083 covers data on the transport chains, the total of GHG emissions and GHG emission intensity, as well as the total of GHG emissions and emission intensity for TCEs of each mode of transport and for hub operations, as further presented below. Depending on the reporting format, additional elements may need to be included in the report.[2]

For more comprehensive reporting, organizations may choose to follow the SFC and WBCSD's End-to-End guide[1], or requirements for reporting as defined by the GHG Protocol,[3] CDP[4] or SBTi[5]. These frameworks require additional reporting elements beyond the ISO report (see also Info box Additional reporting requirements by other standards.)

It is recommended that organizations start with a basic report and then progress to more comprehensive reporting as they mature in their sustainability efforts and stakeholder engagement.

In either case, depending on practical issues, the report can take the form of either a single long report or a short report complemented with other information made available separately.[2] A single long report provides a comprehensive and detailed analysis of GHG emissions, which can be useful for stakeholders who require a more detailed understanding of the organization's or service provider's emissions. The alternative, a short report complemented with other information made available separately, can provide a summary of GHG emissions that is easier to understand for stakeholders who require a quick overview of the organization's or service provider's emissions. The form and scope of reporting should be determined based on the organization's or service provider's goals, the intended audience and purpose of the report, and practical considerations such as data availability and resources.

3. Reporting levels

Once the calculations have been completed, the results can be used to report and declare emissions. ISO 14083 provides two options for the level of reporting:[2]

- Reporting at the organizational level and
- Reporting at the level of transport or hub services

Reporting at the organizational level

The objective of organizational-level reporting is to reflect the GHG emissions resulting from transport and hub operations that are either used or provided by an entire organization or clearly defined parts of it.

This reporting format is suitable for both organizations that operate all transport services they use, as well as those that purchase a significant amount of transportation services and wish to report on the GHG emissions associated with their entire transport chain(s). It can be used for an entire organization or parts of it, such as business units, profit centers, geographical regions of operation, subsidiaries or any other relevant criteria.

This level of reporting requires a comprehensive and detailed analysis of emissions from all modes of transportation and operational services used by the organization, including the use of fuels, their provision and all associated emissions.

The report must include as basic information:[2]
1. the identification of the transport chains covered;
2. the absolute value of the total GHG emissions of the covered transport chains, including all related energy provision emissions;
3. the total GHG emission intensity of the entire covered transport chains, including all related energy provision emissions, specifying the type of transport activity distance used;
4. the total GHG emissions for each mode of transport, for each hub operation, and all related energy provision emissions included in the transport chains covered by the report;
5. the total GHG emission intensity for the TCEs of each mode of transport, of each hub operation, including all their related energy provision, specifying the type of transport activity distance used;
6. a reference specifying where all relevant supporting information can be found.

Reporting at the level of transport or hub services

The transport or hub service level report is suitable for service providers who want to report on the GHG emissions of a specific set of transport or hub services that they provide to a service user. This level of reporting requires a more focused analysis of emissions associated with the specific set of services provided.

When reporting at the level of transport or hub services, the report can either apply to a single TCE or to a set of TCEs that comprise part of or a full transport chain. The identification of transport or hub services covered by the report can either be done by listing all services included or by specifying the period of time during which they were provided and used.

The report requirements are similar to those for the report at operational level and must include as basic information:[2]
1. the identification of the TCE(s) or transport chain(s) covered;
2. the absolute value of the total GHG emissions of the covered TCEs, including all related energy provision emissions;
3. the total GHG emission intensity of the TCEs covered by the report, including all related energy provision emissions, specifying the type of transport activity distance used;
4. a reference, specifying where all relevant supporting information can be found;
5. the transport activity covered by the report, including a specification of the type of distance used;
6. the hub activity covered by the report;
7. GHG emissions related to all vehicle operations and hub operations;
8. the operational GHG emission intensity of transport operations and hub operations, and the transport activity distance used, or any other freight transport activity unit used (e.g., number of twenty-foot equivalent units (TEUs));
9. the total GHG emissions, transport activity and/or GHG emission intensities for each mode of transport and for each hub operation, specifying the type of transport activity distance used.

Furthermore, a report at the level of transport or hub services should include the following details to provide transparency and enable improvements of sustainability and efficiency of the operations:[2]

- *Split by hub and transport service:* All information provided needs to be split by hub or transport service they are related to.
- *Split total operational and energy provision GHG emissions:* The report must split the total GHG emissions into i) operational and ii) energy provision GHG emissions. Additionally, the report should provide a breakdown of GHG emissions by energy carrier.
- *Split of total GHG intensity per mode and hub:* When reporting GHG intensity, an average for the entire organization as well as of the intensity of each transport mode and hub must be provided.

When reporting GHG intensity, indicate the granularity of the categories used to group similar trips or logistics sites over a set period. This will help ensure that all emissions incurred are accounted for, even if there were empty trips.

The table below summarizes the basic reporting requirements and the **recommended requirements** of ISO 14083 for reporting GHG emissions at the organizational level and the level of transport or hub services:[2]

Reporting requirements	Organizational level	Transport or hub services level
Identification of transport chains/services	Report on all or part of transport chains operated or used by an organization	Identification of TCE(s) or transport chain(s) covered by the report
Reference to ISO 14083	Required	Required
Total GHG emissions	Required	Required
Total GHG emission intensity	Required, specifying the type of transport activity distance used	Required, specifying the type of transport activity distance used
Total GHG emissions for each mode of transport and hub operation	Required	Required
Total GHG emission intensity for each mode	Required, specifying the type of transport activity distance used	Required, specifying the type of transport activity distance used
Reference to the location of supporting info	Required	Required
Report Frequency	At least on an annual basis covering all operations performed or purchased during a 12-month period	At least on an annual basis covering all operations performed or purchased during a 12-month period
Data Quality	Specification of data quality applied (primary or secondary, modeled or default values)	Specification of data quality applied (primary or secondary, modeled or default values)
Specification of any deviation to standard processes	Required, including explanation for deviation and resulting impacts	Required, including explanation for deviation and resulting impacts
Additional Details strongly recommended	• Disaggregation of GHG emissions by mode of transport and by hub location • disaggregation of total GHG emissions into operational GHG emissions and energy provision GHG emissions • breakdown of GHG emissions by energy carrier.	• Disaggregation of GHG emissions by mode of transport and by hub location • disaggregation of total GHG emissions into operational GHG emissions and energy provision GHG emissions • breakdown of GHG emissions by energy carrier.

4. Tracking emission reductions in conformance with the GLEC principles beyond ISO 14083

There are many ways to calculate aggregated and mode-specific logistics GHG emission reductions on a year-on-year basis. In the following, KPIs under the principles of the GLEC are listed and explained:

- Reduction of absolute emissions
- Reduction of relative emissions
- Reduction of relative emissions in case no measured data for transport activity is available
- Reduction of relative emissions per mode of transport

KPI: Reduction of absolute emissions

This is a simple approach to measure a reduction in emissions by subtracting the previous year's total transport service-related GHG emissions in tonnes of CO_2e from the current year's total emissions:

Absolute year-on-year (YOY) GHG emissions change

= total current year emissions - total previous year emissions

Information value of the KPI: it communicates the overall bigger picture, and for reaching climate targets we need to reduce our overall transport emissions.

Limitation of information value: This absolute result does not reflect relative reductions of an organization's emissions, e.g., if an organization has grown in business and at the same time has improved its energy efficiency, then the absolute emissions could remain unchanged, despite this improvement in energy efficiency.

In addition to the calculation of the change in absolute emissions, it is therefore important to consider the change in relative emissions.

KPI: Reduction of relative emissions

For the identification of a structural reduction or avoidance of logistics emissions, it is important to put emissions into the context of actual transport activity (tkm) or hub operation activity of the reporting entity. This is particularly important for transport operators and service providers. If the relative number (e.g., emission intensity) in the current year is lower than in the previous year then this is evidence of structural emission reductions in logistics processes or avoided emissions in case of total activity growth.

For the calculation of the change in relative emissions, the following steps have to be carried out:

1. Take the previous year´s emission intensity value (in tonnes CO_2e/tkm)

2. Take the current year´s total transport activity (in tkm)

3. Multiply the previous year's emission intensity value by the current year's total transport activity;

Relative change in emissions in tonnes CO_2e = **Current year's total transport emissions** in tonnes CO_2e – **Current year's total transport activity** in tkm X **Previous year's emission intensity**

4. Calculate the absolute value of the current year's total emissions in tonnes CO_2e.
5. Subtract from the current year's actual emissions the value calculated in Step 3. The result is the relative change in emissions in tonne CO_2e.

Information value of the KPI: By multiplying the previous year's emission intensity value with the current year's total transport activity, you obtain the quantity of CO_2e that would have been emitted in the current year, had there been no change in emission intensity compared with the previous year.

If the resulting relative change in emissions in CO_2e is negative, this indicates that the emission intensity of the current year is lower than that of the previous year. The value of the "relative change in emissions" indicates the mass of CO_2e corresponding to the GHG emissions that have been avoided during the current year's activity compared to the previous year.

If the resulting value of the relative change in emissions is positive, this indicates an increase in the emission intensity. The value of "relative changes in emissions" indicates the tonnes CO_2e produced in addition to those that would have been generated had the emission intensity remained unchanged.

Limitation of information value: This relative value communicates the organization-specific improvement or decrease in energy efficiency and therefore emission intensity. However, to reach overall climate targets we also need to reduce total transport emissions. Therefore, it is important to calculate absolute as well as relative emissions.

KPI: In case no measured data for transport activity is accessible

Emission intensities based on activity data are most relevant for transport operators and logistics service providers. They can also be useful for the purchasers of transport services to understand the efficiency of their purchased transport. However, it is also possible, and potentially more relevant for shippers who don´t have access to such accurate transport activity data, to make a similar calculation using an emission intensity value based on another metric (e.g., tonnes CO_2e/t product, tonnes CO_2e/products sold) to allow for changes in business activity. The process is similar to that explained previously where the business activity for the current year is multiplied by the emission intensity of the previous year to calculate a notional baseline for the current year. This value is then compared with the total emissions for the current year.

Use of turnover as the alternative metric is discouraged as it is less closely related to actual logistics activities, as witnessed by the huge variations in market prices for logistics services in recent years.

Information value of the KPI: A YOYchange in emissions calculated using values such as the amount of transported goods instead of transport activity can give an idea of the development of the real emission intensity development over the considered period. It can be particularly beneficial if supply chain restructuring is taking place, as the impact of shortening or lengthening supply chains is taken out of consideration (as km is removed from the metric). It always remains an approximation though, and in particular if monetary values are included, inflation and changes in currency value can distort the information.

Limitation of information value: The value-calculated still needs to be considered alongside the total GHG emissions and can be impacted by many other factors, especially if a financial approach is taken (e.g., change in exchange rates, change in value of goods, change in market availability driving transport price fluctuations).

KPI: Per mode of transport

A similar approach can be followed to track emissions avoided per mode of transport by using emission intensity and transport activity data specific to each mode. Below is an example of road transportation.
Analysis by mode of transport is a very valuable additional KPI to render the development of transport efficiency transparent. This KPI is computed by using emission intensity and transport activity data specific to each mode of transport or for each hub. The calculation approach remains unchanged to the KPI for relative emissions: For this example of road transport, the emission intensity of the previous year is multiplied by the road-specific transport activity of the current year. In the next step, this product is subtracted from the total road transport-related emissions of the current year. The difference between the two values is the change in tonne CO_2e (road).

Relative change in emissions of road transport in tonnes CO_2e = **Current year's total road transport emissions** in tonnes CO_2e – **Current year's total road transport activity** in tkm X **Previous year's road emission intensity**

Information value of the KPI: Such an analysis allows us to distinguish the development of emission intensity of the different transport modes. It can be identified whether, for example, the emission intensity of train transport improved, while the emission intensity of road transport worsened. Further analysis can then be carried out on what the reasons for such changes might be (e.g. an increase in traffic jams.) The analysis in this case, therefore, would support the consideration of shifting transport from one mode to another with the perspective of an improvement of the overall emission intensity of the transport services used or provided.

If the resulting number is negative, this indicates that the emission intensity of this specific mode or hub during the current year is lower than during the previous year. The current year's mode-specific transport activity was carried out with a lower emission intensity than previously, and the value of the "relative change in emissions" indicates the mass of CO_2e corresponding to the GHG emissions that have been avoided.

If the resulting value of the relative change in emissions is positive, this indicates an increase in the specific transport mode emission intensity. The value of "relative changes in emissions" indicates the tonnes of CO_2e produced in addition to those generated had the emission intensity remained unchanged.

It communicates the overall bigger picture, and for reaching climate targets we need to reduce our overall transport emissions (considering changes in CO_2e intensity and allowing for a change in business and transport activity compared to the previous year.)

Limitation of information value: There is no specific limitation to the information value other than the quality of the available data.

Additional reporting requirements by other standards

A range of widely recognized approaches for GHG emission reporting exists. These can be distinguished into three groups:

- overarching global standards (e.g., ISO 14064, GHG Protocol, European Union Emissions Trading System (EU ETS))
- transport specific standards (e.g., GLEC, formerly EN 16258, ISO 14083)
- reporting initiatives (e.g., CDP, SBTi, Dow Jones Sustainability Index (DJSI)

In particular, the SBTi[5] and CDP[4] offer detailed guidance on establishing meaningful targets and accounting and reporting transport-related emissions in a meaningful way, thus supporting organizations in improving their reporting accuracy and transparency.

All these standards are in alignment with the principles and minimum requirements outlined in the GLEC Framework v3. Therefore, companies that adhere to these standards can be confident that they are meeting the necessary reporting criteria for freight transport-related emissions while also going above and beyond to improve their sustainability reporting more broadly.

By using these standards, companies can ensure that their reporting is credible, comparable and transparent, which can enhance their reputation with stakeholders and ultimately contribute to the transition towards a more sustainable transport sector.

These different methodologies and frameworks are interconnected and support each other in promoting sustainable and low-carbon accounting and reporting practices.

GHG Protocol[3]

The development of the GHG Protocol started in 1998 as a joint effort between the World Resources Institute (WRI) and the WBCSD. Its first version was published in 2001, and it has since become a globally recognized framework for measuring and managing emissions across various sectors. The protocol categorizes emissions into three scopes, as described in Section 1 Chapter 4 "Information and Requirements for the Individual Transport Modes and Hubs" of this document.

GHG Protocol guidance is part of SBTi's criteria and recommendations, as well as the base methodology for CDP reporting.

The GHG Protocol Corporate Accounting and Reporting Standard - Revised Edition provides guidance for companies reporting their GHG emissions.

Continued on next page...

Required information for Scope 1 and 2 accounting and reporting includes:

- Total Scope 1 and 2 emissions that are not related to GHG trades
- Separate emissions data for each scope
- Emissions data for all seven GHGs (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3) in metric tons and in tonnes of CO_2 equivalent. While GHG Protocol requires the splitting of the emissions, the other approaches only require a value for the combined CO_2e.
- For comparisons and target setting, a base year must be chosen and related policy measures have to be stated, along with a description of the related context so that any significant emissions changes in relation to the base year can be recalculated.
- Emissions data for direct CO_2 emissions from biologically sequestered carbon
- Methodologies used to calculate or measure emissions, including any calculation tools used
- Any sources, facilities and/or operations excluded from the inventory

For the calculation of Scope 3 emissions the GHG protocol provides The Corporate Value Chain (Scope 3) Accounting and Reporting Standard Supplement. It outlines required and optional information that companies should publicly report in their GHG emissions report. Required information includes:

- Scope 1 and Scope 2 emissions reported in conformance with the GHG Protocol Corporate Standard
- Total Scope 3 emissions reported separately by Scope 3 category (for full list of Scope 3 categories see the relevant CDP section)
- List of Scope 3 categories and activities included and excluded from the inventory with justification for exclusion
- For each Scope 3 category:
- Total emissions of GHGs (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3) reported in metric tons of CO_2e, excluding biogenic CO_2 emissions and independent of any GHG trades
- Any biogenic CO_2 emissions reported separately
- A description of the types and sources of data used to calculate emissions, and a description of the data quality of reported emissions data
- A description of the methodologies, allocation methods, and assumptions used to calculate Scope 3 emissions
- The percentage of emissions calculated using data obtained from suppliers or other value chain partners
- For comparisons and target setting, a base year must be chosen and related policy measures have to be stated, along with a description of the related context so that any significant emissions changes in relation to the base year can be recalculated.

SBTi Transport Target Setting Guidance[5]
The SBTi, a collaboration between CDP, World Resources Institute (WRI), the WWF and the United Nations Global Compact (UNGC), was formed in 2015 to establish science-based environmental target setting as a standard corporate practice. SFC and the SBTi have joined forces to collaborate and standardize greenhouse gas accounting, conventions and high-level principles to set global 1.5°C-aligned pathways for the transport industry.[7] The collaboration aims to update the SBTi Transport Sector Guidance d. It will develop new technical guidance, comprehensively update existing resources and define best practices for accounting, monitoring and reporting of transport emissions.

The transport guidance covers a range of end-users, including passenger transport companies, logistics service providers, shippers, carriers, postal companies, road vehicle manufacturers and companies with significant transport emissions in their value chain. It offers guidance on the transport categories it covers, the data required for target modeling, and the expected output. It also provides specific guidance for different end-users, such as those who control a fleet of vehicles or those who manufacture road vehicle parts. The guidance covers GHG emissions that an organization should estimate to model a target, including the aggregation of emissions scopes to obtain WTW emissions, definitions of activity units, approaches for setting science-based targets and the interpretation of results obtained with the Sustainable Development Agenda (SDA)

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Carbon Disclosure Project[4]

The CDP, started in the UK in 2002, has become a multinational NGO to which thousands of companies disclose their GHG emissions. CDP allows a range of protocols for reporting, and most companies report their GHG emissions to CDP using the GHG Protocol or a protocol based on it. Since 2018 the GLEC Framework has been recognized by CDP as a mechanism for calculating and reporting logistics GHG emissions as part of a broader corporate report.

In 2018, CDP released guidance on creating transportation emission intensity metrics.[8] In addition to reporting on emissions, CDP's questionnaire helps companies to evaluate the relevance of each category's emissions, assess the potential to collaborate with suppliers to reduce emissions and evaluate the risks associated with supply chain transport emissions.

CDP guidance includes provisions on how to consider transportation in Scopes 1 and 2, and detailed reporting requirements for each of the 15 categories in Scope 3 (listed below).[9] Of these categories, only five are included in the ISO standard, namely: 1. Purchased goods and services, 3. Fuel- and energy-related activities, 4. Upstream transport and distribution, 9. Downstream transport and distribution, 12. End-of-life treatment of sold products.

- **Category 1: Purchased goods and services.** This includes WTW emissions from transportation embedded in goods and services purchased by the reporting organization. These are cradle-to-gate emissions only; transportation from the supplier to the reporting organization is included in Category 4.
- **Category 2: Capital goods.** Like Category 1, this category contains WTW emissions for transport embedded to capital goods purchased by the reporting organization.
- **Category 3: Fuel- and energy-related emissions (not included in Scope 1 or 2.** Emissions related to the production and distribution of fuels (WTT) burned in Scope 1 are included here.
- **Category 4: Upstream transportation and distribution.** This category covers WTW emissions from outsourced logistics services used to transport or distribute products from tier 1 suppliers to organization facilities or transport between the organization's own facilities. These are generally services paid for by the reporting organization.
- **Category 5: Waste generated in operation.** This category includes WTW emissions related to logistics activities used in the disposal and treatment of waste from an organization's waste generated in Scope 1 activities.
- **Category 6. Business travel.** While transportation is central to this category, it is pertaining to the movement of people, not freight. While still important, it is not covered by the GLEC Framework.
- **Category 7. Employee commuting.** Same as for Category 6.
- **Category 8: Upstream leased assets.** WTW emissions from facilities or vehicles leased by the reporting organization, i.e., where the reporting organization is the lessee, are included here, if not already reported in Scope 1 or Scope 2.
- **Category 9: Downstream transportation and distribution.** This category contains WTW emissions from transportation and distribution of goods from the reporting organization and the end customer. In general, these are logistics services not paid for by the reporting organization.
- **Category 10: Processing of sold products.** WTW emissions resulting from the transport and distribution of sold products, e.g., by a stakeholder in the downstream value chain, are covered here.
- **Category 11. Use of sold products.** These include the lifetime transport emissions from the use phase of sold products. This may be particularly relevant for transport equipment manufacturers.
- **Category 12. End of life treatment for sold products.** Particularly important for the circular economy, transportation emissions from the disposal or treatment of a sold product are included here.
- **Category 13. Downstream leased assets.** WTW emissions from facilities or vehicles leased from the reporting organization, i.e., where the reporting organization is the lessor, are included in this category.
- **Category 14. Franchises.** WTW emissions related to transportation by franchises should be considered here.
- **Category 15. Investments.** WTW logistics emissions from investments made by the reporting organization should be tallied here.

Other relevant questions in the Scope 3 questionnaire include the following:

- **Evaluation status.** Determine the relevance of each category's emissions based on criteria noted in the *GHG Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard,* such as:
  - *Size of impact.* Use the GLEC Framework default factors to conduct a high-level assessment of supply chain transport required to distribute products, looking for hotspots by mode and region.
  - *Potential to influence reduction.* Examine the potential to collaborate with suppliers around emissions reduction, particularly in the identified hotspots.
  - *Demand by stakeholders.* Supply chain partners, investors and consumers are increasingly asking for transparency on environmental and social impacts on consumers and the general public, such as air quality and climate impacts from freight transport in urban areas.
  - *Risk.* Evaluate potential regulations or brand-related risks from supply chain transport emissions.
- **Emissions calculation methodology.** Let everyone know you used the GLEC Framework by listing it as the method used to calculate your freight transportation emissions.
- **Percentage of emissions calculated using data obtained from suppliers or value chain partners.** Use the guidance related to input data from the GLEC Declaration to determine percentages.
- **Explanation.** Additional useful information could be included in the explanation section, such as:
  - GLEC Framework data type
  - Sources of default data used
  - Notes on terminology, calculations, etc.

2 Chapter 2 Beyond reporting

Emission accounting and reporting is a tool and the purpose of the GLEC Framework is to support you in making the best use of it both for yourself, in optimizing the activities of your organization, and for all of us, in reaching climate targets. The GLEC Frameworks supports you in this in all the activities above. You've put in the effort to calculate and report emissions, and gained insight into emission hotspots from your freight activities — so now:

- Set targets
- Use carbon emissions reduction as a KPI
- Develop reduction plan
- Make your efforts visible
- Motivate staff
- Leverage sales and procurement
- Advocate for policy

Different aspects of this list might have a different relevance for your specific situation. It is important to start with a first step, regardless of how big or small it is.

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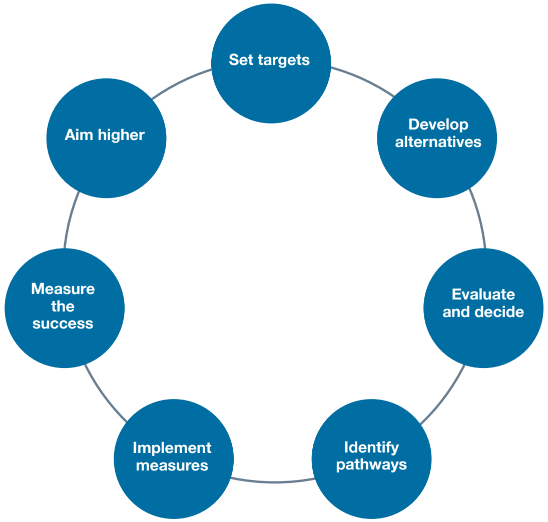
Figure 1
Emission accounting improvement cycle



Set targets

A recommended first step is to use your collected data to establish a baseline and set targets in line with the Paris Agreement targets of staying within 1.5°C of global warming. Develop goals based on both total emissions and emission intensity, ideally on a transport mode level. These goals help you to identify target values for your emission reduction efforts. Once these goals have been established, you can use the GLEC Framework to evaluate different alternative measures you could take and estimate which of those measures holds the potential to help achieve your goals. Once you have decided on the strategy you want to take, the GLEC Framework is also the ideal tool to establish intermediate goals and measure whether you are approaching those targets. Once you have reached your goals, set higher targets. It is important that the targets you set are the starting point for a continuous emission reduction process.

By establishing concrete targets not only for 2050, but also for the next 5, 10 or 15 years, it becomes easier to check if your organization is on track.

Use Carbon emission reduction as a KPI

Emission reduction targets need to be integrated into the management information system of your organization and they need to be supported at all levels of your organization, led by the directors. Sustainability, and with that the reduction of carbon emissions, should be a key element of your vision and strategy and needs to be supported by strong corporate policies favoring low carbon freight and logistics. Precise and regular emission accounting is an important tool to measure and optimize against your efficiency KPIs and minimize your GHG emissions. It enables you to:

- Track progress of emissions over time and against targets, and steer the management of emissions
- Evaluate different transport and logistics solutions and compare them
- Identify hot spots in your freight activities where efficiency improvements are most needed or where easily attainable areas for emissions reduction projects exist
- Hold logistics and operations directors accountable, by using carbon emissions as a KPI alongside cost, quality, timeliness, etc., in order to understand the climate implications of new technologies, shipping routes, carriers and other metrics, or to decide upon emissions reduction strategies, carbon offsets and other mitigation measures
- Compare yourself to others and determine where you can do better, share your experiences with others, or turn your efficiencies into something marketable
- Prepare for a low-carbon world by applying a fictive price or price range to emissions and use the carbon price as a parallel KPI in decision-making.

Develop a reduction plan

Five solution areas for reducing GHG emission have been identified by Professor Alan McKinnon: covering freight demand, freight transport modes, asset utilization, fleet energy efficiency and carbon content of energy.[29] The GLEC Framework supports you in identifying which measure of these areas helps you achieve your emission target. It helps you to identify the most pressing areas for action, as well as to prioritize measures and changes to your supply chain, transport and logistics network. Furthermore, it helps to determine if selected solutions are collectively sufficient to achieve corporate reduction targets.
What solutions companies can implement or influence depends on whether you are a buyer or supplier of freight services, or both.

Figure 2
Areas and approaches for reducing emissions in freight transport

Reduce freight transport demand	Optimize freight transport modes	Increase assets utilization	Improve fleet energy efficiency	Reduce carbon content of energy
Supply chain restructuring	Modal shift	Load consolidation	Cleaner and efficient technologies	Cleaner and lower carbon fuels
Standardized modules/boxes	Multi-modal optimization	Load optimization	Efficient vehicles and vessels	Electrician
3D printing	Synchromodality	Logistics centers and warehouse management	Driving behavior	Fuel management
Dematerialization			Fleet operation	
Consumer behavior			Fleet maintenance	

Source: McKinnon 2018 and GLEC

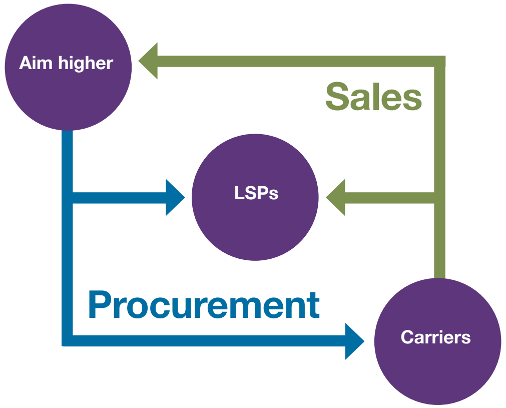
Make your efforts visible

The use of standardized GHG emission accounting is a valuable, respected and increasingly requested action for companies to render their sustainability efforts visible and to prove their commitment to meeting climate targets. In areas such as financing and insurance, as well as in tender processes, this commitment is taken into consideration for evaluation of organizations. Adopting the GLEC Framework v3, and therefore the ISO 14083, ensures that organizations are prepared for such demands and expectations from their stakeholders. It also equips them with a KPI corporates can share with their customers, who are increasingly looking for sustainably produced products and services.

Motivate your staff

The impact of learning about processes and procedures within your own organization in the course of the data collection for your emission accounting should not be underestimated. Many companies who introduced GHG emission accounting have reported that this analysis of transport and logistics processes in connection with the data collection has already resulted in insights about inefficiency and improvement potentials.

Figure 3
Sales and Procurement – powerful levers for emission reduction



Leverage sales and procurement

Two important business mechanisms to leverage carbon reduction, and where reliable emissions data are essential, are sales and procurement.

- **Sales.** If your organization is making sustainable investments such as electric vehicles, driver training and fuel-efficient routing, this information can be used to drive brand value as a provider or user of sustainable transport. Emission intensity KPIs, such as CO_2e per tonne-kilometer, provide information that allows your investments to be showcased and celebrated. This information, in turn, can be used as a KPI in logistics planning activities, such as choice of transport modes, routes or vehicle.
- **Procurement**. Just as you can provide GHG emission accounting information for your customers, you can also use the GLEC Framework in your procurement, to ensure that the services you purchase are aligned with your corporate values. The Smart Freight Procurement Guidelines document provides practical guidance on how to integrate climate into freight transport and logistics procurement practices.[10] The Guidelines suggest several actions to reduce GHG emissions that can be undertaken in the various procurement phases, i.e., planning, tendering, contracting and contract-based supplier management, with subcontracted transport chain operators such as freight forwarders, carriers and LSPs.

Advocate for policy

A main driver for companies to take charge of logistics emissions is to avoid governments imposing mandatory requirements. Companies can use results from emissions calculations to demonstrate that reduction efforts are successful. This is best done through voluntary reporting schemes or green freight programs. United States Environmental Protection Agency (US EPA) SmartWay, ObjectifCO_2 in France, and the Low Emissions Reduction Scheme in the United Kingdom are some examples.

With the ISO 14083 a norm that can be applied on a global scale is now available. This internationally applicable norm renders it possible for organizations to apply one GHG emission and reporting approach to all modes, all over the world. Using the GLEC Framework v3, which is fully aligned with this norm and with reporting programs such as CDP and SBTi, is therefore also a way of advocating for a universally aligned GHG emission calculation format.

A further use of emission data is to inform the development of national climate plans. Countries implementing the Paris Accords are responsible for developing and implementing an emissions reduction plan to collectively reach 2050 global temperature goals: < 1.5°C warming from pre-industrial times. Whilst transport as a whole is acknowledged in most Nationally Determined Contributions (NDCs), freight transport is often not explicitly referenced, nor are transport-specific targets set.[11,12]

Although the above picture is slowly changing, there is still a great potential to leverage industry's expertise and data on logistics emissions to enable more countries, regions and municipalities to better understand and reduce their logistics emissions. Through the sharing of data and aligning best practices with the principles of the GLEC Framework and GLEC Declaration, governments and industry can work together to track and meet 2050 climate goals.

2 Chapter 3
Outlook & the path towards global uptake

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ISO 14083 is a further step realized on the path towards global uptake of standardized transport chain GHG emission accounting and reporting. With its publication, the basis for a globally harmonized emission reduction effort is here. The GLEC Framework v3 renders this basis accessible for everyone. Furthermore, the GLEC, as platform for industry and experts, facilitates the necessary cooperation for further implementation. Next important steps are:

- Data quality assurance
- Data exchange
- Further alignment of emission tools and approaches
- Sustainability initiatives
- Assurance
- Policy
- Research and development

Data quality assurance

With a standard for emission accounting and reporting in place, it is important to develop guidance and assurance processes for data quality as a next step. Such data quality assurance protects companies' efforts from greenwashing by validating their efforts. Along with data exchange, these two steps are key for a global uptake, and one supports the other. Reliable and assured data quality is needed for data exchange. At the same time data exchange and big data is required for establishing meaningful default data basis.

Data exchange

Improved access to reliable data will help both business and governments make better decisions to collectively reach climate goals. To get there, improved data exchange and supportive programs, tools, initiatives, standards, policy and research are key. Access to good quality, preferably independently verified, data is a condition for transport operators and their customers to maximize the impact of applying the GLEC Framework. Data collection and sharing initiatives exist, such as Clean Cargo and SmartWay. For transport operators, particularly in the road freight sector, their customers, information technology system providers and operators of energy efficiency and emissions data platforms further efforts are needed to:

- Harmonize the approach to the collection of the data necessary for comprehensive and meaningful freight emissions KPIs.
- Develop consistent formats to enable data sharing between an interoperable network of platforms.
- Incorporate consistent reporting of carbon emissions, and hence the development and implementation of a widespread GHG emission reduction strategy.

We are already in a world of big data, and with digital technologies that coordinate the complex movement of millions of tonnes of goods each day, the amount of data is only going to increase. Digitization creates the breeding ground for new opportunities to design data-driven decarbonization strategies. To achieve that, data collection and exchange is needed. Smart Freight Centre is currently running the iLEAP project (Integrating Logistics Emissions and Product Carbon Footprints) which aspires to standardize the attributes for emissions and activity-related data exchange in logistics. Once this work matures and is widely adopted as a semantics blueprint, the use of the GLEC Framework would also naturally scale more globally across many geographies and industries. In addition, in an effort to research how can B2B data exchanges scale, the report of the SFC Exchange Network project[21] summarizes the conditions needed for technology, governance and assurance in establishing such an interoperable, decentralized industry-wide data exchange network.

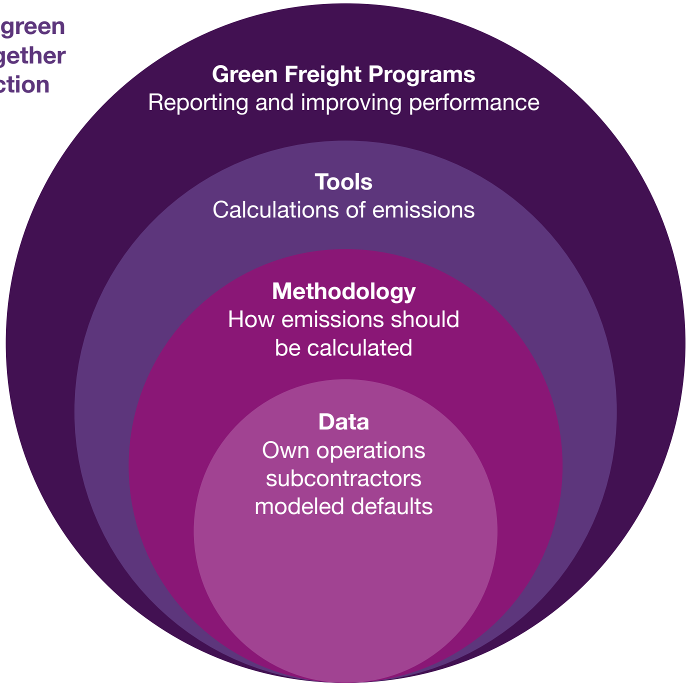
Further alignment of emission tools and approaches

Next to the alignment of data quality and its assurance, the further alignment of emission tools and approaches is an important step towards global uptake. The more programs are aligned, the more easily companies can improve their accounting and reporting, as they do not have to adjust to different requirements. Full alignment ensures transparency on emission accounting and reporting requirements. As one of these steps, the GLEC Framework has supported the development of the ISO 14083 and is now presenting itself in the third version fully aligned with this norm.

The GLEC Framework is, and has always been, a methodology, and not a calculation tool or program. Green freight programs promote sustainability within the logistics sector, often by engaging both the transport supplier and buyer.[13] These programs provide a pathway for industry to collaborate, share data and benchmark performance. Incentives such as awards, ratings and labels draw attention to good performance, encouraging reluctant companies to further invest in sustainability. Programs that include emission reporting either have their own tools, such as SmartWay, or prescribe a methodology for member companies to use, such as Green Freight Asia.

Companies and others who make use of external tools or programs should check with their providers whether their methodology is in conformance with the GLEC Framework v3 and ISO 14083. Those that are in conformance can be recognized though a Smart Freight Centre certification label.

Figure 1
Data, methods, tools and green freight programs work together to support emission reduction



Sustainability initiatives

A further effective way to realize widespread uptake of the GLEC Framework is through climate and sustainability initiatives that reach beyond the freight sector.

The CDP already recommends using the GLEC Framework for companies that report logistics emissions to the scheme.[14] It is also the basis of the SBTi's guidance for the transport sector, allowing companies to include logistics in their corporate targets.[15] The GLEC Framework is one of the actions of the Global Green Freight Action Plan, which is a transport initiative under the Marrakech Partnership for Global Climate Action of the United Nations Framework Convention on Climate Change.[16] All initiatives with a climate or sustainability focus, including socially responsible investment funds, are encouraged to follow suit.

The freight sector is not in control of its own destiny but merely responds to market demand. For that reason, mainstreaming the inclusion of logistics GHG emissions through the GLEC Framework and ISO 14083, into sectoral sustainability initiatives, is key. The electronics sector is leading the charge through inclusion of the GLEC Framework in the Electronic Product Environmental Assessment Tool (EPEAT) standards of the Green Electronics Council.[17] Similarly, it has been incorporated in guidance for container port terminals.[18] Ideally, product labels, such as for cotton, food and forestry products, will all assess whether logistics emissions is a blind spot.

Assurance

Many companies have started to disclose sustainability information such as GHG emissions in yearly reports or Business-to-Business declarations.

Assurance, in the form of verification of corporate emission calculations and claims and the certification of calculation tool methodologies, is important for these companies for two reasons: transparency towards others, and clarity and reliability towards their own management.

As far as transparency is concerned, independent assurance confirms to external partners and stakeholders that accounting and reporting are carried out reliably according to a specified norm. The assurance is confirmation to external partners of the efforts made by an organization. At the same time, such assurance supports customers to trust the reported emissions, and is the basis used by governments to establish policy measures.

Assurance also confirms that the GHG Emissions Report has been prepared based on an approved approach. As emission accounting is used as the basis for important strategy decisions by management, it is crucial to know that the methodology is correct, and the results have been verified.

SFC and the GLEC are supporting industry along the assurance path, by:
- Helping organizations to find a competent Verification Body,
- Providing a practical emissions reporting template that covers all of ISO 14083 (including guidance in the GLEC Framework),
- Offering high-quality training on Emissions Accounting and Reporting tailored to the Freight sector.

Policy

Supportive policy is essential to help business. It is already 10 years since a coherent set of policy recommendations was developed in consultation with government, industry and civil society representatives to ensure wide acceptability.[19] These recommendations are timely and relevant. They are grouped around four "enablers" of accounting and reporting:
- Methodology development for logistics emissions accounting
- Data collection and exchange
- Assurance of logistics emissions data and related information
- Use of results by business, government and other stakeholders

The objective is, through recommending policy priorities, to enable policy making that is aligned with both high-level targets and industry needs and activities. It can be used by national governments in countries worldwide, the European Commission, and related organizations involved in setting or implementing policy agenda such as development banks and non-governmental organizations.

Methodology development
- Back the GLEC Framework and now ISO 14083
- Back a single global set of fuel emission factors, including alternative fuels
- Support awareness and information campaigns for industry

Assurance
- Give companies incentives to collect high quality data and obtain assurance
- Explore assurance needs in case of mandatory reporting or carbon pricing
- Support standardized assurance guidance and reporting template

Data collection and exchange
- Back International Maritime Organisation (IMO)/ Internation Air Transport Association (IATA) protocols and alignment
- Support development of global (or EU) data exchange protocol(s)
- Explore development of neutral platform and IT architecture with a Transport Management System (TMS) link
- Take a more central role in data exchange

Use of results
- Establish national green freight programs
- Make government targets relevant to the sector
- Support industry surveys and recognition
- Include in NDCs/national plans: infrastructure, vehicles/vessels and their operation

Research

A lot has been achieved through the close cooperation between industry and research over the past years. Currently, climate change and its impacts are becoming more and more visible. We are all on a learning curve, learning from cooperation and developments that have already taken place, and the impact of our actions and non-actions. The journey to sustainability is therefore continuing and requires further adjustment and developments. Supportive research is important to inform and advance action by industry. Yet it is unclear what research is most needed on emission accounting and reporting. A research agenda was developed that recommends five areas of further research to:[19]

- Improve input data, emission calculation and disclosure across different modes, countries and industry sectors
- Standardize the way data is exchanged between parties, using protocols and platforms and updating transport management systems, and address trust issues between parties
- Extend emission calculations to include ICT, infrastructure, packaging and air pollutants
- Allow for emissions calculation as part of project and infrastructure planning and organization of the logistics supply chain

The aim is to help make informed choices when deciding what new research to carry out or fund. It can be used by national and international governments, as well as research institutes, industry and civil society. It is emphasized that efforts should involve industry, accompanied by pilots for testing and validation in cooperation with research institutes.

In conclusion

Society and your business need you to track and reduce carbon emissions from freight transport. We believe the GLEC Framework plays a crucial role in this by providing a common language to track climate impacts. Adopt the GLEC Framework and ISO 14083 today!

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3

Data

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3 Module 1 **Emission factors**

Emission factors play a crucial role in the calculation of transport emissions and the calculation of carbon footprint. They provide a consistent metric to convert the fuel and energy used to power freight transportation into greenhouse gas emission values.

You might think that one sort of fuel always causes identical emissions. This is not the case though. If tracked in any detail, the emission factor associated with fuel purchased on any particular day at a particular location would have a natural variability associated with it. This is because emission factors vary, depending e.g., on the nature of the original feedstock, the locations of production and consumption, the distribution mechanisms used, the energy inputs to and the nature of the production processes used. In general, conventional (i.e., fossil) fuels tend to be blends that originate from a mix of sources and processes developed over many years to ensure that they fit within the tolerances of the prevailing local fuel quality standards. As a result, it is not standard practice to try to put an exact figure on every batch of fuel. Instead, it is accepted practice to use representative values with the understanding that emissions will, over time, average out and match the representative value (assuming that it is truly representative). Variations in national fuel standards and local industrial energy efficiency can be identified in the figures quoted in some national emission factor databases.

Generally, variations tend to be relatively low and the potential feedstocks and production processes for conventional fuels are relatively well known. In contrast "new fuels," including some renewable fuels and fuels quoted as having low life cycle GHG emissions, tend to have a less well-established production process. They have a greater variability over the full life cycle as well as a wider range of possible feedstocks. Therefore, generalization of emission factors for biofuels is less appropriate and could lead to greater uncertainties and inaccuracies, at least under current market conditions. Full consideration of emission factors for "new fuels" can be necessary, even if this involves a time-consuming and costly process. This is applicable to pure biofuels as well as higher-blend products. It is not necessary for blends with relatively low percentages (5-10%) of biofuels with conventional fuels, which are commonplace.

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How we source the emission factors

It is vital that emission factors are based on the most credible sources and are developed by specialists. Full development of emission factors is outside the technical scope of the Global Logistics Emission Council (GLEC).

Instead, we make use of the best available sources in line with the approach developed for, and described in, Annex J of ISO 14083. The ISO 14083 approach recommends that the emissions associated with fuel and energy production infrastructure are included, although this is an approach which is not yet commonplace across emission factor sources.

The emission factors quoted in this GLEC Framework module are presented in the same layout as ISO 14083, i.e., the tables present CO_2e emissions for the well-to-tank (WTT), tank-to-wheel (TTW) and full well-to-wheel (WTW) phases of the fuel cycle. Values are shown by mass and energy content. Density is provided where appropriate so that emissions per volume can also be calculated, given that conventional liquid fuels are generally sold by volume. We include a value for non-CO_2 operational GHG emissions. Non-CO_2 operational greenhouse gases include methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6) and other fluorinated gases. We also include the biogenic CO_2 operational values for the bio-based fuels as required for a complete Scope 3 reporting under the GHG Protocol.

The input data is from the latest updates of the same sources. The sources that have seen significant revisions, namely the release of the, EcoTransIT methodology 2024, ecoinvent version 3.9.1 and the GREET 2023 annual update.

Additionally, the latest Global Warming Potential (GWP), Intergovernmental Panel on Climate Change (IPCC) AR6,[1] has been used to convert all the fuel emission factors to current CO2e. These are based on new values of GHGs, for the values in Annex K of ISO 14083, which is based on IPCC AR5.[2]

The use of ecoinvent 3.9.1 is particularly significant because its content was updated following identification of previously unknown/ unquantified high levels of methane venting direct to atmosphere in the fossil fuel extraction phase. The result is that the energy production (WTT) emissions are significantly higher, in some cases up to 50%, for fossil and fossil- derived fuels than previous energy production emission estimates.

We have taken all possible steps to provide a detailed starting point for companies wishing to calculate emissions in a harmonized and representative way. However, the higher energy provision (WTT) values that result from the ecoinvent update do highlight how easy it is for emission factors from different sources to become significantly misaligned with each other until consensus is re-established.

Because the emission factors of renewable fuels tend to have a much wider variability, the values quoted here tend to be conservative (i.e., at the higher end of the possible range). We encourage you to use the specific emission factor, backed up by the associated documentation, whenever you are able to identify the energy carrier you have used and when you have access to a certified emission factor for this product, provided by a reputable organization (e.g., RSB, International Sustainability & Carbon Certification (ISCC) that follows the emission factor guidance set out in Annex J of ISO 14083.

Methane slip

Methane is a potent greenhouse gas. Therefore, the potential for leakage of methane, in the upstream chain, the refueling and at the engine, must be taken into account when calculating the WTW emissions of compressed natural gas (CNG) and liquefied natural gas (LNG) fuels. Venting of methane from refueling the tank or at various points further up the supply chain is considered in the WTT component of the overall emission factor.

The TTW emissions must be considered in a slightly more complex way than for other fuels. The impact of any unburned fuel that is released to the atmosphere, known as “methane slip,” is calculated using the GWP of methane alongside the emissions that result from the combustion of the majority of the fuel. The extent of the methane slip varies according to the vehicle technology and any emission abatement technology that is fitted. Furthermore, the legislation that applies to engines used in different situations varies, with different limits on methane emissions applying by application, location and mode. The result is that it can be difficult to put a definitive value on emissions from the use of LNG or CNG. We have included a first estimate of methane slip and consequent impact on the TTW emissions, differentiating by engine technology where information is available.

National, regional and international values

The emission factors have been chosen with the aim of maximizing overlap with nationally published values, existing transportation standards and values used by the representative UN bodies for air and water transportation.

However, several countries including France, UK, Japan, Australia and Canada have published national emission factors. Emission factor guidance is also provided for air transport via Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), whilst the IMO published its own WTW emission factors . Much of this work has been conducted in partial isolation and may lead to confusion and uncertainty in the short term as to which values to use in the near future.

As increasing emphasis is placed on GHG emissions, it is likely that further, coordinated effort will be placed on developing a coherent and comprehensive set of GHG emission factors that can be used to enable consistent reporting from the global logistics sector such as the CLEVER project which is co-funded by European Union. Until that point, where specific emission factors are mandated in national or international legislation then they should be used and the values stated clearly in the explanatory notes, as it is not the role of the GLEC Framework to advise companies to act against the locally prevailing law.

For countries where there is no clearly stated emission factor, we recommend that you use the higher of the values quoted for the fuel in question in the China, European and North American tables, in order to avoid accidental understatement of the results.It is likely that all the emission factors will need to be further updated in subsequent versions of the Framework as knowledge of the subject develops further.

Emission factors: European sources

Energy carrier	Example application	Lower heating value *MJ/kg*	Density *kg/l*	GHG emission (operational/TTW) *g CO_2e/MJ*	GHG emission (total/WTW) *g CO_2e/MJ*	GHG emission (operational/TTW) *kg CO_2e/kg*	GHG emission (total/WTW) *kg CO_2e/kg*	Non-CO_2 GHG emissions (operational/TTW) *g CO_2e/MJ*	Biogenic GHG emissions (operational/TTW) in g CO_2e/g	Source
Gasoline		42.5	0.74	75.0	99.0	3.19	4.21	0.14	n.a.	ecoinvent v3.9.1[3]
Ethanol (40% maize, 35% sugar beet, 25% wheat)		27.0	0.78	0.1	48.0	0.00	1.30	0.14	1.91	ifeu, infras & Fraunhofer IML, 2024[18]
Diesel		42.8	0.83	75.3	97.8	3.22	4.19	1.16	n.a.	ecoinvent v3.9.1 cut-off[3]
Biodiesel (50% rapeseed, 40% used cooking oil, 10 % soybean)		37.0	0.89	1.2	35.4	0.04	1.31	1.16	2.83	ifeu, infras & Fraunhofer IML, 2024[18]
Liquefied Petroleum Gas (LPG)		45.5	0.55	67.0	90.1	3.05	4.10	0.23	n.a.	ecoinvent v3.9.1 cut-off[3]
Hydrogen (from SMR)		120.0	n.a.	0.0	101.3	0.00	12.16	0	n.a.	ifeu, infras & Fraunhofer IML, 2024[18]
HVO*/ HEFA (SAF) (50% rapeseed, 50% used cooking oil)		44.0	0.77	1.2	29.7	0.05	1.31	1.16	3.12	ifeu, infras & Fraunhofer IML, 2024[18]
Electricity European average (EU 27, 2021, including average losses)		n.a.	n.a.	0.0	99.0	n.a	n.a	n.a	n.a.	ifeu, infras & Fraunhofer IML, 2024[18]
Compressed Natural Gas (CNG)	Europe spark ignition truck	49.2	n.a.	56.1	77.1	2.76	3.79	0.94	n.a.	ifeu, infras & Fraunhofer IML, 2024[18]

Continued on next page

Emission factors: European sources

Energy carrier	Example application	Lower heating value *MJ/kg*	Density *kg/l*	GHG emission (operational/TTW) *g CO_2e/MJ*	GHG emission (total/WTW) *g CO_2e/MJ*	GHG emission (operational/TTW) *kg CO_2e/kg*	GHG emission (total/WTW) *kg CO_2e/kg*	Non-CO_2 GHG emissions (operational/TTW) *g CO_2e/MJ*	Biogenic GHG emissions (operational/TTW) in g CO_2e/g	Source
Liquefied Natural Gas (LNG)	Europe spark ignition truck	48.0	n.a.	57.4	83.1	2.75	3.99	0.93	n.a.	ifeu, infras & Fraunhofer IML, 2024[18]
Bio-CNG (40% maize, 40% manure, 20% biowaste)	Europe spark ignition truck	50.0	n.a.	0.9	25.7	0.05	1.28	0.93	2.86	ifeu, infras & Fraunhofer IML, 2024[18]
Bio-LNG (40% maize, 40% manure, 20% biowaste)	Europe spark ignition truck	50.0	n.a.	0.9	29.8	0.05	1.49	0.93	2.86	ifeu, infras & Fraunhofer IML, 2024[18]
Liquefied Natural Gas (LNG)	otto duel fuel ship (medium speed)	48.0	n.a.	77.6	96.1	3.73	4.61	20.33	n.a.	IMO MEPC 81[28]
Liquefied Natural Gas (LNG)	otto duel fuel ship (slow speed)	48.0	n.a.	67.5	86.0	3.24	4.13	10.20	n.a.	IMO MEPC 81[28]

^ Factors based on long distance/heavy duty road transport only, as LNG is not recommended for light duty/urban distribution.

- GHG emission factors for biofuels can vary considerably according to feedstock mix and process. Certified waste stream feedstocks can lead to low or even negative emission factors under certain circumstances; emission factors need to be carefully checked in such circumstances to avoid unintended consequences and overstatement of emission reduction benefits.
- Bio-LNG and bio-CNG based on GHG reduction threshold to qualify under the Renewable Energy Directive II (RED II.)[8]
- Emission factors sourced from ecoinvent v3.9.1 and the European electricity emission factor above are the only ones confirmed to include fuel and energy production infrastructure in the WTT element as this is a new requirement.
- Electricity emission factor above is from a different source to that used to calculate EU rail default emission intensities as we are unable to quote the IEA values here.

Emission factors: North American Sources

Energy carrier	Lower heating value *MJ/kg*	Density *kg/l*	GHG emission (operational/TTW) *g CO_2e/MJ*	GHG emission (total/WTW) *g CO_2e/MJ*	GHG emission (operational/TTW) *kg CO_2e/kg*	GHG emission (total/WTW) *kg CO_2e/kg*	Non-CO2 GHG emissions (operational/TTW) *g CO_2e/MJ*	Biogenic GHG emissions (operational/TTW) in g CO_2e/g	Source
Gasoline	41.7	0.749	73	89.6	3.04	3.74	0.30	n.a.	GREET 2023[9]
Ethanol (corn)	27	0.789	0.33	55.9	0.01	1.51	0.33	1.91	GREET 2023[9]
Diesel	42.6	0.847	75.7	90.9	3.22	3.87	0.82	n.a.	GREET 2023[9]
Biodiesel (soybean)	37.7	0.881	0.78	22.0	0.03	1.17	0.78	2.83	GREET 2023[9]
HVO (tallow)	44	0.779	0.78	18.3	0.03	0.80	0.78	3.12	GREET 2023[9]
Liquefied Petroleum Gas (LPG)	46.6	0.508	64.8	77.8	3.02	3.63	0.30	n.a.	GREET 2023[9]
Electricity US average (including average losses)	n.a	n.a.	0	104.3	n.a	n.a	n.a	n.a.	USEPA eGRID Summary Tables, 2022[10]
Compressed Natural Gas (CNG)- North America Spark ignition truck	47.1	n.a.	57.4	74	2.70	3.49	1.20	n.a.	GREET 2023[9]
Liquified Natural Gas (LNG)- North America spark ignition truck	48.6	n.a.	57.6	76.6	2.80	3.72	1.10	n.a.	GREET 2023[9]

Emission factors: China sources

Energy carrier	Lower heating value *MJ/kg*	Density *kg/l*	GHG emission (operational/TTW) *g CO_2e/MJ*	GHG emission (total/WTW) *g CO_2e/MJ*	GHG emission (operational/TTW) *kg CO_2e/kg*	GHG emission (total/WTW) *kg CO_2e/kg*	Non-CO2 GHG emissions (operational/TTW) *g CO_2e/MJ*	Biogenic GHG emissions (operational/TTW) in g CO_2e/g
Gasoline	43.1	0.74	69.8	92.0	3.01	3.96	1.86	n.a.
Diesel	42.7	0.83	73.8	96.2	3.15	4.10	1.18	n.a.
Liquefied Petroleum Gas (LPG)	50.2	0.54	63.7	85.7	3.20	4.30	1.90	n.a.
Electricity - China Average	n.a	n.a	n.a.	158.4	n.a.	n.a.	n.a.	n.a.
Liquified Natural Gas (LNG) - China spark ignition truck	44.2	0.42	65.4	93.2	2.89	4.12	3.56	n.a.

- China fuel emission factors are mainly calculated based on the official data and aligned with latest IPCC AR6 GWP100. Electricity values are based on grid emission factors from China.
- European fuel emission factor (TTW to WTW ratio) from the GLEC Framework 3.0 have been used to uplift the TTW to WTW values for China emission factors.

GHG Emissions from Electricity

The understanding of what is included in an electricity GHG emissions factor, primarily based on ISO 14083 requirements can be seen in Figure 1. This entails different electricity stages upstream (fuel production) and combustion (power generation) emissions. As the figure points out, part of the electricity is used for own-use, load-balancing (e.g. by pumping), and trade. Transmission and distribution losses are the difference between supplied and consumed electricity. The larger arrows in the figure represent larger amounts of electricity available, and their darker color represents a "dirtier" mix, so a higher carbon intensity of electricity

For Europe, Figure 2 represents the GHG emissions factors from different types of energy sources. The fossil-fuel-powered electricity mix will have a higher emission factor than renewable and nuclear-powered. The figure provides more information on upstream emissions (up to 100 gCO_2e/kWh)) for fossil fuels (or 10 to 20% of the total) should be included in the calculation. On the other hand, the emissions from renewable power generation infrastructure range from 10 to 40 gCO_2e/kWh. The emissions from this will only become a significant portion of the total when the share of renewable energy is high. For example, if the energy consumption is based on half natural gas and half solar PV, the emissions from sole infrastructure would constitute 9% of total. (SFC. Measuring and Reporting the Carbon Footprint of Electric Freight Vehicle Operations: Whitepaper. 2024.)[35]

Considering the trade of electricity, which drastically changes the consumption emission factor, depending on the average power generation emission factor of the exporting and importing country. Taking an example, the electricity emission factor of Estonia in 2019 dropped by one third due to the import of predominantly low carbon electricity. The amount and type of energy traded can drastically change from year to year, such as when there is a shortage in natural gas.

Average transmission and distribution (T&D) losses varies depending on type of voltage distribution (i.e., low to high voltage grid connections). The final consumption at high and medium voltage sites are about 1 to 10% lower than at low voltage sites, reflecting about 1 to 78 g CO_2e per kWh of consumption as compared to the EU average which is 3 to 4% and 15 to 19 g CO_2e per kWh of consumption. Most databases typically provide a national average for the T&D losses, which is suitable for emissions disclosure.

Figure 1

Carbon intensity from upstream activities to consumption (Moro & Lonza, 2018)

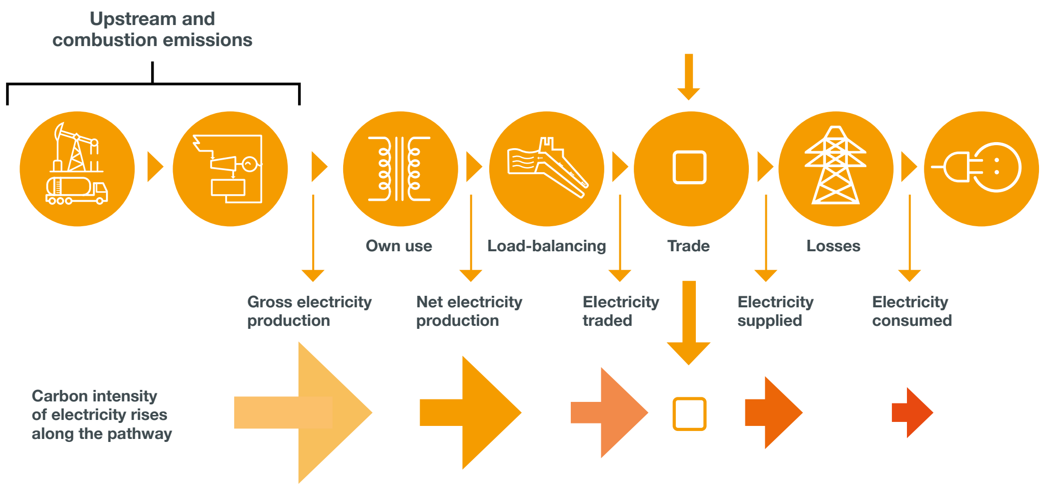
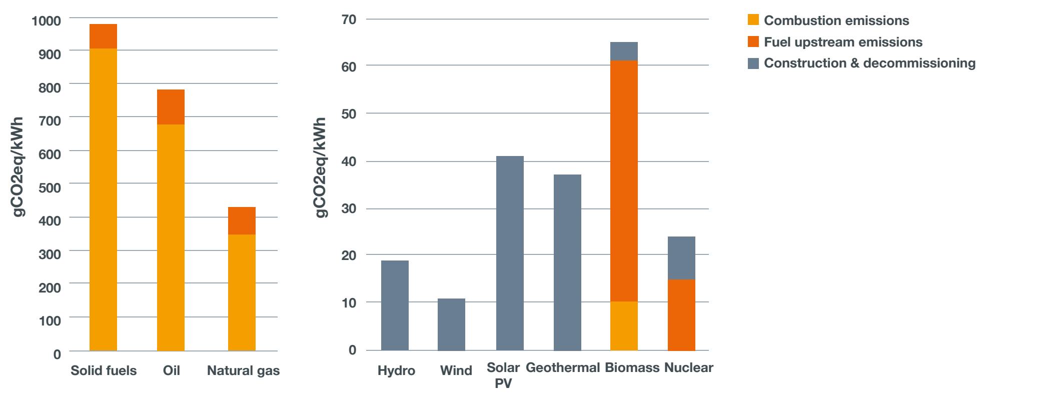


Figure 2

GHG emission factors from electricity producing facilities in EU27 (Scarlat et al.,2022)



The final consumption emission factor provides the most appropriate basis to then compare the emissions intensity of an EV and diesel truck. Figure 3 provides a country-level comparison for emissions from electricity consumption in European countries in 2019 (Scarlat et al., 2022), as well as a comparison with the emission intensity of a diesel truck (Smart Freight Centre, 2019).[38] The values include fuel production, power generation, infrastructure, trade, and transmission & distribution losses. The analysis shows that approximately half provide an electricity emission factor less than that of a diesel truck, and only 8 countries reduce emissions by at least 50%. An EV operating within the EU-27 would have an emission intensity reduction of 16%. In the US, based on eGRID subregion 2021, which does not include the effects of fuel production and infrastructure, only 3 out of 27 regions provide an emissions reduction of more than 25%.

Figure 3

Full electricity emission factor for European countries in 2019 (Adapted data from Scarlat et al., 2022)

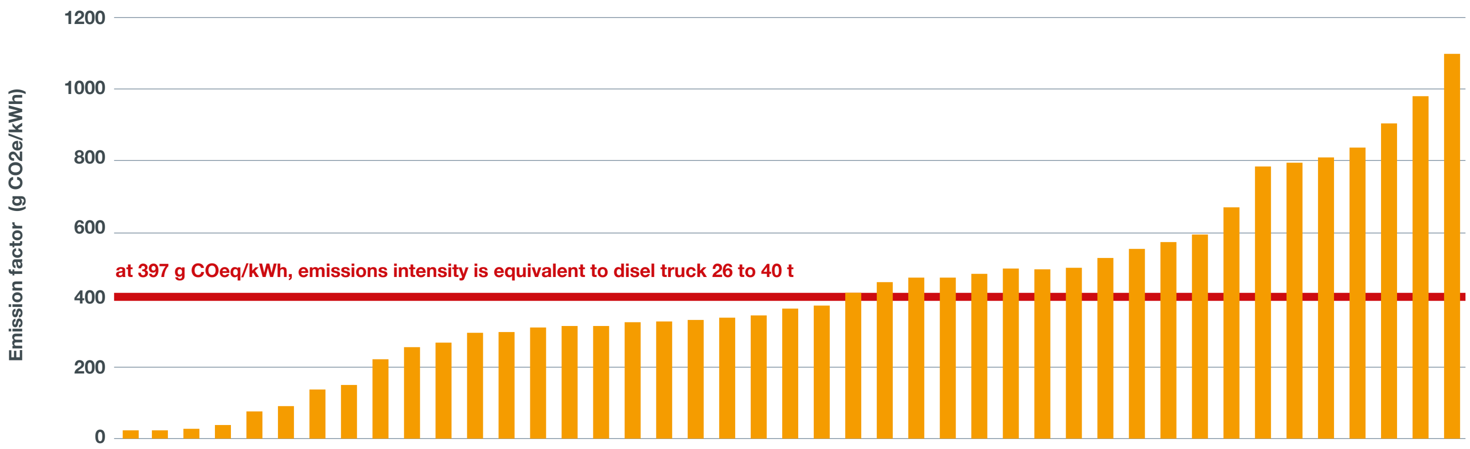


Table 1 compares several prominent databases. ISO 14083 recommends using the best available national GHG emission factors. Considering reporting of the global footprint of Electricity, the IEA emission factor database, which is updated annually would have seemed to be sufficient. However, based on Table 1, the database does not include the full spectrum of emission categories for electricity such as emissions from fuel production.

Other national databases or emission factors, such as supplied by the Dutch, UK and US government include power generation, trade effects, and transmission and distribution losses.The Dutch database, however, provides the fuel production emission factors, and as reference the emissions from infrastructure, based on the analysis CE Delft (2022).[40]

EcoTransIT World (2024) and Ecoinvent v3.9.1 provides emission factors at the country-level, with electricity mix based on generation and consumption.

Table 1
A comparison of selected emission factor sources

Emission factor source	Scope	Emission factor units	Fuel production	Power generation	Power generation infrastructure	Transmission and distribution losses	Trade included
IEA Emission Factors (annual)[39]	Global scope, regional and country-level	gCO_2e/kWh	No	Yes	No	Yes	Yes
Netherlands Government's CO2 Emissiefactoren	Netherlands	gCO_2e/kWh	Yes	Yes	Yes	Yes	Yes
UK Government's Greenhouse gas reporting conversation factors 2023	UK	gCO_2e/kWh	No	Yes	No	Yes	Yes
eGrid 2022[10]	US, eGrid regions	Lb or kg $gCO_2e/kWhh$	No	Yes	No	Yes	Yes
EcoTransIT 2024	Global scope, regional and country-level	gCO_2e/kWh	Yes	Yes	Yes	Yes	Yes
Ecoinvent v3 9.1	Global scope, regional and country-level, division by low, medium and high voltage network	$kgCO_2e/kWh$	Yes	Yes	Yes	Yes	Yes

Marine Fuel Emission Factors

Energy carrier	Example applications	Lower heating value *MJ/kg*	GHG emission (operational/TTW) *g CO_2e/MJ*	GHG emission (total/WTW) *g CO_2e/MJ*	GHG emission (operational/TTW) *kg CO_2e/kg*	GHG emission (total/WTW) *kg CO_2e/kg*	Non-CO_2 GHG emissions (operational/TTW) *g CO_2e/MJ*	Biogenic GHG emissions (operational/TTW) in gCO_2e/g	Source
HFO (VLSFO)		40.2	78.7	95.5	3.16	3.84	1.26	n.a.	IMO MEPC 81[28]
HFO (HSHFO)		40.2	78.7	92.8	3.16	3.73	1.26	n.a.	IMO MEPC 81[28]
LFO (ULSFO)		41.2	77.7	90.9	3.20	3.75	1.23	n.a.	IMO MEPC 81[28]
LFO (VLSFO)		41.2	77.7	90.9	3.20	3.75	1.23	n.a.	IMO MEPC 81[28]
MDO/MGO (ULSFO)		42.7	76.3	94.0	3.26	4.01	1.19	n.a.	IMO MEPC 81[28]
MDO/MGO (VLSFO)		42.7	76.3	90.7	3.26	3.87	1.19	n.a.	IMO MEPC 81[28]
LPG (propane)		46.3	65.9	73.7	3.05	3.41	1.10	n.a.	IMO MEPC 81[28]
LPG (butane)		46.3	66.5	74.3	3.08	3.44	1.10	n.a.	IMO MEPC 81[28]
LNG	Otto dual fuel (medium speed)	48.0	77.6	96.1	3.73	4.61	20.33	n.a.	IMO MEPC 81[28]
LNG	Otto dual fuel (slow speed)	48.0	67.5	86.0	3.24	4.13	10.20	n.a.	IMO MEPC 81[28]
LNG	LNG Diesel	48.0	58.8	77.3	2.82	3.71	1.47	n.a.	IMO MEPC 81[28]
LNG	LBSI	48.0	72.6	91.1	3.48	4.37	15.26	n.a.	IMO MEPC 81[28]
LNG	Steam turbine & boilers	48.0	58.0	76.5	2.78	3.67	0.68	n.a.	IMO MEPC 81[28]
Bio-LNG	Otto dual fuel (medium speed)	50.0	19.6	48.5	0.98	2.43	19.62	2.86	IMO MEPC 81[28] and ifeu, infras & Fraunhofer IML, 2024[18]
Bio-LNG	Otto dual fuel (slow speed)	50.0	9.8	38.7	0.49	1.94	9.84	2.86	IMO MEPC 81[28] and ifeu, infras & Fraunhofer IML, 2024[18]
Bio-LNG	LNG Diesel	50.0	1.4	30.3	0.07	1.52	1.42	2.86	IMO MEPC 81[28] and ifeu, infras & Fraunhofer IML, 2024[18]
Bio-LNG	LBSI	50.0	14.7	43.6	0.74	2.18	14.73	2.86	IMO MEPC 81[28] and ifeu, infras & Fraunhofer IML, 2024[18]
Bio-LNG	Steam turbine & boilers	50.0	0.7	29.6	0.03	1.48	0.65	2.86	IMO MEPC 81[28] and ifeu, infras & Fraunhofer IML, 2024[18]

Marine Fuel Emission Factors

Energy carrier	Example applications	Lower heating value *MJ/kg*	GHG emission (operational/TTW) *g CO_2e/MJ*	GHG emission (total/WTW) *g CO_2e/MJ*	GHG emission (operational/TTW) *kg CO_2e/kg*	GHG emission (total/WTW) *kg CO_2e/kg*	Non-CO_2 GHG emissions (operational/TTW) *g CO_2e/MJ*	Biogenic GHG emissions (operational/TTW) in gCO_2e/g	Source
Biodiesel (FAME)		37.2	1.4	22.2	0.05	0.82	1.36	2.83	Fuel.EU Maritime amended[7] & RED II[8]
HVO		44.0	1.2	16.1	0.05	0.71	1.15	3.12	Fuel.EU Maritime amended[7] & RED II[8]
Hydrogen	From Natural gas	120.0	0.0	132.0	0.00	15.84	0.00	n.a.	Fuel.EU Maritime amended[7] & RED II[8]
Ammonia	From Natural gas	18.6	0.0	121.0	0.00	2.25	0.00	n.a.	Fuel.EU Maritime amended[7] & RED II[8]
Methanol	From Natural gas	19.9	68.3	100.6	1.36	2.00	-0.81	n.a.	Fuel.EU Maritime amended[7]; RED II[8]; & ifeu, infras & Fraunhofer IML, 2024[18]
Bio-methanol		19.9	0.2	16.4	0.00	0.33	0.19	1.38	Fuel.EU Maritime amended[7]; RED II[8]; & ifeu, infras & Fraunhofer IML, 2024[18]
Bio-ethanol		26.8	0.1	48.0	0.00	1.29	0.14	1.91	Fuel.EU Maritime amended[7]; RED II[8]; & ifeu, infras & Fraunhofer IML, 2024[18]

The GHG emission factors presented is based on the latest IMO GHG data as published in the output from MEPC81. Where MEPC81 has not provided a necessary data point as input to the calculation this data has been sought from the final Fuel.EU regulation. If there is still an input data gap then the required data has been sourced from an alternative, well-established, peer-reviewed source for GHG emission factors that follows the approach set out in ISO 14083 and used in the GLEC Framework.

- The calculation here uses the latest IPCC global warming potential (GWP) 100 Interim Assessment Report (AR 6) 2023 as compared to IMO and Fuel. EU calculations, which we believe IMO will update to latest values at some point.
- Viscosity is the primary variable that defines a fuel within the IMO fuel oil classifications. Within each viscosity class there are subdivisions based on sulfur content which is why the terms ULSFO and VLSFO recur repeatedly in the fuel names. It would be helpful if the IMO tidied up t this naming convention
- LFO and LPG are lower due to a lower WTT contribution to the total; potentially due to the new source (Fuel.EU) lagging on acknowledging the latest knowledge on methane emissions in the production phase.
- LNG and Bio-LNG in dual fuel medium speed engines are higher as the latest IMO value is higher than in earlier drafts or in Fuel.EU
- Biodiesel (FAME) and HVO are lower as IMO now includes WTT values that were not previously present and which are lower than the RED II values included previously.
- The IMO or Fuel.EU do not have complete emission factor estimates for production of hydrogen or ammonia from non-fossil fuel sources and limited emission factor estimates for methanol or ethanol.

Air Fuel Emission Factors

Energy carrier	Lower heating value MJ/ kg	Density kg/l	GHG emission (operational/TTW) g CO2e/MJ	GHG emission (total/WTW) g CO2e/MJ	GHG emission (operational/TTW) kg CO2e/kg	GHG emission (total/WTW) kg CO2e/kg	Non-CO2 GHG emissions (operational/TTW) g CO2e/MJ	Biogenic GHG emissions (operational/TTW) in gCO2e/g	Source
Jet Kerosene (Jet A1 and Jet A)	43.1	0.802	73.9	89.0	3.18	3.84	0.74	n.a.	Revised Calculations

In air transport context, GHG emission factors provide a consistent metric to convert the fuel/ energy used on board to transport freight or passenger into GHG emission values. The efforts were made previously to align the emission factors between GLEC framework and relevant IATA recommended practices. This was on a tank to wheel (TTW or operational emission) basis and only covered the CO_2 component of GHG emissions. However, with wider acknowledgement of well to wheel/wake, CO_2e reporting, for example via the release of ISO 14083, together with the uptake of SAF in the aviation sector means that the time has come to realign emission factors across the GLEC Framework and the IATA recommended practices. There are clear differences between the North American and European values, stemming from multiple sources that may reflect geographical variations in input data and fuel production processes, as well as methodological differences.

In the near short term, we believe that for aviation it would be pragmatic, to adopt a single set of emission factors for use irrespective of geography while efforts are ongoing to align the scope, input data and methodologies across emission factor databases across modes at international level.

Notes about main sources

ecoinvent
ecoinvent is a not-for-profit association based in Zurich, Switzerland. Its main activity is the publication of the ecoinvent database, which is used worldwide as a background database in LCA and other environmental assessments including a comprehensive set of emission factors for a range of energy carriers. The latest database, version 3.9.1 contains various updates including expanded data on the global production of natural gas and crude oil. The update also integrates data on the flaring of natural gas from the Global Gas Flaring Reduction Partnership (GGFR) of the World Bank and on methane emissions from gas venting and fugitive emission source from the International Energy Agency's Methane Tracker 2022. In combination with an update to the regional consumption mixes for crude petroleum oil to North America and Europe this has led to a significant change in the energy production emissions for fossil fuels.

GREET
The vast majority of the North American values are derived from the 2023 GREET model published by Argonne National Laboratory.[9] The values in GREET are presented for the various phases of fuel production and use for a wide range of vehicle types.

IFEU/EcoTransIT
The applied calculation method closely follows the methodological rules of the RED and RED II, extending the scope from greenhouse gas emissions to include non-GHG pollutants. The tool used for this was created as part of the BioEm project11 and adapted for the purposes here in the databases. It includes direct and upstream emissions from cultivation, processing and transport of raw materials, intermediate products and biofuels to the filling station.
The BioEm tool also enables the inclusion of emissions from land-use change. However, this was excluded for the emission factors determined here. The reason for this is the lack of consensus among experts on an agreed methodological approach. This would have to be revised for future updates, as factors for land-use change have been recently published with the CORSIA emission factors,4 meaning such factors now enter into general use.

IMO MEPC 81
These guidelines provide the GHG intensity assessment for all fuels and other energy carriers (e.g. electricity) used on board a ship and aim at covering the whole fuel life cycle (with specific boundaries) from feedstock extraction/cultivation/ recovery, feedstock conversion to a fuel product, transportation as well as distribution/bunkering, and fuel utilization on board a ship. The scope includes well-to-tank (WTT), tank-to wake (TTW), and well-to-wake (WTW). The GHG emissions are calculated as CO_2-equivalent (CO_2e), using the global warming potential (GWP100) as per the fifth IPCC Assessment Report,

Biofuel Blends

In many countries national regulations specify a minimum and/or maximum content of biofuel to be mixed with fossil fuel. It is recommended that GHG emission factors for such fuels are calculated based on the percentage composition of the fuel. This may be defined by energy content, volume, or mass according to the local legislation. Because of the variation in legislation from country to country it is not possible to provide a comprehensive list of such emission factors. However, the following tables does provide an indication of how it would work for gasoline/ ethanol, diesel/ biodiesel and diesel/HVO blends.

Energy carrier	Lower heating value *MJ/kg*	Density *kg/l*	Volumetric energy density *MJ/l*	GHG emission (energy provision / WTT) *g CO_2e/MJ*	GHG emission (operational/ TTW) *g CO_2e /MJ*	GHG emission (total/WTW) *g CO_2e/MJ*	GHG emission (energy provision/ WTT) *kg CO_2e/kg*	GHG emission (operational/ TTW) *kg CO_2e/kg*	GHG emission (total/WTW) *kg CO_2e/kg*
Diesel-Biofuel Blends Emission factors: Europe									
100% Diesel	42.8	0.832	35.6	22.6	75.3	97.8	0.97	3.22	4.19
99% Diesel, 1% Biodiesel	42.7	0.833	35.6	22.7	74.5	97.2	0.97	3.19	4.15
98% Diesel, 2% Biodiesel	42.7	0.833	35.6	22.8	73.8	96.6	0.97	3.15	4.12
95% Diesel, 5% Biodiesel	42.5	0.835	35.5	23.1	71.6	94.7	0.98	3.04	4.03
93% Diesel, 7% Biodiesel	42.4	0.836	35.4	23.4	70.1	93.4	0.99	2.97	3.96
90% Diesel, 10% Biodiesel	42.2	0.838	35.4	23.7	67.9	91.6	1.00	2.86	3.87
80% Diesel, 20% Biodiesel	41.6	0.844	35.1	24.9	60.4	85.3	1.04	2.52	3.55
50% Diesel, 50% Biodiesel	39.9	0.862	34.4	28.4	38.2	66.6	1.13	1.52	2.66
100% Biodiesel (50 % rapeseed, 40 % used cooking oil, 10 % soybean)	37.0	0.892	33.0	34.2	1.2	35.4	1.27	0.04	1.31

Energy carrier	Lower heating value *MJ/kg*	Density *kg/l*	Volumetric energy density *MJ/l*	GHG emission (energy provision / WTT) *g CO_2e/MJ*	GHG emission (operational/ TTW) *g CO_2e /MJ*	GHG emission (total/WTW) *g CO_2e/MJ*	GHG emission (energy provision/ WTT) *kg CO_2e/kg*	GHG emission (operational/ TTW) *kg CO_2e/kg*	GHG emission (total/WTW) *kg CO_2e/kg*
Gasoline-Ethanol Blends Emission factors: Europe									
100% Gasoline	42.5	0.743	31.6	24.0	75.0	99.0	1.02	3.19	4.21
99% Gasoline, 1% Ethanol	42.3	0.743	31.5	24.2	74.2	98.5	1.03	3.14	4.17
98% Gasoline, 2% Ethanol	42.2	0.744	31.4	24.5	73.5	98.0	1.03	3.10	4.13
95% Gasoline, 5% Ethanol	41.7	0.745	31.1	25.2	71.2	96.4	1.05	2.97	4.02
93 % Gasoline,7% Ethanol	41.4	0.746	30.9	25.7	69.7	95.4	1.06	2.89	3.95
90% Gasoline, 10% Ethanol	41.0	0.747	30.6	26.4	67.5	93.9	1.08	2.76	3.84
80% Gasoline, 20% Ethanol	39.4	0.750	29.6	28.8	60.0	88.8	1.13	2.36	3.50
50% Gasoline, 50% Ethanol	34.8	0.762	26.5	36.0	37.6	73.5	1.25	1.30	2.55
100% Ethanol (40% maize, 35% sugar beet, 25% wheat)	27.0	0.780	21.1	47.9	0.1	48.0	1.29	0.00	1.30
Diesel-HVO Blends Emission factors: Europe									
100% Diesel	42.8	0.832	35.6	22.6	75.3	97.8	0.97	3.22	4.19
90% Diesel, 10% HVO	42.9	0.826	35.4	23.2	67.9	91.0	0.99	2.91	3.91
80% Diesel, 20% HVO	43.0	0.820	35.3	23.8	60.4	84.2	1.02	2.60	3.62
50% Diesel, 50% HVO	43.4	0.801	34.8	25.6	38.2	63.8	1.11	1.66	2.77
100% HVO*/ HEFA (SAF) (50% rapeseed, 50% used cooking oil)	44.0	0.770	33.9	28.6	1.2	29.7	1.26	0.0510	1.31
Diesel-HVO Blends Emission factors: North America									
100% Diesel	42.6	0.847	36.1	15.2	75.7	90.9	0.65	3.22	3.87
90% Diesel, 10% HVO	42.7	0.826	35.3	23.2	67.9	91.0	0.99	2.90	3.89
80% Diesel, 20% HVO	42.9	0.820	35.1	23.8	60.4	84.2	1.02	2.59	3.61
50% Diesel, 50% HVO	43.3	0.801	34.7	25.6	38.2	63.8	1.11	1.65	2.76
100% HVO (tallow)	44.0	0.779	34.3	17.5	0.8	18.3	0.77	0.0343	0.81

Energy carrier	Lower heating value *MJ/kg*	Density *kg/l*	Volumetric energy density *MJ/l*	GHG emission (energy provision / WTT) *g CO_2e/MJ*	GHG emission (operational/ TTW) *g CO_2e /MJ*	GHG emission (total/WTW) *g CO_2e/MJ*	GHG emission (energy provision/ WTT) *kg CO_2e/kg*	GHG emission (operational/ TTW) *kg CO_2e/kg*	GHG emission (total/WTW) *kg CO_2e/kg*
Biofuel Blends Emission factors: North America									
100% Diesel	42.6	0.847	36.1	15.2	75.7	90.9	0.65	3.22	3.87
99% Diesel, 1% Biodiesel	42.6	0.833	35.4	22.7	74.5	97.2	0.96	3.17	4.14
98% Diesel, 2% Biodiesel	42.5	0.833	35.4	22.8	73.8	96.6	0.97	3.14	4.10
95% Diesel, 5% Biodiesel	42.4	0.835	35.4	23.1	71.6	94.7	0.98	3.03	4.01
93% Diesel, 7% Biodiesel	42.3	0.836	35.3	23.4	70.1	93.4	0.99	2.96	3.95
90% Diesel, 10% Biodiesel	42.1	0.838	35.3	23.7	67.9	91.6	1.00	2.86	3.86
80% Diesel, 20% Biodiesel	41.6	0.844	35.1	24.9	60.4	85.3	1.04	2.52	3.55
50% Diesel, 50% Biodiesel	40.2	0.862	34.6	28.4	38.2	66.6	1.14	1.53	2.67
100% Biodiesel (soybean)	37.7	0.881	33.2	30.3	0.8	31.1	1.14	0.0294	1.17
Gasoline-Ethanol Blends Emission factors: North America									
100% Gasoline	41.7	0.749	31.2	16.6	73.0	89.6	0.69	3.04	3.74
99% Gasoline, 1% Ethanol	41.6	0.743	30.9	24.2	74.2	98.5	1.01	3.08	4.09
98% Gasoline, 2% Ethanol	41.4	0.744	30.8	24.5	73.5	98.0	1.01	3.04	4.06
95% Gasoline, 5% Ethanol	41.0	0.745	30.5	25.2	71.2	96.4	1.03	2.92	3.95
93 % Gasoline,7% Ethanol	40.7	0.746	30.3	25.7	69.7	95.4	1.04	2.84	3.88
90% Gasoline, 10% Ethanol	40.2	0.747	30.0	26.4	67.5	93.9	1.06	2.71	3.78
80% Gasoline, 20% Ethanol	38.8	0.750	29.1	28.8	60.0	88.8	1.12	2.33	3.44
50% Gasoline, 50% Ethanol	34.4	0.762	26.2	36.0	37.6	73.5	1.24	1.29	2.52
100% Ethanol (Corn)	27.0	0.789	21.3	55.6	0.3	55.9	1.50	0.0089	1.51

Scaling emission factors: GLEC Version 3 to GLEC Version 3.1

We understand that with updated values every year in alignment with the source's revision of the methodology and database, which are used in the GLEC Framework may cause a significant problem for companies that have already committed to certain emission reduction trajectories. It may take time for adjustment to these new values, as revising an emission baseline and readjusting future targets and trajectories is not a trivial process.

The following approximate scaling factors are therefore provided to help companies that calculate their emission using the latest European and North American values put the new values into the context of their previous baseline.

Europe Table

Fuel	WTT % increase	TTW % increase	WTW % increase
Diesel	1%	2%	1%
Gasoline	0%	0%	0%
LPG	-1%	0%	0%
Jet A	-24%	1%	-5%
HFO	21%	3%	6%
LNG	4%	2%	3%
CNG	-1%	-1%	-1%

Based on the above:
- a company where aviation emissions dominate might expect to report a 5% decrease in WTW emissions across all fuels;
- a company where road transport emissions dominate might expect to report a 1% increase in WTW emissions across all fuels;
- a company where maritime emissions dominate might expect to report a 6% increase in WTW emissions across all fuels.

North America Table

Fuel	WTT % increase	TTW % increase	WTW % increase
Diesel	-6%	0%	-1%
Gasoline	15%	0%	-1%
LPG	69%	0%	-1%
Jet A	-7%	1%	5%
HFO	88%	0%	-1%
LNG	14%	0%	-1%
CNG	5%	0%	-1%

Based on the above:
- a company where aviation emissions dominate might expect to report a 5% increase in WTW emissions across all fuels;
- a company where road transport emissions dominate might expect to report a 1% decrease in WTW emissions across all fuels;
- a company where maritime emissions dominate might expect to report a 1% decrease in WTW emissions across all fuels.

3 Module 2
Default fuel efficiency and GHG emission intensity values

Click here to go back to ***Section 3*** *contents page*

As explained in the main body of the GLEC Framework, there remains a need for default values as a "fall back" option in cases where details of contracted transport services, or access to primary data, is limited or unavailable. For some transport modes there is a vast choice of reference data and default values for emission intensity which can lead to comparability issues, whereas for other modes reference data and default data might be scarce, resulting in difficulties generating a representative output. This module contains a set of default fuel efficiency and GHG emission intensity values across almost all modes, to support consistent and comparable reporting.

The information provided is intended to inform reporting by shippers or logistics service providers (LSPs) who want to start estimating and reducing their Scope 3 GHG emissions from transporting cargo as part of their inbound or outbound supply chains, before progressing to using more accurate approaches.

The results are presented as a set of tiered levels of detail. These levels are designed to match the level of understanding of potential users of the information. Up to three levels of detail have been provided for each mode.

1. A single, conservative value where the user's knowledge is highly limited, often to the mode of transport used with little, if any, additional information.
2. A basic level of disaggregation where a service type is known, but detailed information of the vehicle or operational characteristics, which could help refine the value used, remains unknown.
3. A more granular set of values, for use where some knowledge about the vehicle type, vehicle size and fuel exists.

Technically it would be possible to provide a very detailed set of default values that takes into consideration a wide variation in load factors, cargo types, fuel mixes, regional variations etc. However, we believe that producing such a list would be misleading, because it would imply a level of precision that is inappropriate to its likely subsequent use, as default values can only provide an indication of emissions. The results generated by using such values might therefore create wrong impressions regarding inefficiencies and emissions of your specific organization. Furthermore, they could discourage organizations from progressing toward the use of higher quality data in the form of detailed modeling, or, preferably, good quality primary data, which is better suited to decision-making in support of emission reduction.

To put this another way, we hope that, in time, the default values provided here will no longer be needed because, increasingly, organizations will have enough information to use high-quality emissions modeling or verified primary data sources to support precise reporting and better-informed emission reduction decisions. The GLEC default factors have been produced with certain constraints in mind, particularly:

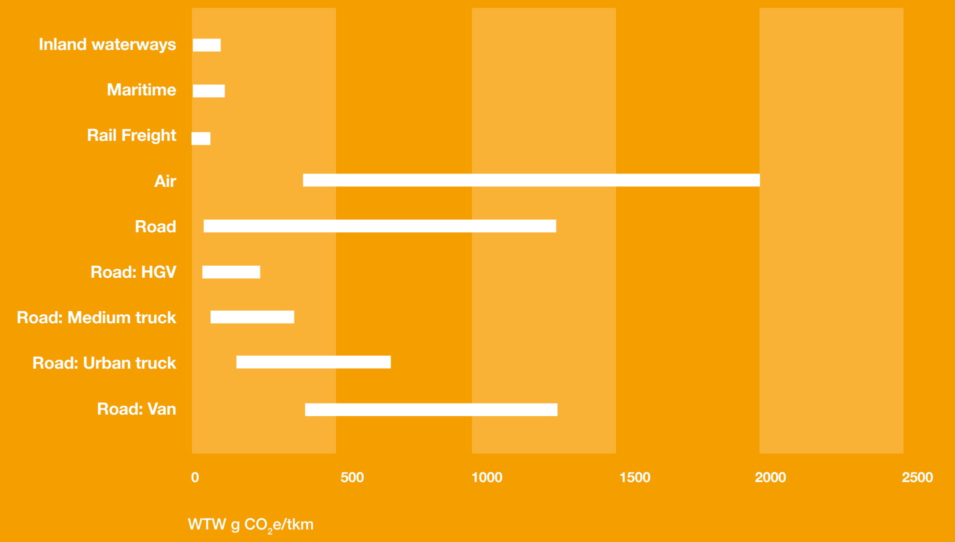
- The default values quoted are, to the best of our knowledge, conservative: in most cases they are likely to give a higher value than if primary data is used in a calculation. The reasoning behind this is that there should not be a penalty in terms of an increase in reported emissions when a company progresses to the use of more precise input data.
- There are some variations in the approach taken or the data available for emission calculation by global geographic region.
- Among the many sets of default values that have been published over the years there are some that carry legal weight. For example, the Base Carbone data in France and the “Guideline for Shipper Energy Conservation Action” in Japan contain energy intensity values that are embedded within national emission reporting legislation, and as such are required to be used for estimation of emissions from domestic transportation by companies based in those countries.
- The values are generally quoted to a limited number of significant figures in order to emphasize that they only provide estimates of Scope 3 GHG emissions. As stated in the main body of the Framework, Scope 1 emissions, or attempts to calculate accurate Scope 3 emission values, should be based on a more sophisticated approach, for example, using verified primary data and/or a certified calculation tool.
- Justification as to data sources, operational assumptions and choices made has been provided to a level considered appropriate for an industry-led initiative. The GLEC default factors are not a peer-reviewed, scientific publication but rather our best attempt to provide reliable estimates as a first step on a company’s journey to inclusive, high-quality GHG emission reporting. That said, this module will continue to be updated when new datasets become available for inclusion, as harmonization or standards are adopted, and as understanding improves over time.
- Unless specified otherwise, values are globally applicable.

Taking this approach also allows a comparison of representative values across and within modes at a general level. The following graph shows a high-level comparison of the possible range of emission intensities associated with each mode.

The values are drawn from the broader database that informs the values presented for each mode on the subsequent pages and should only be considered as indicative.

A very wide range is possible within each mode, depending on the specific operational and technical characteristics of the individual transport, although general trends are also clearly visible. Four more specific examples have been added for road transport to show how, even within sub-classes, wide variations are still possible, which again emphasizes the need to define the specific nature of the transport as closely as possible to obtain an accurate output.

Figure 1
Examples of WTW emission intensity values for different types of freight transport, based on 2019 GLEC default factors



Air transport

Many factors influence the emissions from air transportation, not least the aircraft type and detailed routing which may not be immediately apparent. The following default emission intensity values have been produced for air freight transport to provide LSPs and shippers with indicative values for their reporting of Scope 3 emissions where primary data is not available from the airline, or there is insufficient information (e.g., specific aircraft type or load factor are unknown) to allow detailed modeling of the emissions.

Since publication of the GLEC Framework v2 in 2019, the International Air Transport Association (IATA) has updated its methodology guidance for partitioning of emissions between passengers and belly cargo so that there is currently consistency between IATA RP 1678, ISO 14083 and the European Union Emissions Trading System (EU ETS). Although there is still some debate as to whether this may be further updated, it is the approach represented in these GLEC emission intensities.
Emissions are quoted on a WTW, CO_2e basis, using the fuel emission factor for jet fuel quoted in Module 1 of the Framework.

In compiling the following air freight default values, several possible data sources were identified which produced or quoted widely varying values. Based on discussion with various stakeholders the following approach has been used:

Values of aircraft fuel consumption, both freight and passenger aircraft, were calculated for routes indicative of both short- and long-haul air transport, following the definitions used by Science-Based Targets initiative (SBTi) and in ISO 14083, using information provided in the International Civil Aviation Organisation (ICAO) Carbon Emissions Calculator Methodology Version 11.[12]
Additionally, a set of values is provided for companies that are unable to determine whether their air freight has been transported as belly freight or on a freighter. This has been calculated as a weighted average of the belly freight and freighter values in the ratio 55% belly freight, 45% freighter.

The fuel consumption has been converted into an emission intensity value for each aircraft type and route combination using the latest IATA average values for passenger and freight load factors. For the purpose of this default calculation, the currently low average Sustainable Aviation Fuel (SAF) content of aviation fuel has been excluded to avoid even the marginal risk of double counting where an airline is able to report a figure based on primary data that reflects known SAF use.

These values were then validated through private communications with GLEC member companies that operate their own aircraft fleets.

We understand that this is a simplification, because overall fuel, and hence emission intensity, varies steadily with distance for any particular aircraft and loading condition. We also recognize that there is not a single definition of the terms, short- and long-haul. These are all indications as to why it would be better to rely on either verified airline data or detailed modeling from a reputable source than these default data.

Air Freight emission intensity values include a +95km distance conversion to account for emissions related to diversionary and/or out-of-route distances.

Bearing in mind all these caveats the proposed air sector defaults are as follows:

Table 1
Air transport emission intensity factors

		WTT g CO_2e/t-km	TTW g CO_2e/t-km	WTW g CO_2e/t-km
Freighter	**Short-haul (< 1500 km)**	261	1255	1516
	Long-haul (> 1500 km)	105	503	608
Belly freight	**Short-haul (< 1500 km)**	213	1026	1239
	Long-haul (> 1500 km)	161	775	936
Unknown	**Short-haul (< 1500 km)**	234	1129	1363
	Long-haul (> 1500 km)	135	653	788

Inland waterway transport

Although the following emission intensities are proposed as global values, the data is primarily based on European operational information on major waterways and combined according to weighted averages for common vessel categories.

The nature of the waterway system has a significant impact both on the type and size of vessel that can navigate it and the ease of transit due to the prevalence of locks, underwater clearance and speed of flow. Generic information does not reflect the specific situation. It is therefore important that you base your calculations on good quality primary data. Failing that, inland waterway or country-specific data should be sought wherever possible.

The value for the smallest vessel size category in Table 2 is drawn from the Base Carbone database,[13] which contains values generated from national operational data for France that generally suggest a higher energy and emission intensity than the rest of the more general European data that is used to populate the rest of the table.

Table 2
Inland waterways transport emission intensity values

Vehicle characteristics and size	Loading Basis Combined Load Factor & Empty Running	Fuel type	Fuel intensity (kg/t-km)	Fuel intensity (l/t-km)	Emission intensity (g CO_2e/t-km)		
					WTT	TTW	WTW
Motor vessels < 50 m (< 650 t)	N/A	Diesel	0.0184	0.0221	17.8	59.2	77.1
Motor vessels < 50-80 m (650 - 1000 t)	55%	Diesel	0.0081	0.0097	7.9	26.1	33.9
Motor vessels 85–110 m (1000–2000 t)	52%	Diesel	0.0051	0.0062	4.9	16.4	21.4
Motor vessels 135 m (2000–3000 t)	50%	Diesel	0.0052	0.0063	5.0	16.7	21.8
Coupled convoys (163–185 m)	61%	Diesel	0.0047	0.0056	4.6	15.1	19.7
Pushed convoy – push boat + 2 barges	70%	Diesel	0.0048	0.0057	4.7	15.5	20.1
Pushed convoy – push boat + 4/5 barges	70%	Diesel	0.0027	0.0032	2.6	8.7	11.3
Pushed convoy – push boat + 6 barges	70%	Diesel	0.0020	0.0024	1.9	6.4	8.4
Tanker vessels	65%	Diesel	0.0059	0.0070	5.7	19.0	24.7
Container vessels 110 m	75%	Diesel	0.0070	0.0084	6.8	22.5	29.3
Container vessels 135 m	75%	Diesel	0.0054	0.0065	5.2	17.4	22.6
Container vessels – Coupled convoys	68%	Diesel	0.0054	0.0065	5.2	17.4	22.6

Pushed convoy data applicable to US operations.

Logistics hubs

The development of default emission intensities for logistics hubs is still at a relatively early stage. To overcome the data gap on operational GHG emissions of logistics hubs, the international partners of the GILA project – Fraunhofer IML, Politecnico di Milano, GreenRouter and Universidad de los Andes – organized market studies to update their initial data base on GHG emission intensity values of logistics hubs.[14]

Table 3
Logistics hubs emission intensity values

Hub type unit	Ambient	Sample size	Temperature-controlled	Sample size	Mixed	Sample size
Transshipment kg CO_2e/t	1.3	(99)			2.5	(8)
Storage + transshipment kg CO_2e/t	5.6	(57)			18.4	(10)
Warehouse kg CO_2e/t	45.5	(67)			≥ 50.0	estimate by Fraunhofer IML
Liquid bulk terminals kg CO_2e/t	3.3	(23)			7.2	(23)
Maritime container terminals kg CO_2e/ container	10.7	(15)	12.6	(15)		

As a result of this collaboration and previous work, an expanded set of default emission intensity values for a more disaggregated range of logistics hubs has been produced and is presented in Table 3.

The underlying data, i.e., annual information on energy consumption, refill of refrigerants and throughput, collected by each institution were processed, anonymized and finally merged into one database from which the final emission intensities per hub were calculated. This database differentiates five hub types, as follows:
1. Hubs where transshipment is the main service (>80% of goods handled);
2. Hubs where both transshipment and warehousing are relevant services;
3. Hubs where warehousing is the main service (>80% of goods handled);
4. Liquid bulk terminals;
5. Maritime container terminals.

As an additional categorization, the site conditions have been classified as ambient, temperature-controlled or mixed sites. Table 3 summarizes current average emission intensity values of the defined hub types. The corresponding sample size per hub type is outlined in brackets. While data on terminals originate from various regions worldwide, the main focus for warehouses and transshipment sites is Europe. Further background information on the calculations can be found on the REff Tool® website via https://s.fhg.de/reff.

Values quoted are the median value from each sample which was considered more representative than the mean for small sample sizes with large variations and some apparent outliers. The hub sizes vary from a few tonnes to more than 1.7 million tonnes outbound, with around 70,000 tonnes as median value for storage and transshipment sites and 250 tonnes to 23 million tonnes with a median value of 650,000 tonnes for liquid bulk terminals. 22% of the operators specified a site-specific electricity mix. However, only an average national emission factor was used for calculating the average emission intensity specified in the table. Natural gas is the main heating energy source; liquid bulk terminals also use steam for heating purposes. Energy sources for non-electrified material handling are diesel, biodiesel-blends, petrol, propane or LPG. The refrigerant types R-410A, R-404A and R-717 are the most frequently used ones as specified by the participating sites.

The sample size that these values are based on is still relatively small; the values will continue to be updated over time assuming that more and better data becomes available and is shared with Fraunhofer IML. We expect this to improve accuracy and to broaden the range of defaults offered, e.g., additional definitions and size categorization of logistics hubs or values for specific regions where ambient climate conditions can have a strong influence on the amount of heating or cooling required. As is the case for all default values, the data in Table 3 should be used as a last resort when primary data is not available, or as a starting point that can lead on to future calculations based on primary data. If you, as a logistics hubs operator, are not happy for your customers to use the values quoted then the onus is on you to provide them with more accurate information based on primary data and calculations that follow the Fraunhofer IML "Guide for Greenhouse Gas Emissions Accounting at Logistics Hubs."[15]

Future Development

Fraunhofer IML is working in partnership with SFC and other organizations to attempt to build a broader GILA database of hub emissions, from which better knowledge of emission reduction opportunities and a wider range of default values will become available, e.g., in terms of regional differences. This is achieved through application of the REff Tool®, which is provided online via https://s.fhg.de/reff. To participate in this work, please contact either contact-reff@iml.fraunhofer.de or SFC to discuss how to provide logistics hubs activity data to help grow this knowledge base.

Rail transport

Region: Europe

EU average (where traction energy type unknown*): 18.5 g CO_2e/t-km (WTW)

EU average (diesel traction): 31 g CO_2e/t-km (WTW)

EU average (electric traction): 11 g CO_2e/t-km (at the average 2020 EU electricity generating mix**)

* UIC Railway Handbook 2017: 62% of EU rail tracks are electrified. This does not necessarily refer to relative flows but is used as a proxy for the default value.[16]

** Average energy consumption of EU Electric train sourced from EcoTransIT World: Environmental Methodology and Data Update 2024[18]

Region: North America

For North America, Tier 1 railroads are required to report information to the Surface Transportation Board in a specified format. Information is collected, aggregated and published through the American Association of Railroads in the form of revenue ton-mile output per gallon of fuel used, following the Eastern Regional Technical Advisory Committee (ERTAC) methodology. Conversion to the common units used in the GLEC Framework, and conversion using the latest GREET fuel emission factors, gives the following average WTW emission intensity value.

US average (diesel):
16.1 g CO_2e/t-km.
(WTT = 2.7 and TTW =
13.4 g CO_2e/t-km respectively)

Many North American railroad companies have their own calculators which calculate according to the ERTAC approach and can be accessed online.

European diesel traction

The EcoTransIT 2024 Methodology Update includes information about typical train, wagon and operating characteristics for different commodity types that can be used to provide more disaggregated default factors.

Load factors, empty running and train characteristics are sourced from EcoTransIT World Methodology and Data Update, 2024.[18]

Truck + trailer and trailer only on train provide derived average values, including allowance for return trips where there is zero return load. Based on 34–40 t articulated truck/truck trailer combination, including average truck loading and empty running characteristics. Tonne-kilometer in these circumstances refers to the net load within the truck.

Table 4
European rail diesel traction emission intensity values

Load characteristics	Basis		Fuel intensity		Emission intensity (g CO_2e/t-km)		
	Load factor	Empty running	(kg/t-km)	(l/t-km)	WTT	TTW	WTW
Average/mixed	60%	33%	0.0073	0.0088	7.1	23.6	30.7
Container	50%	17%	0.0068	0.0082	6.6	21.9	28.5
Cars	85%	33%	0.0158	0.0189	15.3	50.7	66.0
Chemicals	100%	50%	0.0063	0.0076	6.1	20.3	26.4
Coal & Steel	100%	50%	0.0049	0.0059	4.7	15.7	20.4
Building Materials	100%	50%	0.0061	0.0073	5.9	19.7	25.6
Manufactured Products	75%	38%	0.0064	0.0077	6.2	20.7	26.9
Cereals	100%	38%	0.0048	0.0058	4.7	15.5	20.2
Truck + trailer on train	85%	33%	0.015	0.018	13.9	49.0	62.9
Trailer only on train	85%	33%	0.010	0.011	8.7	30.8	39.4

European Electric Traction

The EcoTransIT 2024 Methodology Update provides additional information about typical train, wagon and operating characteristics for different commodity types that can be used to provide a more disaggregated default factors.

Load factors, empty running and train characteristics sourced from EcoTransIT World Methodology and Data Update, 2024
Truck + trailer and trailer only on train provide derived average values, including allowance for return trips where there is zero return load. Based on 34–40 t articulated truck/truck trailer combination, including average truck loading and empty running characteristics. Tonne-kilometer in these circumstances refers to the net load within the truck.

Average energy consumption of EU Electric train sourced from EcoTransIT World: Environmental Methodology and Data Update 2024.[18]

Temperature Controlled Rail Freight

Apply a 12% uplift. Based on the recommendation to apply the temperature controlled Road Freight uplift for Europe, South America, Asia and Africa in the absence of rail specific values.

Table 5
European rail electric traction emission intensity values

Load characteristics	Basis		Emission intensity (g CO_2e/t-km) @ average 2024 EU electricity generating mix		
	Load factor	Empty running	Distribution losses	Generation and other Upstream Emissions	Total emissions
Average/mixed	60%	33%	0.4	11.0	11.5
Container	50%	17%	0.4	10.3	10.7
Cars	85%	33%	0.9	23.8	24.7
Chemicals	100%	50%	0.4	9.5	9.9
Coal & Steel	100%	50%	0.3	7.4	7.6
Building Materials	100%	50%	0.4	9.2	9.6
Manufactured Products	75%	38%	0.4	9.7	10.1
Cereals	100%	38%	0.3	7.3	7.6
Truck + trailer on train	85%	33%	0.9	14.6	15.5
Trailer only on train	85%	33%	0.6	9.2	9.7

Road transport

This section sets out the current GLEC default values for road transport. The main datasets presented are for North America and Europe. These datasets are presented separately because the data in the primary inputs are arranged in a different way.

The primary inputs used are:

1. SmartWay truck data 2023 for North America[19]
2. Handbook of Emission Factors (HBEFA) database values[20] processed internally by SFC to approximate the current (2024) typical operational parameters of each truck type and size
3. UK Government GHG Conversion Factors for Company Reporting[21]
4. Base Carbone, as used in application of article L. 1431-3[13] of the French Transport code (September 2018)
5. Network for Transport Measures (NTM)[22]

Road Freight emission intensity values include a + 5% distance conversion to correct for the difference between actual and shortest feasible distance

Table 6
North American road emission intensity values

SmartWay category*	Fuel intensity factor (kg/t-km)	Fuel intensity factor (l/t-km)	Emission intensity (g CO_2e/t-km)		
			WTT	TTW	WTW
Van (<3.5 t)	0.22	0.26	153	756	909
General	0.027	0.031	18	91	110
Auto Carrier	0.028	0.033	19	96	115
Dray	0.024	0.028	17	82	98
Expedited	0.177	0.209	123	607	730
Flatbed	0.020	0.024	14	70	84
Heavy Bulk	0.023	0.027	16	77	93
LTL/Dry Van	0.056	0.067	39	194	233
Mixed	0.027	0.031	18	91	110
Moving	0.097	0.114	67	332	399
Package	0.237	0.280	164	815	979
Refrigerated	0.023	0.027	16	80	96
Specialized	0.032	0.038	22	111	133
Tanker	0.017	0.020	12	58	70
TL/Dry Van	0.023	0.027	16	79	95

* The SmartWay Category designation for each fleet is based on the Operation and Body Type options selected by the carrier when entering data into the SmartWay database.

Data is sourced from US EPA SmartWay, except that for van, which is sourced from NTM. Fleets are characterized by:
1. Business type: for-hire and private fleets. There are relatively few private fleets compared to for-hire fleets; generally, the private fleets are well used and so not detrimental to the overall value if included with the for-hire fleets; hence, for simplicity, no differentiation is made.
2. Operational type: Full Truckload (FTL), Less than Truckload (LTL), dray, expedited or package;
3. Equipment type, relating to the type of cargo carried: dry truck (or van), temperature-controlled truck (or van), flatbed, chassis (container), heavy/bulk, auto carrier, moving and specialized (e.g., hopper, livestock.) Fleets can be classified as "mixed" if they have more than a set percentage of its operational mileage outside of one particular service or equipment category.
4. Current year averages for empty running and load factor based on primary data inputted by carriers into the SmartWay tool, and hence implicitly included in the calculations, are not publicly available.

The dry truck category and chassis (or intermodal container) category are combined in SmartWay as similar operational characteristics exist.

Most temperature-controlled fleets are FTL with relatively fewer LTL so this category is also combined.

Region: Europe and South America

For users who have little knowledge other than a basic vehicle type, the starting points for vehicles without temperature control would be:

- Van (<3.5 t Gross vehicle weight (GVW)): 840 g CO_2e/t-km (WTW)
- Urban truck (3.5-7.5 t GVW): 335 g CO_2e/t-km (WTW)
- MGV (7.5-20 t GVW): 210 g CO_2e/t-km (WTW)
- HGV: (>20 t GVW): 125 g CO_2e/t-km (WTW)

Each of these values is based on a particular set of assumptions and chosen from the much larger set of possibilities available in the full dataset below. As explained in the introduction the choice is highly unlikely to be "right" (i.e., highly accurate) for the majority of applications, but can be considered suitable as a starting point where there is little detailed knowledge. Where there is a greater level of knowledge about the vehicle and fuel type, the following, disaggregated values can be used.

Road Freight emission intensity values include a + 5% distance conversion to account for emissions related to diversionary and/or out-of-route distances

Table 7

Europe and South America road emission intensity values

Mode	Vehicle characteristics and size	Combined Load Factor & Empty Running	Fuel	Fuel intensity factor (kg/t-km)	Fuel intensity factor (l/t-km)	Emission intensity (g CO_2e/t-km)		
						WTT	TTW	WTW
Road	Van < 3.5 t	36%	Diesel	0.201	0.242	195	647	842
		24%	Petrol	0.239	0.322	244	763	1007
		36%	CNG	0.235	-	243	648	892
		36%	LPG	0.234	0.425	246	713	959

Table 8

Europe and South America road emission intensity values

* LNG/bio-LNG consumption # diesel consumption

Vehicle characteristics and size	Load characteristics	Basis		Fuel	Fuel intensity (kg/t-km)	Fuel intensity (l/t-km)	Emission intensity (g CO_2e/t-km)		
		Load Factor	Empty Running				WTT	TTW	WTW
Rigid truck 3.5–7.5 t GVW	Average/mixed	60%	17%	Diesel	0.080	0.096	78	258	335
				CNG	0.084	-	86	231	317
Rigid truck 7.5–12 t GVW	Average/mixed	60%	17%	Diesel	0.053	0.064	52	172	223
				CNG	0.056	-	58	154	211
Rigid truck 12–20 t GVW	Average/mixed	60%	17%	Diesel	0.046	0.055	44	147	191
				CNG	0.048	-	49	131	181
Rigid truck 20–26 t GVW	Average/mixed	60%	17%	Diesel	0.033	0.040	32	107	139
				CNG	0.036	-	37	99	136
				LNG	0.037	-	47	105	152
Rigid truck 26–32 t GVW	Average/mixed	60%	17%	Diesel	0.030	0.036	29	96	125
	Container	72%	30%		0.029	0.035	29	95	123
Artic truck up to 34 t GVW	Average/mixed	60%	17%	Diesel	0.030	0.036	29	95	124
	Container	72%	30%		0.029	0.035	29	95	123
Artic Truck 34-40 t GVW	Average/mixed	60%	17%	Diesel	0.024	0.029	23	78	101
	Container	72%	30%		0.024	0.029	23	78	101
Artic Truck 34-40t GVW SI engine	Average/mixed	60%	17%	LNG	0.025		31	71	102
				CNG	0.025		25	73	98
				Bio-LNG	0.024		35	3	38
	Container	72%	30%	LNG	0.025		31	71	102
				CNG	0.025		25	73	98
				Bio-LNG	0.024		35	3	38
Artic Truck 34-40 t GVW HPDI	Average/mixed	60%	17%	LNG/diesel	0.020*	0.002#	27	64	91
				CNG/diesel	0.020*	0.002#	23	65	87
				Bio-LNG/diesel	0.020*	0.002#	31	9	39
	Container	72%	30%	LNG/diesel	0.020*	0.002#	27	64	91
				CNG/diesel	0.020*	0.002#	23	65	87
				Bio-LNG/diesel	0.020*	0.002#	31	9	39

The default emission intensities for road freight transport are calculated using the same approach used by national reference databases such as HBEFA, [France] and Great Britain. That is, for a given driving cycle the fuel consumption for a vehicle when empty and when fully laden are used as the two extremes with a linear relationship between the two depending on loading. We have selected a typical drive cycle for each vehicle size category together with the fuel consumptions associated with it, using HBEFA database as the most comprehensive and representative reference option for Europe.

Typical levels of loading and empty running, as shown in tables 7-11, are factored into the calculation. The age profile used for each vehicle type is that of a 5 year old vehicle to avoid overly positive fuel consumption of new vehicles that would not be representative of the whole fleet.

Continued on next page

Table 9

Europe and South America road emission intensity values (continued)

Vehicle characteristics and size	Load characteristics	Basis		Fuel	Fuel intensity factor (kg/t-km)	Fuel intensity factor (l/t-km)	Emission intensity (g CO_2e/t-km)		
		Load Factor	Empty Running				WTT	TTW	WTW
Artic truck 40 t GVW, incl. lightweight trailer	Heavy	100%	38%	Diesel	0.019	0.023	19	62	80
Artic truck 40-44 t GVW	Light	30%	9%	Diesel	0.034	0.041	33	110	143
	Average/mixed	60%	17%	Diesel	0.021	0.026	21	69	89
	Heavy	100%	38%	Diesel	0.018	0.022	18	59	77
	Container	72%	30%	Diesel	0.021	0.026	21	69	90
Artic truck up to 60 t GVW	Average/mixed	60%	17%	Diesel	0.017	0.020	16	54	70
	Heavy	100%	38%	Diesel	0.014	0.017	14	46	60
	Container	72%	30%	Diesel	0.017	0.020	16	54	70
Artic truck up to 72 t GVW	Heavy	100%	38%	Diesel	0.012	0.014	11	36	47
	Container	72%	30%		0.014	0.016	13	42	54

Bio-LNG based on GHG reduction threshold is to be qualified under RED II.[8] Lower values are possible depending on feedstock, production pathway and blending of sources and can be used where reputable certification is available.

The main source for the European data is HBEFA[19].The data has been chosen to reflect the current average fleet age and modified to match the typical operating profile for each vehicle. This means it is not a direct representation of a single HBEFA scenario. Specifically, it is not based on the newest vehicle specifications because this would misrepresent the fact that there is a significant proportion of older vehicles operating in the overall fleet. Emissions are based on the latest European emission factors presented in Module 1.

Table 10

Europe and South America road emission intensity values

Vehicle characteristics and size	Combined Load Factor & Empty Running	Fuel	Energy intensity factor (kWh/tkm)
Van < 3.5 t	31%	Electricity	1.2

Table 11

Europe and South America road emission intensity values

Vehicle characteristics and size	Load characteristics	Basis		Fuel	Energy intensity factor (kWh/tkm)
		Load Factor	Empty Running		
Rigid truck 3.5–7.5 t GVW	Light	30%	9%	Electric	0.86
	Average/mixed	60%	17%		0.44
Rigid truck 7.5–12 t GVW	Light	30%	9%	Electric	0.65
	Average/mixed	60%	17%		0.34
Rigid truck 12-20t GVW	Light	30%	9%	Electric	0.40
	Average/mixed	60%	17%		0.22
Rigid truck 26-40t GVW	Light	30%	9%	Electric	0.28
	Average/mixed	60%	17%		0.16

The below set of China Road emission intensity default values was first published in the China Default GHG Emission Values V1.0 report(2024)[30]. With the GLEC FW v3.1 update, we applied + 5% distance conversion to correct for the difference between actual and shortest feasible distance.

The main source of the fuel efficiency and transport activity and performance data (e.g., distance, load factor, empty running rate) is from Xi'an Jiaotong University's report "Preliminary Investigation and Research on Freight Industry"[31]. The calculation of road emission intensity factors follows mainly the 2006 IPCC Guidance[32], GHG Protocol, and GLEC Framework, as well as China's national-level and industry standards regarding transport GHGs accounting and report, e.g., NDRC's "GHGs Accounting Methods and Reporting Guidelines for Land Transport Enterprises"[33]. Other sources related to calculations including WB/T 1135-2023 (2023.7) "Requirements of the GHG emission Accounting and Reporting for Logistics Service Provider" (物流企业温室气体排放核算与报告要求)[34], "Guidance for Compiling Provincial Greenhouse Gas Emission Lists (Trial)" (省级温室气体清单编制指南(试行))[35], and IPCC AR6[1].

Table 12
China road emission intensity values

Vehicle characteristics and size	Load characteristics	Basis		Fuel	Fuel intensity factor (kg/t-km)	Fuel intensity factor (l/t-km)	Emission intensity (g CO_2e/t-km)		
		Load Factor	Empty Running				WTT	TTW	WTW
Rigid Truck LDT 3.5-4.5 t GVW	Average	93%	19.50%	Diesel	0.113	0.136	109.61	360.83	470.44
Rigid Truck MDT 4.5-5.5 t GVW	Average	93%	19.50%	Diesel	0.101	0.121	97.15	319.79	416.94
Rigid Truck MDV 5.5-7.0 t GVW	Average	93%	19.50%	Diesel	0.097	0.117	93.37	307.37	400.74
Rigid Truck MDV 7.0-8.5 t GVW	Average	93%	19.50%	Diesel	0.075	0.091	72.33	238.08	310.41
Rigid Truck MDV 8.5-10.5 t GVW	Average	93%	19.50%	Diesel	0.063	0.076	60.88	200.39	261.27
Rigid Truck MDV 10.5-12.5 t GVW	Average	93%	19.50%	Diesel	0.056	0.068	53.99	177.72	231.7
Rigid Truck HDV 12.5-16.0 t GVW	Average	93%	19.50%	Diesel	0.052	0.062	49.39	162.57	211.96
Rigid Truck HDV 16.0-20.0 t GVW	Average	93%	19.50%	Diesel	0.037	0.045	35.5	116.85	152.34
Rigid Truck HDV 20.0-25.0 t GVW	Average	93%	19.50%	Diesel	0.026	0.031	24.85	81.81	106.67
Rigid Truck HDV 25.0-31.0 t GVW	Average	93%	19.50%	Diesel	0.022	0.027	21.25	69.96	91.21
Rigid Truck HDV >31.0t GVW	Average	93%	19.50%	Diesel	0.023	0.028	22.24	73.2	95.44
Articulated Truck HDV up to 18.0 t GVW	Average	93%	19.50%	Diesel	0.038	0.046	36.7	120.81	157.51
Articulated Truck HDV 18.0-27.0 t GVW	Average	93%	19.50%	Diesel	0.026	0.032	24.99	82.26	107.25
Articulated Truck HDV 27.0-35.0 t GVW	Average	93%	19.50%	Diesel	0.024	0.029	22.54	74.21	96.75
Articulated Truck HDV 35.0-40.0 t GVW	Average	93%	19.50%	Diesel	0.02	0.024	18.84	62.02	80.86

Continued on next page

Table 12

China road emission intensity values (continued)

Vehicle characteristics and size	Load characteristics	Basis		Fuel	Fuel intensity factor (kg/t-km)	Fuel intensity factor (l/t-km)	Emission intensity (g CO_2e/t-km)		
		Load Factor	Empty Running				WTT	TTW	WTW
Articulated Truck HDV 40.0-43.0 t GVW	Average	93%	19.50%	Diesel	0.019	0.023	18.22	59.96	78.18
Articulated Truck HDV 43.0-46.0 t GVW	Average	93%	19.50%	Diesel	0.018	0.022	17.49	57.57	75.05
Articulated Truck HDV 46.0-49.0 t GVW	Average	93%	19.50%	Diesel	0.018	0.022	17.34	57.09	74.43
Articulated Truck HDV above 49.0 t GVW	Average	93%	19.50%	Diesel	0.018	0.022	17.22	56.67	73.89
Dump Truck LDT 3.5-4.5 t GVW	Average	93%	19.50%	Diesel	0.135	0.162	130.16	428.46	558.61
Dump Truck MDT 4.5-5.5 t GVW	Average	93%	19.50%	Diesel	0.1	0.121	96.73	318.43	415.16
Dump Truck MDV 5.5-7.0 t GVW	Average	93%	19.50%	Diesel	0.095	0.114	91.62	301.6	393.22
Dump Truck MDV 7.0-8.5 t GVW	Average	93%	19.50%	Diesel	0.074	0.089	71.07	233.96	305.04
Dump Truck MDV 8.5-10.5 t GVW	Average	93%	19.50%	Diesel	0.064	0.077	61.12	201.19	262.31
Dump Truck MDV 10.5-12.5 t GVW	Average	93%	19.50%	Diesel	0.055	0.066	52.39	172.48	224.87
Dump Truck HDV 12.5-16.0 t GVW	Average	93%	19.50%	Diesel	0.05	0.06	48.04	158.14	206.18
Dump Truck HDV 16.0-20.0 t GVW	Average	93%	19.50%	Diesel	0.037	0.045	35.6	117.21	152.81
Dump Truck HDV 20.0-25.0 t GVW	Average	93%	19.50%	Diesel	0.024	0.029	23.28	76.63	99.91
Dump Truck HDV 25.0-31.0 t GVW	Average	93%	19.50%	Diesel	0.023	0.027	21.47	70.68	92.15
Dump Truck HDV above 31.0 t GVW	Average	93%	19.50%	Diesel	0.02	0.024	18.62	61.3	79.92
Articulated Truck 14-24 t GVW	Average	93%	19.50%	LNG	0.062	0.148	74.95	175.72	250.67
Articulated Truck 24-25 t GVW	Average	93%	19.50%	LNG	0.03	0.071	35.84	84.02	119.85
Articulated Truck 25-29 t GVW	Average	93%	19.50%	LNG	0.025	0.059	29.84	69.95	99.79

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Table 12

China road emission intensity values (continued)

Vehicle characteristics and size	Load characteristics	Basis		Fuel	Fuel intensity factor (kg/t-km)	Fuel intensity factor (l/t-km)	Emission intensity (g CO_2e/t-km)		
		Load Factor	Empty Running				WTT	TTW	WTW
Articulated Truck 29-31 t GVW	Average	93%	19.50%	LNG	0.021	0.049	24.66	57.83	82.49
Articulated Truck 31-60 t GVW	Average	93%	19.50%	LNG	0.017	0.04	19.87	46.58	66.45
Dump Truck 14-24 t GVW	Average	93%	19.50%	LNG	0.048	0.114	57.89	135.72	193.61
Dump Truck 24-25 t GVW	Average	93%	19.50%	LNG	0.024	0.056	28.63	67.12	95.75
Dump Truck 25-29 t GVW	Average	93%	19.50%	LNG	0.02	0.049	24.69	57.88	82.57
Dump Truck 29-31 t GVW	Average	93%	19.50%	LNG	0.017	0.04	20.38	47.79	68.17
Dump Truck 31-60 t GVW	Average	93%	19.50%	LNG	0.014	0.032	16.4	38.44	54.83
Rigid Truck 14-24 t GVW	Average	93%	19.50%	LNG	0.048	0.114	58.28	136.64	194.92
Rigid Truck 24-25 t GVW	Average	93%	19.50%	LNG	0.024	0.056	28.63	67.12	95.75
Rigid Truck 25-29 t GVW	Average	93%	19.50%	LNG	0.02	0.048	24.14	56.59	80.73
Rigid Truck 29-31 t GVW	Average	93%	19.50%	LNG	0.017	0.041	20.49	48.04	68.53
Rigid Truck 31-60 t GVW	Average	93%	19.50%	LNG	0.014	0.033	16.52	38.74	55.26
Truck LDV up to 4.5 t GVW	Average	93%	19.50%	Electricity	-	-	135.44	-	135.44
Truck MDV 4.5-12.0 t GVW	Average	93%	19.50%	Electricity	-	-	74.87	-	74.87
Truck HDV above 12 t GVW	Average	93%	19.50%	Electricity	-	-	145.25	-	145.25
Truck LDV up to 4.5 t GVW	Average	93%	19.50%	Hydrogen	0.03	-	328.1	-	328.1
Truck MDV 4.5-12.0 t GVW	Average	93%	19.50%	Hydrogen	0.016	-	173.1	-	173.1
Truck HDV above 12 t GVW	Average	93%	19.50%	Hydrogen	0.018	-	198.86	-	198.86

Region: Asia (except China) and Africa*

For vans (up to 3.5 t GVW) apply a 13% uplift to the regional values for Europe and South America.

For heavier vehicles (> 3.5 t GVW) apply a 22% uplift to the regional values for Europe and South America.

Temperature controlled Road Freight**

For vans (up to 3.5 t GVW) apply a 15% uplift to the regional values for Europe, South America, Asia and Africa.

For heavier vehicles (> 3.5 t GVW) apply a 12% uplift to the regional values for Europe, South America, Asia and Africa.

* Based on extrapolation analysis by NTM of data from https://www.theicct.org/publications/literature-review-real-world-fuel-consumption-heavy-duty-vehicles- united-states-china

** Private Communication from TK'Blue, validated using USEPA 2019 SmartWay Truck Carrier Partner Tool Technical Documentation

Sea transport emission intensities

Data is based on information presented in the Fourth (IMO) Greenhouse Gas Study[23]. The starting point is the median fuel consumption for each size category with the addition of 10%, which equals the range between lower and upper quartile values, to avoid a risk of underestimation. Emissions are based on the latest North American emission factors presented in Module 1.

Values for Tanker, General cargo and Bulk carrier are derived from IMO Fourth GHG study.

Ro-Ro: Tonne-kilometer in these circumstances refers to the gross load of truck and cargo contained, as this is the cargo transported by the vessel. These emissions will need to be reallocated to the cargo in the truck by the cargo owner.

Non-container shipping freight emission intensity values include a + 15% distance conversion to correct for the difference between the actual and the shortest feasible distance.

Table 13
Sea transport emissions intensity values – Non-container vessels

Vessel Characteristics and size		Unit	Fuel	Emission intensity (g CO_2e/t-km)			With 15% DAF
				WTT	TTW	WTW	WTW
Bulk carrier	*0-9999*	dwt	HFO	4.7	26.5	*31.2*	*35.9*
			VLSFO	5.6	26.5	*32.1*	*36.9*
			MDO	4.8	25.6	*30.5*	*35.0*
	10000-34999	dwt	HFO	1.3	7.3	*8.6*	*9.8*
			VLSFO	1.5	7.3	*8.8*	*10.1*
			MDO	1.3	7.0	*8.4*	*9.6*
	35000-59999	dwt	HFO	0.9	5.3	*6.3*	*7.2*
			VLSFO	1.1	5.3	*6.5*	*7.4*
			MDO	1.0	5.2	*6.1*	*7.0*
	60000-99999	dwt	HFO	0.8	4.4	*5.2*	*5.9*
			VLSFO	0.9	4.4	*5.3*	*6.1*
			MDO	0.8	4.2	*5.0*	*5.8*
	100000-199999	dwt	HFO	0.5	3.0	*3.5*	*4.0*
			VLSFO	0.6	3.0	*3.6*	*4.1*
			MDO	0.5	2.9	*3.4*	*3.9*
	200000-+	dwt	HFO	0.5	2.7	*3.1*	*3.6*
			VLSFO	0.6	2.7	*3.2*	*3.7*
			MDO	0.5	2.6	*3.1*	*3.5*

dwt = dead weight tonnage

Continued on next page

Table 13

Sea transport emission intensity values – Non-container vessels (continued)

Vessel Characteristics and size		Unit	Fuel	Emission intensity (g CO_2e/t-km)			With 15% DAF
				WTT	TTW	WTW	WTW
Chemical tanker	0-4999	dwt	HFO	9.1	51.2	60.3	69.3
			VLSFO	10.9	51.2	62.1	71.4
			MDO	9.3	49.6	58.9	67.7
	5000-9999	dwt	HFO	4.0	22.7	26.7	30.7
			VLSFO	4.8	22.7	27.5	31.6
			MDO	4.1	22.0	26.1	30.0
	10000-19999	dwt	HFO	2.8	15.4	18.2	20.9
			VLSFO	3.3	15.4	18.7	21.5
			MDO	2.8	15.0	17.8	20.4
	20000-39999	dwt	HFO	1.7	9.4	11.1	12.8
			VLSFO	2.0	9.4	11.4	13.2
			MDO	1.7	9.1	10.9	12.5
	40000-+	dwt	HFO	1.3	7.2	8.5	9.8
			VLSFO	1.5	7.2	8.8	10.1
			MDO	1.3	7.0	8.3	9.6
General cargo	0-4999	dwt	HFO	4.0	22.4	26.4	30.4
			VLSFO	4.8	22.4	27.2	31.3
			MDO	4.1	21.7	25.8	29.7
	5000-9999	dwt	HFO	3.2	18.1	21.3	24.5
			VLSFO	3.9	18.1	21.9	25.2
			MDO	3.3	17.5	20.8	23.9
	10000-19999	dwt	HFO	2.9	16.1	18.9	21.8
			VLSFO	3.4	16.1	19.5	22.4
			MDO	2.9	15.6	18.5	21.3

Vessel Characteristics and size		Unit	Fuel	Emission intensity (g CO_2e/t-km)			With 15% DAF
				WTT	TTW	WTW	WTW
General cargo (Continued)	20000-+	dwt	HFO	1.5	8.3	9.8	11.3
			VLSFO	1.8	8.3	10.1	11.6
			MDO	1.5	8.1	9.6	11.0
Liquefied gas tanker	0-49999	cbm	HFO	7.2	40.2	47.4	54.5
			VLSFO	8.6	40.2	48.8	56.1
			MDO	7.3	39.0	46.3	53.2
	50000-99999	cbm	HFO	2.1	11.7	13.7	15.8
			VLSFO	2.5	11.7	14.1	16.3
			MDO	2.1	11.3	13.4	15.4
	100000-199999	cbm	HFO	1.6	9.2	10.8	12.5
			VLSFO	2.0	9.2	11.2	12.8
			MDO	1.7	8.9	10.6	12.2
	200000-+	cbm	HFO	1.7	9.7	11.5	13.2
			VLSFO	2.1	9.7	11.8	13.6
			MDO	1.8	9.4	11.2	12.9
Oil tanker	0-4999	dwt	HFO	13.0	73.0	86.1	99.0
			VLSFO	15.6	73.0	88.6	101.9
			MDO	13.3	70.8	84.1	96.7
	5000-9999	dwt	HFO	7.2	40.1	47.2	54.3
			VLSFO	8.5	40.1	48.6	55.9
			MDO	7.3	38.8	46.1	53.1
	10000-19999	dwt	HFO	5.6	31.4	37.0	42.5
			VLSFO	6.7	31.4	38.1	43.8
			MDO	5.7	30.4	36.1	41.5

dwt = dead weight tonnage
cbm = cubic metres

GT = gross tonnes

Continued on next page

Table 13

Sea transport emission intensity values – Non-container vessels (continued)

Vessel Characteristics and size		Unit	Fuel	Emission intensity (g CO_2e/t-km)			With 15% DAF
				WTT	TTW	WTW	WTW
Oil tanker (Continued)	20000-59999	dwt	HFO	2.7	15.3	18.1	20.8
			VLSFO	3.3	15.3	18.6	21.4
			MDO	2.8	14.9	17.7	20.3
	60000-79999	dwt	HFO	1.6	8.8	10.3	11.9
			VLSFO	1.9	8.8	10.6	12.2
			MDO	1.6	8.5	10.1	11.6
	80000-119999	dwt	HFO	1.2	6.9	8.1	9.3
			VLSFO	1.5	6.9	8.4	9.6
			MDO	1.3	6.7	7.9	9.1
	120000-199999	dwt	HFO	0.9	5.1	6.0	6.9
			VLSFO	1.1	5.1	6.1	7.1
			MDO	0.9	4.9	5.8	6.7
	200000-+	dwt	HFO	0.6	3.1	3.7	4.2
			VLSFO	0.7	3.1	3.8	4.3
			MDO	0.6	3.0	3.6	4.1
Other liquids tankers	0-999	dwt	HFO	185.4	1038.3	1223.6	1407.2
			VLSFO	221.4	1038.3	1259.7	1448.7
			MDO	189.3	1006.0	1195.3	1374.6
	1000-+	dwt	HFO	5.0	27.8	32.8	37.7
			VLSFO	5.9	27.8	33.8	38.8
			MDO	5.1	27.0	32.0	36.9
Ferry-RoPax	0-1999	GT	HFO	80.9	453.0	533.8	613.9
			VLSFO	96.6	453.0	549.6	632.0
			MDO	82.6	438.9	521.5	599.7

Vessel Characteristics and size		Unit	Fuel	Emission intensity (g CO_2e/t-km)			With 15% DAF
				WTT	TTW	WTW	WTW
Ferry-RoPax (Continued)	2000-4999	GT	HFO	39.1	218.8	257.9	296.6
			VLSFO	46.7	218.8	265.5	305.3
			MDO	39.9	212.0	251.9	289.7
	5000-9999	GT	HFO	30.3	169.5	199.7	229.7
			VLSFO	36.1	169.5	205.6	236.5
			MDO	30.9	164.2	195.1	224.4
	10000-19999	GT	HFO	19.3	108.3	127.7	146.8
			VLSFO	23.1	108.3	131.5	151.2
			MDO	19.8	105.0	124.7	143.4
	20000-+	GT	HFO	14.6	81.8	96.4	110.9
			VLSFO	17.5	81.8	99.3	114.2
			MDO	14.9	79.3	94.2	108.3
Refrigerated bulk	0-1999	dwt	HFO	24.0	134.4	158.4	182.2
			VLSFO	28.7	134.4	163.1	187.6
			MDO	24.5	130.2	154.8	178.0
	2000-5999	dwt	HFO	11.6	65.1	76.8	88.3
			VLSFO	13.9	65.1	79.0	90.9
			MDO	11.9	63.1	75.0	86.2
	6000-9999	dwt	HFO	8.7	48.8	57.5	66.1
			VLSFO	10.4	48.8	59.2	68.0
			MDO	8.9	47.3	56.1	64.6
	10000-+	dwt	HFO	6.4	35.9	42.3	48.7
			VLSFO	7.7	35.9	43.6	50.1
			MDO	6.5	34.8	41.3	47.5

dwt = dead weight tonnage
GT = gross tonnes

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Table 13

Sea transport emission intensity values – Non-container vessels (continued)

Vessel Characteristics and size		Unit	Fuel	Emission intensity (g CO_2e/t-km)			With 15% DAF
				WTT	TTW	WTW	WTW
Ro-Ro	0-4999	dwt	HFO	30.7	172.2	202.9	233.4
			VLSFO	36.7	172.2	208.9	240.2
			MDO	31.4	166.8	198.2	228.0
	5000-9999	dwt	HFO	6.7	37.7	44.4	51.0
			VLSFO	8.0	37.7	45.7	52.6
			MDO	6.9	36.5	43.4	49.9
	10000-14999	dwt	HFO	5.6	31.3	36.9	42.5
			VLSFO	6.7	31.3	38.0	43.7
			MDO	5.7	30.3	36.1	41.5
	15000+	dwt	HFO	2.9	16.5	19.5	22.4
			VLSFO	3.5	16.5	20.0	23.0
			MDO	3.0	16.0	19.0	21.8
Vehicle	0-29999	GT	HFO	14.9	83.7	98.7	113.5
			VLSFO	17.9	83.7	101.6	116.8
			MDO	15.3	81.1	96.4	110.8
	30000-49999	GT	HFO	7.1	39.9	47.1	54.1
			VLSFO	8.5	39.9	48.5	55.7
			MDO	7.3	38.7	46.0	52.9
	50000+	GT	HFO	5.8	32.5	38.3	44.0
			VLSFO	6.9	32.5	39.4	45.3
			MDO	5.9	31.5	37.4	43.0

dwt = dead weight tonnage
GT = gross tonnes

Container Shipping

Default maritime container end user factors are derived from the latest Clean Cargo trade lane GHG emission factors (reporting year 2023.) Three levels of details are presented depending on the level of information about origin and destination known to the user:

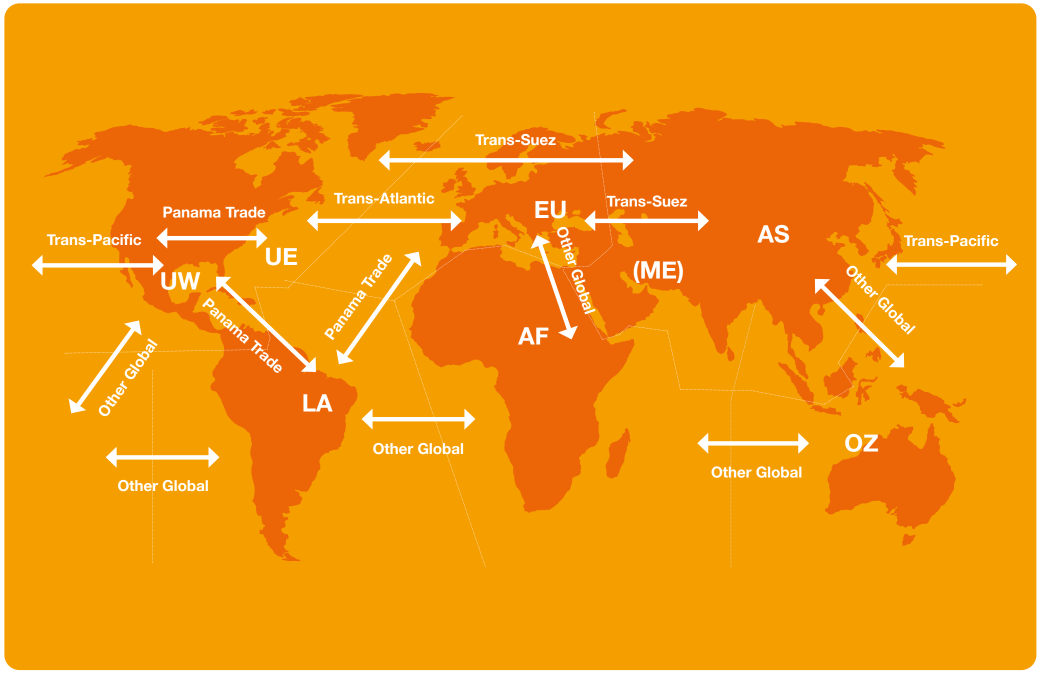
- The overall Clean Cargo Working Group (CCWG) industry average
- Five sets of aggregated data for major trade lane groupings (see figure below) based on a weighted average of flows on the detailed trade lanes included within each grouping.
- The full set of CCWG trade lanes

All the end user values for containerized shipping are calculated according to the stages presented in the CCWG methodology.[24] The values are on a WTW CO_2e basis, based on a 70% industry average load factor and the end user factors include a + 15% distance conversion to correct for the difference between actual and shortest feasible distance.

The values have been adjusted to take account of the latest North American emission factors presented in Module 1. Hence, the values are marginally higher than the values shown in the Clean Cargo 2022 annual report.

Figure 1

Common trade lanes for sea transport[18]



Source: EcoTransIT

Table 14

Sea transport emission intensity values – Container Vessels

Trade lane		Aggregate average trade lane emission intensity	End user emission intensity		
		g CO_2e/TEU-km	WTT g CO_2e/TEU-km	TTW g CO_2e/TEU-km	WTW g CO_2e/TEU-km
Industry Average (to be used in cases where the origin-destination pair is unknown)	Dry	63.7	11.0	61.7	72.7
	Reefer	129.7	22.4	125.6	148.0
Aggregated Major Trade Lanes					
Panama Trade	Dry	80.4	13.9	77.9	91.8
	Reefer	148.8	25.7	144.1	169.8
Trans-Atlantic	Dry	74.2	12.8	71.9	84.7
	Reefer	141.7	24.5	137.2	161.6
Trans-Suez	Dry	41.0	7.1	39.7	46.8
	Reefer	104.7	18.1	101.3	119.4
Trans-Pacific	Dry	55.7	9.6	53.9	63.5
	Reefer	117.6	20.3	113.8	134.1
Other Global	Dry	77.4	13.4	74.9	88.3
	Reefer	143.6	24.8	139.0	163.9
Detailed Trade Lanes					
Asia to-from Africa	Dry	72.3	12.5	70.0	82.5
	Reefer	140.6	24.3	136.1	160.4
Asia to-from Mediterranean/ Black Sea	Dry	42.1	7.3	40.8	48.0
	Reefer	109.0	18.8	105.5	124.3
Asia to-from Middle East/ India	Dry	64.2	11.1	62.1	73.2
	Reefer	127.9	22.1	123.8	145.9
Asia to-from North America EC / Gulf	Dry	54.1	9.3	52.4	61.7
	Reefer	114.0	19.7	110.4	130.1
Asia to-from North America WC	Dry	56.8	9.8	55.0	64.8
	Reefer	120.7	20.9	116.8	137.7
Asia to-from North Europe	Dry	38.7	6.7	37.5	44.1
	Reefer	100.6	17.4	97.4	114.8
Asia to-from Oceania	Dry	85.0	14.7	82.3	97.0
	Reefer	152.4	26.3	147.5	173.9
Asia to-from South America (incl. Central America)	Dry	61.0	10.5	59.0	69.6
	Reefer	120.7	20.9	116.8	137.7
Europe (North & Med) to-from Africa	Dry	89.4	15.4	86.5	102.0
	Reefer	163.9	28.3	158.7	187.0
Europe (North & Med) to-from South America (incl. Central America)	Dry	71.7	12.4	69.4	81.8
	Reefer	138.3	23.9	133.9	157.8
Europe (North & Med) to-from Middle East/India	Dry	54.6	9.4	52.9	62.3
	Reefer	121.1	20.9	117.2	138.2
Europe (North & Med) to-from Oceania (via Suez / via Panama)	Dry	78.6	13.6	76.1	89.7
	Reefer	139.6	24.1	135.1	159.3
Mediterranean/Black Sea to from North America EC/Gulf	Dry	80.4	13.9	77.8	91.7
	Reefer	152.0	26.3	147.1	173.4
Mediterranean/Black Sea to-from North America WC	Dry	56.4	9.7	54.6	64.3
	Reefer	130.6	22.6	126.4	149.0
North America EC/ Gulf/WC to-from Africa	Dry	111.3	19.2	107.7	127.0
	Reefer	180.1	31.1	174.3	205.5
North America EC/ Gulf/WC to-from Oceania	Dry	74.1	12.8	71.7	84.5
	Reefer	133.1	23.0	128.8	151.8
North America EC/ Gulf/WC to-from South America (incl. Central America)	Dry	84.1	14.5	81.4	95.9
	Reefer	152.6	26.4	147.7	174.1

Table 15

Sea transport emission intensity values – Container Vessels

Trade lane		Aggregate average trade lane emission intensity	End user emission intensity		
		g CO_2e/TEU-km	WTT g CO_2e/TEU-km	TTW g CO_2e/TEU-km	WTW g CO_2e/TEU-km
North America EC/ Gulf/WC to-from Middle East/India	Dry	72.8	12.6	70.5	83.1
	Reefer	135.0	23.3	130.7	154.0
North Europe to-from North America EC/ Gulf	Dry	78.0	13.5	75.5	89.0
	Reefer	143.6	24.8	139.0	163.8
North Europe to-from North America WC	Dry	-	-	-	-
	Reefer	-	-	-	-
South America (incl. Central America) to-from Africa	Dry	101.0	17.5	97.8	115.2
	Reefer	174.9	30.2	169.3	199.5
Intra Africa	Dry	115.1	19.9	111.4	131.3
	Reefer	214.0	37.0	207.2	244.1
Intra North America EC/Gulf/WC	Dry	214.5	37.1	207.6	244.7
	Reefer	294.5	50.9	285.1	336.0
Intra South America	Dry	100.1	17.3	96.9	114.2
	Reefer	176.3	30.5	170.7	201.1
SE Asia to-from NE Asia	Dry	90.1	15.6	87.2	102.8
	Reefer	157.8	27.3	152.8	180.0

Trade lane		Aggregate average trade lane emission intensity	End user emission intensity		
		g CO_2e/TEU-km	WTT g CO_2e/TEU-km	TTW g CO_2e/TEU-km	WTW g CO_2e/TEU-km
Intra NE Asia	Dry	100.7	17.4	97.5	114.9
	Reefer	177.1	30.6	171.4	202.0
Intra SE Asia	Dry	116.1	20.1	112.4	132.4
	Reefer	195.2	33.7	189.0	222.7
North Europe to-from Mediterranean /Black Sea	Dry	64.4	11.1	62.3	73.5
	Reefer	131.0	22.6	126.8	149.4
Intra Mediterranean/ Black Sea	Dry	137.5	23.8	133.1	156.9
	Reefer	240.2	41.5	232.5	274.0
Intra North Europe	Dry	141.3	24.4	136.8	161.2
	Reefer	234.9	40.6	227.4	268.0
Intra Middle East/India	Dry	106.3	18.4	102.9	121.3
	Reefer	187.2	32.3	181.2	213.6
Other	Dry	84.9	14.7	82.2	96.9
	Reefer	162.9	28.2	157.7	185.8

3 Module 3 Refrigerant emission factors

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Emission factors for refrigerants need to take into consideration the different chemical formulas of the refrigerant used. Module 3 gives an overview on refrigerant emission factors taking these different formulas into consideration.

Table 1
Emission factors for refrigerant losses of mobile air conditioning and temperature-controlled freight units

	Mobile air conditioning units in commercial trucks	Temperature-controlled mobile freight units (e.g., trailer with a transportation refrigerant unit)
Refrigerant charge capacity	1.5 kg	5.5 kg
Annual leakage rate	15%	32.5%
Annual leakage product	1.5 kg * 15% = 0.225 kg	5.5 kg * 32.5% = 1.7875 kg

Table 2
Refrigerant emission factors[15]

Type	Chemical formula	Alternative name	GWP100, AR6 [g CO_2e / g]
R-12	CF2Cl2 // CCl2F2	Dichlorodifluoromethane	12,500.0
R-22	CHClF2	Chlorodifluoromethane	1,960.0
R-23	CHF3	Fluoroform	14,600.0
R-32	CH2F2	Difluoromethane	771.0
R-115	CClF2CF3	Chloropentafluoroethane	9,600.0
R-124	C2HF4Cl // CHClFCF3	1-Chlor-1,2,2,2-Tetrafluoroethane	597.0
R-125	CHF2CF3	Pentafluoroethane	3,740.0
R-134a	CH2FCF3	1,1,1,2-Tetrafluoroethane	1,530.0
R-142b	C2H3F2Cl	1-Chlor-1,1-difluoroethane	2,300.0
R-143a	CH3CF3	1,1,1-Trifluoroethane	5,810.0
R-152a	C2H4F2 // CH3CHF2	1,1-Difluoroethane	164.0
R-218	C3F8	Octafluoropropane	9,290.0
R-290	C3H8	Propane	0.02
R-401A	Mixture, own calculation: 53% R-22, 13% R-152A, 34% R-124		1,263.1
R-402A	Mixture, own calculation: 60% R-125, 2% R-290, 38% R-22		2,988.8
R-404A	Mixture, own calculation: 44% R-125, 4% R-134a, 52% R-143a		4,728.0
R-407A	Mixture, own calculation: 20% R-32, 40% R-125, 40% R-134a		2,262.2
R-407C	Mixture, own calculation: 23% R-32, 25% R-125, 52% R-134a		1,907.9
R-407F	Mixture, own calculation: 30% R-32, 30% R-125, 40% R-134a		1,965.3
R-408A	Mixture, own calculation: 7% R-125, 46% R-143a, 47% R-22		3,855.6
R-409A	Mixture, own calculation: 60% R-22, 25% R-124, 15% R-142b		1,670.3
R-410A	Mixture, own calculation: 50% R-32, 50% R-125		2,255.5
R-413A	Mixture, own calculation: 88% R-134a, 9% R-218, 3% R-600a		2,182.5
R-417A	Mixture, own calculation: 46,6% R-125, 50% R-134a, 3,4% R-600		2,507.8
R-417C	Mixture, own calculation: 19,5% R-125, 78,8% R-134a, 1,7% R-600		1,934.9

Type	Chemical formula	Alternative name	GWP100, AR6 [g CO_2e / g]
R-422A	Mixture, own calculation: 85,1% R-125, 11,5% R-134A, 3,4% R-600a		3,358.7
R-422D	Mixture, own calculation: 65,1% R-125, 31,5% R-134a, 3,4% R-600a		2,916.7
R-448a	Mixture, own calculation: 26% R-32, 26% R-125, 20% R-1234yf, 21% R-134a, 7% R-1234ze(E)		1,494.4
R-449A	Mixture, own calculation: 25,7% R-134a, 25,3% R-1234yf, 24,7% R-125, 24,3% R-32		1,504.5
R-450A	Mixture, own calculation: 42% R-134a, 58% R-1234ze(E)		643.4
R-452a	Mixture, own calculation: 11% R-32, 59% R-125, 30% R-1234yf		2,291.6
R-502	Mixture, own calculation: 48,8% R-22, 51,2% R-115		5,871.7
R-504	Mixture, own calculation: 48,2% R-32, 51,8% R-115		5,344.4
R-507	Mixture, own calculation: 50% R-125, 50% R-143a		4,775.0
R-507A	Mixture, own calculation: 50% R-125, 50% R-143a		4,775.0
R-509A	Mixture, own calculation: 44% R-22, 56% R-218		6,064.8
R-513A	Mixture, own calculation: 44% R-134a, 56% R-1234yf		673.5
R-600	C4H10	n-Butane	0.01
R-600a	C4H10	Isobutane	0.01
R-717	NH3	Ammonia	-
R-744	CO2	Carbon dioxide	1.0
R-1234ze(E)	C3H2F4//trans-CF3CH=CHF	(E)-1,3,3,3-Tetrafluoropropene	1.4
R-1234yf	C3H2F4//CF3CF=CH2	2,3,3,3-Tetrafluoropropene	0.5
ISCEON 89	Mixture, own calculation: 86% R-125, 9% R-218, 5% R-290		4,052.5
FX 100 (R-427A)	Mixture, own calculation: 50% R-134a, 25% R-125, 15% R-32, 10% R-143a		2,396.7

For the assessment of refrigerant losses, ISO 14083 provides default values for refrigerant charge capacities and annual leakage rates (Chapters I.3.2 and I.3.3)[25]

3 Module 4
Examples of emission calculations - step-by-step

This Module contains examples of transport chains and explains – step by step – how to calculate their emissions. Using the most prevalent modes of transport and combinations of them (multi-modal transport), we guide you through the use of the GLEC Framework.

The examples are developed in such a way that they best cover the different calculation needs of the various actors in the supply chain, taking into consideration different levels of access to primary data. For the examples we use actors of different size with different shares of emissions in the overall carbon footprint of the transport chain, and with different requirements towards the granularity of the calculation. This ensures that you get scenarios which are as realistic as possible.

Furthermore, the examples cover different use cases of the calculation: they may be part of a (company) carbon footprint or a specified project, an impact analysis and/or part of a target setting and tracking assessment.

As mentioned throughout the GLEC Framework, measured (primary) data is preferred to default values. For distances always use the shortest feasible distance (SFD) or Great Circle Distance (GCD) wherever possible.

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1. Calculation of GHG emissions from road transport

Road transport chain elements often occur as part of transport chains with several transport chain elements (TCEs). These TCEs can be with other modes of transport where the road transport builds the first leg pick-up and last leg delivery service; also the road TCE can be part of a more or less complex network consisting solely of road TCEs.

The application of ISO 14083 follows the general calculation steps set out in Section 1 of the GLEC Framework. Therefore, TCEs must be identified for each consignment separately. As the number of consignments can be very high in a dense and large road transport network, it is recommended to use transport management systems (TMS) as the basis for routing information: transport flows and their distances are stored in TMS, and the events created by the scans of shipments at a hub or terminal usually indicate the start or end of a TCE. TMS therefore provide a good source for transport distances at a consignment level. The preferred transport distance type to be used in the GLEC Framework is the SFD, which can be identified per TCE from the TMS or the route planner. In exceptions GCD can be used (please see Section 1 for further information.)

Transport activity for each consignment is calculated by multiplying the consignment's mass by the TCE distance. Next, all transport activities of each journey are added up to build the transport activity of the related transport operation categories (TOC).

Then the GHG emission intensity of the TOC can be calculated.

Example:
If an average of 0.15l "diesel" is consumed per tkm in a TOC, the associated GHG emission intensity when using a typical WTW diesel emission factor for Europe, which includes 5% biodiesel, would be:

0.15 l x 3.36 kg/l CO_2e = 0.504 kg CO_2e per tkm

To calculate the GHG emissions for a specific consignment on a TCE associated with the above TOC, its emission intensity must be multiplied by the TCE's specific consignment mass and activity distance. So, if the consignment mass is 450kg and the distance 20km then, for the above example, the total emissions for the consignment on this TCE would be:

0.45 t x 20 km x 0.504 kg CO_2e per tkm = 4.54 kg CO_2e

The following calculation examples illustrate different angles and use cases, always applying the same logic, starting with a basic use case with access to all relevant GHG activity data (fuel use, refrigerant use etc.), progressing up to more complex transport operations with less access to primary data.

Figure 1
Example of a road transport chain

1.1 Company's own vehicle fleet emission calculations and derived emission intensities

In the following examples, the company has the objective of calculating its own footprint. The related reporting is intended for use by the company itself for gaining insight into its carbon footprint as well as by its suppliers and customers who want to include the reported values in their supply chain emission reporting.

Given the structure of road transport with its high number of consignments, TCEs in road transport are the journey segments along a specific route, from point of departure to destination which an operator consolidates in its vehicle fleet operation, including terminal/ hub handling and transshipments.

NOTE: Consignments consolidated into mixed loads like these need to be captured by their actual mass, not chargeable weights, including packaging but excluding separate load carriers like pallets, metal cages etc., unless tied to the consignments by the original consignor.

As routes and tours are usually kept in a TMS or planning system, their distances in a period of time (usually one year) should be known. This distance (km) per route or tour (TCE) multiplied by the mass of freight gives the transport activity (tkm) of the TCE.

Example:
On the route Hamburg-Munich a total cargo mass of 1,200 tonnes is transported during one year. The TMS gives an SFD of 658 km. Then the total tkm of this route can be calculated as:

658 km x 1,200 t = 789,600 tkm

In case you do not have access to this data from a TMS, the best workaround is to capture total distance on each route and the average load (tonnes) per vehicle class: e.g., in case the 40t trucks in a pool carry 15 tonnes on average and these (e.g., 10) trucks are operating in total 1,000,000 loaded kilometers per year, their total transport activity would be calculated as:

1,000,000 km x 15 t = 15,000,000 tkm

A TOC is always a group of vehicles and associated operations that share the same characteristics (e.g., same vehicle size classes with same temperature condition). TOCs are formed to reflect the transport operations of each TCE.

The transport operator needs to take care that the choices made in defining the TOCs are meaningful and relevant for its own decisions and those of its clients. It is recommended to check the TOC creation and granularity level with the most important clients. Furthermore, it is recommended to always separate transport activity and associated emissions of different temperature conditions, as these are different services for which different carbon intensities need to be calculated and made transparent (to clients, for own efficiency controls). Here you find an overview of example parameters for TOC creation and granularity levels. Flexibility exists to merge or subdivide these examples to match the granularity to the needs of the calculation.

Table 1

Examples of TOC granularity in road transport

TOC examples and granularity levels	Size class	Service type	Hamburg – Frankfurt – Hamburg	All transports in a country	All transports in a region e.g., Europe	All transports in all regions (total operations)
Ambient	<3.5t 3.5-7.49t 7.5-11.99t … 40-50t	Collection and distribution, urban delivery Linehaul deliveries	May be subdivided into different size or service types or considered as a single service type, with the choice clearly stated	May be subdivided into different size or service types or considered as a single service type, with the choice clearly stated	May be subdivided into different size or service types or considered as a single service type, with the choice clearly stated	Tkm run on all ambient vehicles (5)
Temperature condition I	As above	As above	As above	As above	As above	As above
Temperature condition II	As above	As above	As above	As above	As above	As above

Based on this table, examples for TOCs in road transport include:

- An individual vehicle on a specific route, outbound and return
- An individual vehicle in a specific network
- Vehicles of a specific type in a fleet if they share similar or even identical characteristics, e.g. temperature controlled, on a specific route, outbound and return
- Vehicles of a specific type in a fleet if they share similar or even identical characteristics, on all routes operated by a specific organization
- ……

When it comes to the TOC level, transport activity (tkm) needs to be calculated separately per TOC to ensure that the correct emission intensities of each operation category are applied: e.g., per vehicle size class, route type, ambient vs. temperature controlled, etc. To simplify calculations, all similar TOCs (e.g., same vehicle size classes with same temperature condition) can be clustered and their energy use can be summed up. For example:

- All energy use in size class X, driven ambient = total liters of fuel
- All energy use in size class Y, driven ambient = total liters of fuel
- All energy use in size class Y, driven with temperature condition I = total liters of fuel (diesel)
- All energy use in size class Y, driven with temperature condition I = total kWh (BEV)
- ….

Once all energy use is identified, the data can be allocated to the TOCs, at the chosen level of aggregation and depending on the granularity you aim for. In Section 3 Module 1 all associated emission factors can be found for diesel (EU average, US average or composed with a respective biofuel blend) and electricity emission factors.

Once the calculated transport activity (tkm) is matched to the energy use and associated emissions per TOC, in the chosen granularity, you can calculate the emission intensity and emissions of the TOC:

Emission intensity (CO_2e/tkm) = GHG emissions per tkm at the level of granularity chosen for the TOC.

Total emissions (CO_2e) = GHG emissions per TOC = all energy use per TOC multiplied by the appropriate emission factor.

Example calculations for different energy sources used:

- **For total emissions in diesel vehicles:** all liters of fuel multiplied by the WTW emission factor in kg CO_2e/l (see Module 1 of GLEC Framework for example values that follow the ISO 14083 methodology) = total WTW emissions in kg CO_2e

Example:
100,000 liters diesel/5% biodiesel blend consumed in Europe multiplied by the emission factor of 3.36 kg/l (see GLEC Framework emission factor in Module 1)
= 336,000 kg (or 336 tonnes) of CO_2e for this amount of fuel

- **For total emissions in battery electric vehicles:** all kWh of electricity multiplied by the emission factor in kg CO_2e/kWh applicable for the country (location based) or any market-based green electricity provision = total WTW emissions in kg CO_2e

Example:
100,000 kWh electricity consumed in Europe multiplied by the factor of 356.4 g/kWh CO_2e (The EU average value of 99 g/MJ CO2e from Module 1 is equivalent to 356.4 g/kWh CO_2e.)
= 35,640 kg CO_2e.

NOTE: It is important that any different, market-based emission factors are independently certified.

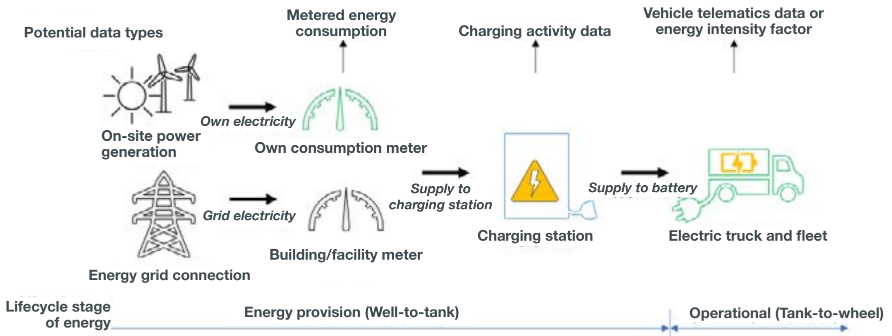
- **For total emissions in hybrid vehicles:** Diesel consumption in liters multiplied by the respective emission factor + energy use in kWh electricity multiplied by the respective emission factor = WTW CO_2e emissions from diesel + WTW CO_2e emissions from electricity.

Example:
Hybrid energy use is composed of 100,000 liters of diesel/5% biodiesel blend and 100,000 kWh of electricity. Using the above European emission factors for diesel and electricity, the calculation would be the same as above, resulting in 336,000 kg of CO_2e from diesel consumption + 35,640 kg of CO_2e from electricity use, giving a total of 371,640 kg CO_2e.

1.2 EV operations emission intensity TOC

Calculations for EV operations should consider both electricity emission factor and potential losses at specific charging locations as shown in figure 1.

Figure 1
Illustration of electricity pathway from grid meter to vehicle and the various data



In EV Fleet operations, charging is often done at various locations, considering regional and long-haul scenarios, for example, in long-haul operations, carriers are expected to charge at their trucks depot overnight, however, additional charging to extend driving ranges may occur at destinations during loading or unloading or en-route at public or highway charging stations, potentially in different countries.

TOC of EV operations include:

- the average grid electricity mixes of countries where charging activity takes place,
- average energy contribution by behind-the-meter power generation, such as the facility's solar panels, and
- the on-site electrical and charging infrastructure layout

Considering these factors, we propose two additional variables to be included in calculation.

Net electricity emission factor: related to the charging location, representing the weighted average emission factor for all sources of electricity used in the charging station

$$\text{Net emission factor} = \frac{\text{Energy}_{grid} * \text{Emission factor}_{grid} + \sum \text{Energy}_{BTM} * \text{Emission factor}_{BTM}}{\text{Energy}_{grid} + \sum \text{Energy}_{BTM}}$$

Where BTM is behind-the-meter power generation.

Charging location energy correction factor: this values represents the ratio between the amount of electricity in kWh transferred to the vehicle and the amount of electricity measured at the meter. Considering there is inefficient empirical data to provide an industry wide estimate, we recommend using a conservative value of 1.11 to represent losses of 90% from meter to vehicle.

Corrected emission factor associated with the charging location is multiplication of both the net electricity emission factor and the charging location correction factor.

$$\text{Corrected emission factor} = \text{Net emission factor} * \text{Energy correction factor}$$

$$\text{TOC Emission Intensity} = \frac{\sum_i (\text{Energy}_i * \text{Corrected emission factor}_i)}{tkm}$$

$$= \text{Energy intensity factor} * \sum_i \text{Charging activity share}_i * \text{Corrected Emission factor}_i$$

Example:
The annual charging activity share divided by locations are presented in the table, including the net electricity emission factor and charging location energy correction factor.

Charging location	Grid emission factor (g/kWh at meter)	Net emission factor (g/kWh at meter)	Charging correction factor (kWh at vehicle/ kWh at meter)	Corrected emission factor (g/ kWh at vehicle)	Charging activity share (%)
Domestic A	100	84	1.11	93	40%
Domestic B	100	100	1.11	111	30%
International C	250	135	1.05	142	10%
International D	250	204	1.09	222	20%

Based on the above data, calculation amounts to 129 g/kWh. If the energy intensity of the fleet is taken as 0.17 kWh/tkm, the TOC emission intensity can be calculated as 22 g/tkm. In the normal methodology used by carriers or shippers, take the reported TOC emission intensity and multiply it by that TOC's annual transport activity to calculate the annual emissions of the EV operations.

1.3 Refrigerants

Replenishment of any refrigerant losses needs to be allocated on top of the energy-based GHG emissions for temperature-controlled services. Hence the coverage of the calculation is:

All fuel consumption converted to WTW GHG emissions (mass of CO_2e) + all refrigerant-loss-related GHG emissions (tonnes or kg). You will find the respective emission factors in Module 3. If the refrigerant type is unknown, you may apply the respective default factor.

Where there are different temperature conditions that lead to different rates of fuel use (and there may also be different refrigerant types), the calculations need to be carried out separately per temperature condition for each transport activity.

Example:
In the TOC for temperature condition A, 6,000,000 tkm have been operated by 10 trucks with mobile refrigerant units. The average volume of the applied refrigerant for air conditioning units is, using ISO 14083 default factors, 1.5 kg charge capacity, with a default loss of 15% = 0.225 kg per unit, and for a temperature-controlled mobile freight unit by default 5.5 kg charge capacity, with a default loss of 32.5% = 1.787 kg per unit.

This results in a refrigerant loss for the 10 trucks of
2.25 kg + 17.87 kg = 20.12 kg

This loss of 20.12 kg needs to be applied across the 6,000,000 tkm to ensure the additional GHG emissions caused by this transport activity due to the temperature condition A are included. Where the same refrigerant is used, the same emission factor applies:

If refrigerant R-134a, with an emission factor of 1,430 kg CO_2e/kg is used, this would result in 321.75 kg CO_2e for each air-conditioned unit, and a further 2,555.41 kg CO_2e for each temperature-controlled mobile freight unit.

The total of 28,771.6 kg CO_2e emissions of refrigerant losses for all 10 trucks would result in an additional GHG emissions of 0.0048 kg CO_2e per tkm.

NOTE: Where different refrigerants are used in one transport, different emission factors for the leakages must be applied.

1.4 Inclusion of HOC emissions

In order to integrate HOC emissions, all terminal/hub energy consumption which is related to the hub operation activities carried out to the freight, needs to be identified per HOC type: e.g. ambient vs. temperature-controlled terminal spaces.

To calculate the total emissions of a transport chain the emissions for all transport and hub related TCEs need to be added together.

1.5 Collection and delivery rounds

Collection and delivery rounds that consist of a roundtrip (or “milkrun”) with several stops where cargo is picked up and/or delivered may be considered just like any other journey. However, information on the routing and distance between the stops and the respective load levels along the journey may not always be available. Furthermore, the actual transport may be carried out differently day by day, depending on demand (amount and location of stops) and other circumstances such as road congestion, lead time slots etc.

The preferred option, assuming a full set of information, is to distribute the calculated emissions for the delivery round according to the transport activity share of the notional point-to-point trips that have been replaced by the round trip.

Example:
A vehicle leaves the base fully loaded and returns to base empty having dropped off loads at 5 intermediate stops.

This example shows that the cumulative distance driven of the round trip (in this case, a total of 30 km) can easily be much shorter than the total return trip distance of the individual trips that have been replaced, leading to greater efficiency and lower overall emissions.

The preferred option to distribute a “fair” share of the emissions in a roundtrip, is to distribute the total GHG emissions of the entire round according to each delivery’s share of notional point-to-point transport activity. In the above example this would mean distributing the emissions caused by the 30-km roundtrip based on the notional point-to-point transport activities that have been replaced by the round trip. This has the benefit of providing stability to the calculation, does not penalize a delivery that is made towards the end of the delivery round and eliminates the variability that comes from schedules that change on a daily basis.

In cases where individual delivery locations or item masses are not tracked, options include calculating the emissions for the round trip based on fuel consumption and then allocating the emissions based on a typical item mass for the specific operation in question (if actual mass is not known) or calculating the emissions on a per-item basis, which may be a more suitable approach for the mail sector where deliveries are not tracked in an often dense distribution network.

Table 2
Example of a road transport routing

Start						Return to base
Point A	Point B Client 1	Point C Client 2	Point D Client 3	Point E Client 4	Point F Client 5	Point A
Full (12.6 t)						**Empty (0t)**
Delivery (t)	5	2	1	4	0.6	
Actual distance driven per leg (km)	5 km	2 km	8 km	5 km	4 km	6 km
Cumulative distance driven (km)	5 km	7 km	15 km	20 km	24 km	30 km
SFD (A to Point X) (km)	5 km	6 km	10 km	8 km	6 km	35 km
Notional transport activity for allocation purposes (tkm)	5 x 5 = 25	2 x 6 = 12	1 x 10 = 10	4 x 8 = 32	0.6 x 6 = 3.6	82.6
Share of notional transport activity for allocation purposes	25 / 82.6 = 0.30	12 / 82.6 = 0.15	10 / 82.6 = 0.12	32 / 82.6 = 0.39	3.6 / 82.6 = 0.04	

1.6 Special case: mail and parcel services

Characteristics of the transport of mail and parcel services are that letters and parcels are not transported individually. The mail and parcel business often takes place on flexible routes and with several consolidations on a journey and it is not possible to track distances individually per letter or parcel. Mail items usually have very little mass (0.02–0.1 kg), yet their mass may vary from 20 g up to 32 kg and it is difficult to track individual consignment mass.

However, it is essential to use an indicator that reflects operations in a meaningful and pragmatic way. The mail and parcel sector is in the process of evaluating suitable categories for mail and parcels.

Until a better solution is identified and brought into line with ISO 14083, the emissions per item are therefore calculated by dividing the total emissions of a TCE (GHG activity) by number of items, to arrive at a carbon intensity.

Where the parcel mass is known, a more specific approach can be taken. The purpose of the following example is to show the difference in application between the generic or the more specific weight-based approach, in particular its impact on the first and last mile of the delivery.

Example: (example from GLEC Framework v.2, updated to take into account revised emission factors)

In the following situation a 250 g package is collected from the sender as part of a tracked collection round, inserted into a consolidated, international mail and parcels network, and delivered as part of a general, untracked delivery network.

Figure 2
Example of a mail and parcel transport chain

The overall calculation framework for the full transport chain from point of collection to delivery is presented below. Starting information is pre-populated for TCE 2 to 8, i.e. from logistics site 2, where the collections are processed, to logistics site 8, where the deliveries are organized.

Table 3
Example of data sources of a mail and parcel transport chain

			WTW emission intensity	Unit	Data category	Transport activity distance (km)	Transport activity (tkm)	WTT emissions (kg CO_2e)	TTW emissions (kg CO_2e)	WTW emissions (kg CO_2e)
1	Tracked collection round	own transport			Primary	-	-	A	A	A
2	Logistics site	own site	4.1	kg CO_2e/t	Primary	-	-			0.0010
3	Road feeder to main terminal	own transport	0.11	kg CO_2e/ t-km	Primary	120	0.030	0.0006	0.0027	0.0033
4	Logistics site	own site	4.6	kg CO_2e/t	Primary	-	-			0.0012
5	Air main haul	own plane	0.563	kg CO_2e/ t-km	Primary	4,800	1.200	0.1452	0.5304	0.6756
6	Logistics site	contracted, shared site	1.3	kg CO_2e/t	Default*	-	-			0.0003
7	Rail feeder to local delivery hub	contracted service	0.03	kg CO_2e/ t-km	Default**	400	0.100	0.0007	0.0023	0.0030
8	Logistics site	contracted, shared site	1.3	kg CO_2e/t	Default*	-	-			0.0003
9	Untracked delivery round	own transport			Primary	-	-	B	B	B

Data category "primary" implies that the data is sourced from a TMS.
Data category "default" implies that the data was sourced from GLEC Framework default value lists:
* logistics site default, ambient transshipment center
** European diesel rail default for general cargo

The above information would apply irrespective of the approach used for the collection and delivery rounds.

The final task is to calculate the values for TCE 1 and 9, figuring as A and B in Table 3. The following calculations show how this could be done for both situations: tracked, in this case a collection round, and untracked, in the above example a delivery round.

TCE1: the tracked collection round

For the tracked collection round the assumption is that the following information exists or can be calculated based on primary data:

- total fuel consumption for the collection round
- SFD between the logistics site and each individual collection point
- mass of each individual item, including packaging
- emission factor to convert fuel to GHG emissions

In the table opposite, 14 collections are shown. The 250 g item that is the focus of this example is collection number 7.

The allocation of emissions is based on the percentage share of the direct tonne-kilometers for each collected item. So, the 250 g item at row 7 gets 0.0024/0.3631 as its share of the total emissions (0.7%).

The emission factor used to convert 4.8 liters to 15.734 kg CO_2e is the US WTW value for diesel fuel from Module 1.

Table 4

Example of a mail and parcel transport chain emission calculation

14 collections	Direct distance collection location to hub (km)	Point-to-point distance driven (km)	Item weight (kg)	Total fuel (l)	Direct transport activity (tkm)	Allocation (%)	WTT emissions (kg CO_2e)	TTW emissions (kg CO_2e)	WTW emissions (kg CO_2e)
Hub									
1	8	7	4		0.0280	7.7%	0.204	1.010	1.213
2	2	7.2	1		0.0072	2.0%	0.052	0.260	0.312
3	4	9	0.25		0.0023	0.6%	0.016	0.081	0.098
4	0.5	8.9	2		0.0178	4.9%	0.130	0.642	0.771
5	3	8.6	20		0.1720	47.4%	1.252	6.202	7.453
6	1	9	2		0.0180	5.0%	0.131	0.649	0.780
7	**2**	**9.5**	**0.25**		**0.0024**	**0.7%**	0.017	0.086	0.103
8	0.5	9.5	3		0.0285	7.8%	0.207	1.028	1.235
9	4	7	0.1		0.0007	0.2%	0.005	0.025	0.030
10	2	6	7		0.0420	11.6%	0.306	1.514	1.820
11	6	8	2		0.0160	4.4%	0.116	0.577	0.693
12	1	7.7	3		0.0231	6.4%	0.168	0.833	1.001
13	2	8.3	0.2		0.0017	0.5%	0.012	0.060	0.072
14	4	7	0.5		0.0035	1.0%	0.025	0.126	0.152
Hub	**4**	**3.5**							
Total	**44**			**4.8**	**0.3631**		**2.643**	**13.091**	**15.734**

TCE 9: Untracked delivery round

For the untracked delivery round the data requirement is less complex and relates to the following items:

- total fuel for the delivery round,
- number of items delivered
- emission factor to convert fuel to emissions

For the example, the 250 g item is one of 275 items delivered as part of an entire mail delivery round.

The total fuel consumption is 7.3 liters

Fuel per item is therefore
7.3l/275 = 0.02655l/item

The GHG emissions per item are as follows:
- Energy provision emissions (WTT): 0.0220kg CO_2e/item
- Operational emissions (TTW): 0.0659 kg CO_2e/item
- Total emissions (WTW): 0.0880 kg CO_2e/item using the EU average WTW value for a 7% biodiesel/diesel blend

The information is now available to insert values A (TCE1) and B (TCE9) into the overall calculation framework, leading to the following completed calculation (see Table 5).

The total WTW emissions for the 250 g package in this example along its full route are 0.875 kg CO_2e; of which 77.2% result from the air transportation main haul.

Table 5
Example of a mail and parcel transport chain by TCEs

			WTW emission intensity	Unit	Data category	Transport activity distance (km)	Transport activity (tkm)	WTT emissions (kg CO_2e)	TTW emissions (kg CO_2e)	WTW emissions (kg CO_2e)
1	Tracked collection round	own transport			Primary		-	0.0173	0.0856	0.1029
2	Logistics site	own site	4.1	kg CO2e/t	Primary	-	-	0.0006	0.0027	0.0010
3	Road feeder to main terminal	own transport	0.11	kg CO2e/t-km	Primary	120	0.030			0.0033
4	Logistics site	own site	4.6	kg CO2e/t	Primary	-	-	0.1452	0.5304	0.0012
5	Air main haul	own plane	0.563	kg CO2e/t-km	Primary	4800	1.200			0.6756
6	Logistics site	contracted, shared site	1.3	kg CO2e/t	Default*	-	-	0.0007	0.0023	0.0003
7	Rail feeder to local delivery hub	contracted service	0.03	kg CO2e/t-km	Default**	400	0.100			0.0030
8	Logistics site	contracted, shared site	1.3	kg CO2e/t	Default*	-	-			0.0003
9	Untracked delivery round	own transport			Primary		-	0.0220	0.0659	0.0879
	Total									**0.8756**

* logistics site default, ambient transshipment center
** European diesel rail default for general cargo

1.6 Limited data access, mix of primary and secondary data

It is not always possible to source all necessary data in the form of primary data. Where primary data for energy consumption or transport activity data (cargo mass and distances on consignment level) are not available, these need to be derived in the form of secondary data, as modeled or default data.

Examples:
If a company has very good data on most linehaul operations but not on the first or last mile delivery, it can get this data or at least a representative example as a basis for modeling data from contracted carriers. If these contracted carriers are not able to provide such data or do not account for a significant amount of data (the threshold depends on the assessed impact the lack of such data has on the final emission results), proxy data needs to be collected, e.g., in the form of information on fleet composition from country authorities or acknowledged databases. As far as information on average filling rates is concerned, default data from Section 3 Module 2 may be used, depending on the cargo mix carried.

If a company operates in countries where there are no statistics on fleet operation and the infrastructure is not comparable to those for which sufficient data is publicly available, studies or data on the transport structure and average fleet of such country needs to be obtained (e.g., from the International Transport Forum (ITF) or the International Council of Clean Transportation (ICCT)). If such studies suggest that the country's infrastructure resembles one of developed countries 5-10 years ago, older versions of HBEFA may be checked for suitable data. Alternatively, local data needs to be tracked which may entail dedicated projects. In case there is no fuel consumption data available, then the fuel/energy consumption and related GHG activity need to be derived solely from the transport activity:

- the sum of freight mass (tonnes) multiplied by the activity distance (km) multiplied by the emission intensity of a modeled TOC

or, failing that, the most appropriate available default emission intensity may be used.

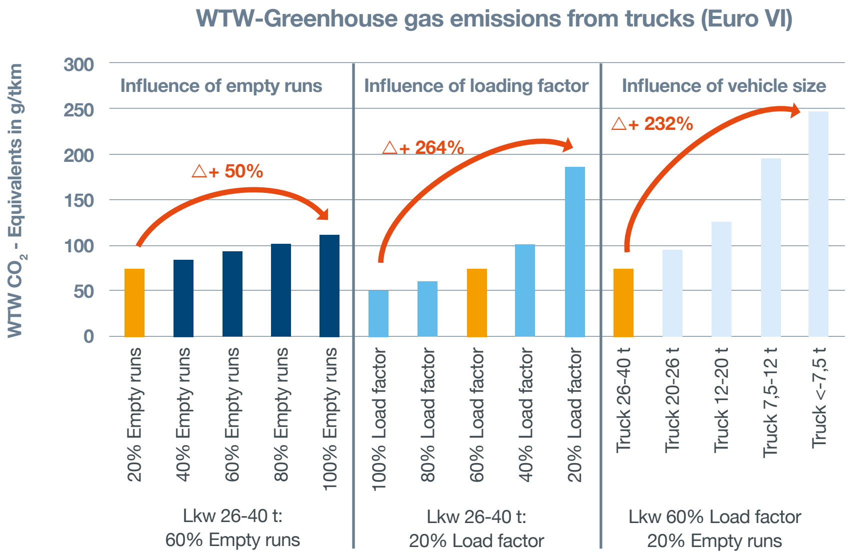
Example:
HBEFA provides a very granular database of default values for vehicle fuel consumption. It takes into consideration the most emission-sensitive parameters. These conditions may be remodeled (by a tool) whereas the actual activity (route in region X with street category Y etc.) is mirrored by the respective parameter combination in the database. For example, if a transport from Munich to Hamburg in Germany needs to be modeled, the average vehicle size operating on that route is taken as basic reference (40t truck, Euro class 6) and related parameters are chosen: 60% filling rate, 17% empty trip, 95% highway share, medium congestion, hilly topography. This combination would lead to a certain fuel/energy consumption which is then applied as the TOC emission intensity value (CO_2e g/tkm WTW).

Alternatively, if primary data for modeling emission intensities is not available, or the respective tool does not combine the parameters case by case bottom up, a default value may be used. When choosing a default value, it is important that the characteristics of the actual transport match as closely as possible the assumptions that are behind the calculation of the default values.

Figure 3 shows the impact that vehicle size, load factor and share of empty runs can have on the resulting emission intensity. This shows how important it is to pick suitable default values to generate results that are representative of the actual transport.

Therefore, default values need to be chosen according to emission sensitive parameters, and ideally assumptions on which they are used should be specified in the reporting. In many cases, the use of measured primary data in combination with the use of secondary data is necessary.

Figure 3
Impact of empty trip share, filling rate and vehicle size on emissions [26]



Quelle: Darstellung auf Basis von EcoTransIT (2017)

Example:
The network contains all planned distances according to the TMS used. The fleet which is running on each origin/destination combination (TCE) is only roughly known: <40t trucks on collection and distribution trips, >40t trucks on linehaul trips.

In such a case, you can create two TOCs: one for the collection and distribution trips, and one for the linehaul trips. For each TOC, you need to indicate the share of primary data used. The remaining share of data may be either modeled based on primary data, or the industry average of the respective country and/or region may be taken as proxy. The process of extrapolation to 100% of vehicles operating in the network needs to be described in a transparent way and it needs to be audited.

As far as filling rates are concerned, the average filling rate in Europe for example is 60%, with an empty trip factor of 17% (see default data in Section 3 Module 2). Where you have access to primary data for filling rates for a certain share of the fleet, you may take these into account.

Any deviation from the default filling rate (60% in Europe) and empty trip factor (17% in Europe) needs to be proven through measurement. For example, if all freight mass is weighed before pick up by a truck and the amount of trucks per size class operating for a certain transport activity is known, an average filling rate may be safely calculated based on this data.

Regarding truck size and pollution standard, if primary data is available for the majority of the fleet, e.g., 80%, then you can apply the GHG intensity data also to the remaining 20% of the fleet. If, however, vehicles from some TOCs are not represented in the primary data at all, or data is available for only a small share of vehicles for one specific TOC, GHG intensity for this TOC must be modeled with a bottom-up approach or using default data, as it cannot always be assumed that the small sample reflects the GHG intensity of the fleet of the entire TOC.

All emission sensitive parameters need to be modeled with care and transparency.

2. Calculation of GHG Emissions from Rail Transport

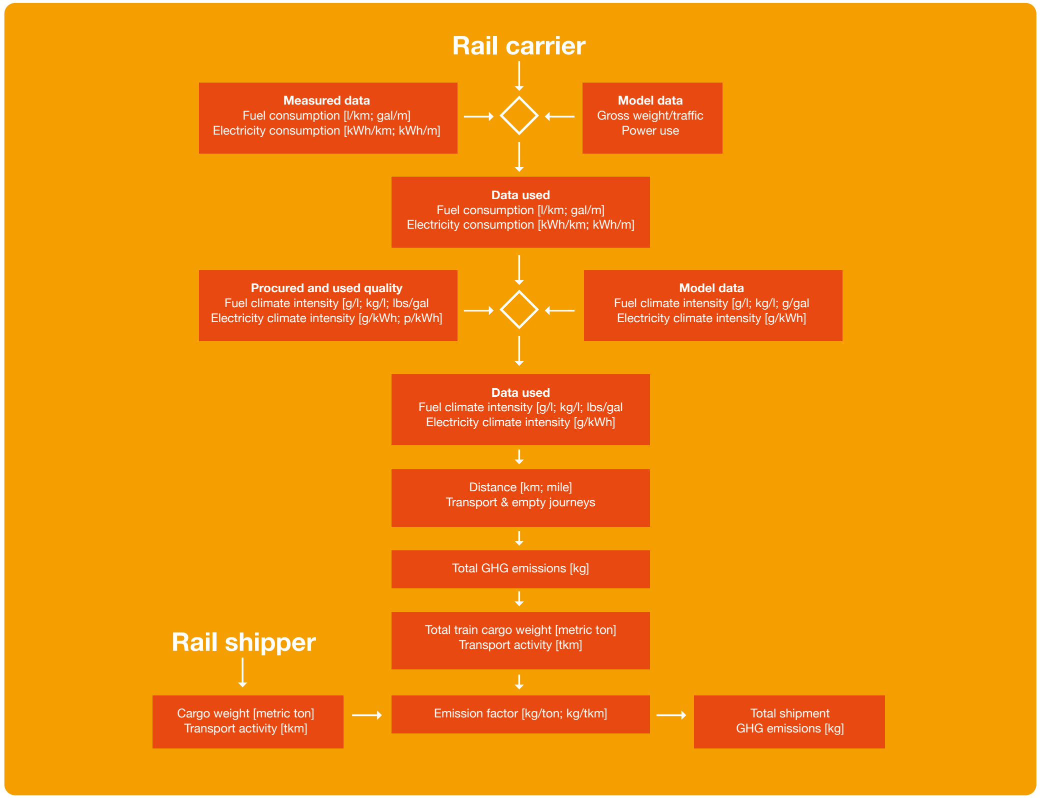
Rail transport can usually be calculated using the same logic as road transport, i.e., the TOCs follow emission sensitive parameters and are applied to the different TCEs. However, some rail-specific characteristics need to be considered:

- Most rail services are operated to a fixed schedule. However, along the schedule the train length may vary.
- Furthermore, train types vary significantly according to their configuration: e.g., trains designed to transport cars carry a certain number of vehicles on their chassis, block trains are composed of wagons of a certain size, container trains carry crane-able road and sea containers.
- The energy mix of rail transport may change when a country border is crossed. Such a change depends on the extent of electrification in a particular country, and the specific grid emission factor which depends on a country's electricity mix.

Therefore, TOCs need to be set up to reflect the different train types and energy sources, using mixes of primary, modeled and default data, as available.

The principles of calculating GHG emissions from rail freight are always similar, regardless of the propulsion system of the train or the geographical location. While rail carriers operating the train system can calculate emissions based on more detailed and usually primary data, shippers are often limited to using either data from the carrier or general rail transport default data. Shippers can use the following process when scrutinizing the data provided by their rail carrier.

Figure 4
Data flow of rail transport – from rail carrier to shipper[27]



Example:
To illustrate the practical implementation of rail GHG emissions two examples are used (US EPA26) with data from GaBi* U.S. EPA 2022, with data from GaBi Version: 10.0.1.92 26).

1. Conventional electric rail wagon operation in Europe
2. Diesel intermodal rail operation in the US

Example 1: Conventional electric rail wagon operation in Europe
This solution is based on a roundtrip going north and south with different use. The shipper making use of this data should use the average emission factor as this takes transport inefficiencies into consideration.

Emissions from the train operator's perspective:

Table 6
Calculation of a conventional rail transport in Europe

Electric cargo train	Unit	South	North	Roundtrip average
Length	m	630	630	630
Number of locomotives	n	1	1	1
Locomotive	tonne	78	78	78
Wagons	tonne	22	22	22
Wagon	tonne	30	30	30
Wagons capacity	tonne	60	60	60
Max gross weight	tonne	2,058	2,058	2,058
Cargo capacity	tonne	1,320	1,320	1,320
Gross weight empty	tonne	738	738	738
Load factor	%	100	60	80
Cargo weight	tonne	1,320	792	1,056
Gross weight	tonne	2,058	1,530	1,794
Electric distribution losses	%	10%	10%	10%
Measured electric consumptions per vehicle km vkm, including distribution losses	kWh/vkm	27	23	25
CO_2 wtw European average	g/kWh	322	322	322
Electric consumption per net-t km, including distribution losses	kWh/tkm	0.021	0.030	0.024
GHG (CO_2 per vehicle km)	g/vkm	8,765	7,557	8,183
Distance	km	400	400	
GHG emissions wtw	kg	3,506	3,023	
Transport activity				
GHG (CO_2e wtw per tkm)	g/tkm	6.64	9.53	7.75

And from the shipper's perspective:

Cargo weight	tonne	50
Distance	km	400
Transport Activity	tkm	20,000
Emission factor	g/tkm	7.75
GHG (CO_2e wtw)	kg	155

* GaBi has now been rebranded as Product Sustainability Solutions Software

Example 2: Diesel intermodal rail operation in the US

This solution is based on a roundtrip going east and west with an assumed average use of 70%. The shipper making use of this data should use the average emission factor as this takes transport inefficiencies into consideration.

Emissions from the train operator's perspective:

Table 7

Calculation of a diesel train operation in the US

Diesel intermodal train	Unit	East	West	Roundtrip average	Comment
Allowed length	ft	6,000	10,000	15,000	Further information
Locomotive length	ft	76	76	76	Further information
Number of locomotives	n	3	4	6	Further information
Total wagon length	ft	5,772	9,696	14,544	
Wagons length	ft	53	53	53	
Wagon use	%	80	80	80	
Number of wagons	n	109	183	274	
Number of TEU per wagon	n	4	4	4	40ft double-stack assumed
Total number of TEU	n	436	732	1098	
Tare weight wagon	ton	30	30	30	
Tare weight TEU	ton	4	4	4	
Locomotive weight	ton	645	860	1,290	Further information
Total tare weight	ton	3,928	6,364	9,538	
TEU weight capacity	ton	29	29	29	
Load factor	%	70	70	70	Further information
Total cargo weight	ton	8,843	14,855	22,283	
Train gross weight	ton	12,771	21,219	31,821	
Fuel consumption	gal/m	12.78	21.24	31.85	Efficiency of 999,1 tm/gal based on 2020 R1 data
GHG wtw	g/gal	11,898	11,898	378,940	
GHG wtw	g/m	152,087	252,690	378,940	
GHG wtw	g/tm	17.2	17.0	17.0	
Energy	MJ/m	1,744	2,897	4,345	
Energy	MJ/tm	0.20	0.20	0.19	
Energy	kWh/tm	0.05	0.05	0.05	

And from the shipper's perspective:

Cargo weight	ton	50
Distance	m	2,672
Transport Activity	tm	133,595
Emission factor	g/tm	17.0
GHG (CO_2e wtw)	kg	2,273

3. Calculation of GHG Emissions from Air Transport

The key calculation aspects to take into account for air cargo transport are set out in Section 1, Chapter 4, on Modal Considerations.

To repeat in short:

- Activities in scope are all fuel use and other GHG activities needed to operate the aircraft, starting with taxiing, and to keep the cargo in the required condition (including the use of refrigerants for perishables and/or air-conditioning).
- Emissions resulting from the handling of cargo in an airport terminal or warehouse are included in the calculation through the definition and use of appropriate hub operation categories (HOCs). The emission calculation for the hub activity in a specific transport chain requires the emission intensity of each of the HOC to be applied to the throughput at each hub in the transport chain.
- The allocation between passengers and freight emissions are only mass based. Passenger mass is actual passenger mass + the mass of their accompanying baggage; if primary data is not available a default mass of 100 kg is applied. Cargo mass is the mass without load carrier, according to the ISO 14083 provision of consignment mass and load carrier definition.
- Where a TCE calculation is made bottom-up based on an emission intensity using actual distance flown, rather than the GCD of the individual leg, then a Distance Adjustment Factor (DAF) of 95 km needs to be applied as part of the calculation.

3.1 Calculations based on primary data

Due to the strict logging of aircraft movements, primary data is always available for the air transport provider. Air carriers can therefore calculate their organizational carbon footprint by simply adding all flight emissions over a year.

For customers of aviation, the situation is very different. For a carbon footprint calculation Scope 3 (forwarders and shippers), the emissions are calculated for the trips (TCEs) booked by the customer. Such calculations should be based on a choice of TOC that enables customers to make reasonable decisions:

- If the customer wants to replace fossil kerosene by (SAF) on a certain route (airport pair), they need to receive emission data at a port pair granularity level, i.e., at least the fleet's average emissions operating on this port pair during the summer and winter schedule.

For calculations in support of SAF replacing kerosene a direction and season agnostic aggregation level needs to be applied because an ISO 14083 compliant calculation needs to balance directional impacts: the emissions on the specific route, e.g., Frankfurt to New York, shall not depend on the direction (with or against the jet stream) and also not on the season when the flight actually takes place to enable a consistent customer promise.

It is also recommended to not separate out seasonal data i.e., don't calculate summer vs. winter flight conditions separately.

- If the customer has their own target with year-on-year (YOY) carbon reduction budgets, they need to receive a robust, evened-out, emission report which reflects the route specifics and is sensitive to any operational or fleet related improvements the airline is undertaking, but not sensitive to any conditions which are neither under the control of the carrier nor of its transport patterns, such as weather conditions or temporary flight restrictions.

Note: It is a community decision whether a pandemic or a war situation is accounted for as "temporary" or not. If the industry risks missing its climate target on a mid-term or even long-term scale, it is certainly not to be regarded as "temporary".

The best aggregation level is always the fleet composition used on each service (port pair) over a period of the whole year.

The recommended maximum aggregated TOC to be applied is the aircraft type's GHG activity in distance clusters, long-haul and short-haul, either split between passenger and freighter aircraft types or combined where this cannot be separated or is unknown. However, where combined the transport activity (RTK/tkm) ratio of two respective aircraft types need to be indicated, i.e., XX% of RTK in belly aircrafts and YY% in freighter aircrafts. If such information is not available, a well-based assumption needs to be taken and the assumptions should be made transparent in the reporting.

Example calculation

Considering one TOC composed of different aircraft types operating over one year, carrying both passengers and belly freight, the table 1 in Section 3 Module 2 gives an indicative example of the calculation of the transport activity of the TOC, expressed in passenger equivalents (peq).

The equivalence used is 100 kg per passenger and luggage, therefore, 1 tonne of freight equals 10 peq.

The assumptions for this example are: 400 flights of 1000 km on average.

The percentage of the total transport activity gives the share of GHG emissions within the TOC between passengers and freight.

Table 8
Example of calculation of share of GHG emissions with a TOC passenger aircraft with belly freight

category	unit	average capacity of aircraft	average occupancy rate (or load factor) (%)	transport activity (unit-km)	mass per unit (tonne)	transport activity (tkm)	share of transport activity per category
passengers	passenger	180	80%	57,600,000	0.1	5,760,000	80%
freight	tonne	5	70%	1,400,000	1	1,400,000	20%
all	peq	230	77.8%	71,600,000	0.1	7,160,000	100%

Assuming a reported primary fuel consumption of 7,000 kg of aviation fuel for the average 1,000 km flight within this TOC, then the calculation for a 275 kg consignment would be as follows:

Energy provision (WTT) TOC GHG emission intensity = 400 x 7,000 x 0.66 / 7,160,000 = 0.258 kg CO_2e / tkm
Operational (TTW) TOC GHG emission intensity = 400 x 7,000 x 3.18 / 7,160,000 = 1.244 kg CO_2e / tkm
Total (WTW) TOC GHG emission intensity = 400 x 7,000 x 3.84 / 7,160,000 = 1.502 kg CO_2e / tkm

For the TCE calculation:

Transport activity = 0.275 x 1000 = 275 tkm

Energy provision (WTT) GHG emissions = 275 x 0.258 = 71.0 kg CO_2e
Operational (TTW) GHG emissions = 275 x 1.244 = 342.1 kg CO_2e
Total (WTW) GHG emissions = 275 x 1.502 = 413.1 kg CO_2e

3.2 Advice for calculations based on secondary data

The use of default data should generally be avoided, particularly in aviation, where flights need to be logged in detail. For cases where such primary data is not available, default emission intensities are provided for a limited selection of air transport TOCs in Module 2.

These values are based on specific assumptions which, while representative for typical industry conditions, may not bear much resemblance to the actual emission intensity of a particular flight because there is a lot of variability in the key influencing parameters. Deviations can easily be +/- 50% from the default value, such that for a default emission intensity of 800 g CO_2e/tkm the actual value could be as low as 400 g/tkm or up to 1,200 g/tkm.

Unless air freight emissions only account for a very small part of a client's (shipper's) carbon footprint, it is recommended that in the absence of primary data the emissions are modeled using a bottom-up calculation (tool) including as a minimum:

- scheduled route, including all transshipment stops. (Note that technical stops do not need to be included in the model. While they add fuel consumption, they enable carrying of less fuel on the aircraft, which by and large evens out the effect.)
- scheduled fleet composition (which includes possible deviation from the actual aircraft operation for certain slots) over the schedule periods on all routes

- modeled fuel consumption of all respective aircraft types involved, i.e., engine-type related fuel consumption (with transparent use of manufacturer data or evaluation of an extensive set of primary data, including any such calculations)
- industry average load per aircraft type (with all passenger and freighter aircraft averages separated as a minimum) during a scheduled period, and calculation with evened out emissions over one year.

Additional, desirable parameters include:

- aircraft type's seat and belly capacity configuration and related load capacity
- knowledge of aircraft type's actual operation, i.e., where is it actually flying (which may deviate from schedule)

NOTE: It is imperative that all GHG activity related parameters, such as aircraft types and their load factor, fuel consumption related thereto, route specifics etc., are modeled and aggregated in a direction and season agnostic way, i.e., evened out in both route directions and over the summer and winter schedule in order to avoid differences in calculation outputs for different clients and Scope 3 reporting entities for the same port pair operated by the same fleet composition at different times of the year or in different directions (FRA–NYC vs. NYC–FRA).

3.3 Calculation of GHG activities other than fuel use

Apart from fuel consumption, other GHG activities such as the use of refrigerants need to be taken into account:

- With primary data, the carrier needs to add the average emissions due to the aircraft's air-conditioning to the emission intensity per tonne-km. Where there is a significant difference between the use of refrigerants in passenger vs. freighter aircraft, or in different distance classes etc., such emissions need to be allocated within the relevant TOC, i.e., proportionately to their end use.
- With modeling, industry average values for specific input parameters may be applied when primary data values are missing, accompanied by an indication of the respective source and literature. It must be applied as an additional GHG per tkm or per kg of freight and indicated as a separate value.
- With temperature-controlled cargo, e.g., perishables such as fresh fish, flowers etc., the applied refrigerants need to be tracked separately and their emissions allocated to the respective cargo.

NOTE: With additional cargo related accessories such as ice bags or similar, these accessories need to be accounted for separately in terms of additional cargo weight (which increases fuel consumption and fuel related emissions): e.g. 1 tonne of fresh fish which requires an ice bed of 500 kg, the total weight would be 1.5 tonnes. In addition, the amount of energy used for the temperature control of the ice bed needs to be accounted for.

4. Calculation of GHG Emissions from Sea Transport

As sea shipping can be conducted on different vessel types (bulk ships, container vessels, RoRo and RoPax ferries, ferries and others), the methodology, especially the allocation to the different cargo types, may vary. It is therefore important to apply the methodology specified for the respective type of service.

4.1 Container Transport

One major type, especially in global shipping, is ocean container vessels. The related methodology has been developed and revised over many years by Clean Cargo (see also Chapter 2.3) which represents 85% of the world's container shipping.

For non-Clean Cargo members trade lane-specific carbon intensities are provided, averaged over all reporting carriers, on an annual basis (see Section 3, Module 2). The user needs to take into account that the emission intensities are based on a 70% industry average load factor and a mix of services on the respective trade lane which contain a different number of port calls. These values may be applied for any port-to-port journey. The end user factors for containerized shipping are calculated according to the stages presented in the Clean Cargo methodology[24] which is currently elevated to a higher granularity level of TOCs.

Currently, three levels of information (TOC aggregation) are available, depending on the level of information about origin and destination known to the user (see tables 16 and 17 in Section 3 Module 2):

- The overall Clean Cargo industry average
- Five sets of aggregated data for major trade lane groupings (see figure below) based on a weighted average of flows on the detailed trade lanes included within each grouping.
- The full set of Clean Cargo trade lanes

These factors may result in less granular calculations than a sophisticated tool. However, as the method is widely accepted and further developed in the Clean Cargo community, it is recommended to apply these factors to enable consistent calculation over different actors in the transport chain.

Where a service purchaser (forwarder, shipper) does not apply the available TOC intensity factors, they may apply an SFC accredited emission calculation tool.

The original emission intensities are based on actual distances, meaning that users would need to apply a DAF of 15% to compensate for the difference between actual and shortest feasible distance. However, the end user factors shown in tables 16 and 17 of Section 3, Module 2 have been adjusted for this already, so that the user can apply the planned distance directly.

Example:
A shipper transports 10 container twenty-foot equivalent units (TEUs) from Hamburg to Shanghai. It may apply the end user emission intensity value for the Asia to-from North-Europe trade lane, which reads 44.1 g CO_2e/TEU-km. A sea-routing tool may tell them that the port-to-port distance would be 21,000 km. The total emission for these 10 TEUs would be:

10 TEUs x 21,000 km x 44.1 g CO_2e/TEU-km = 9.26 tonnes CO_2e.

Where 5 of the 10 TEUs are reefer containers, the emission intensity for reefer transport on this trade lane, which is 114.8 g CO_2e/TEU-km, needs to be applied, resulting in 5 TEU x 21,000 km x 114.8 g/TEU-km = 12.05 tonnes CO_2e for these 5 containers.

4.2 Use of primary data

Clean Cargo provides GHG emission intensities based on primary data at different TOC granularity levels, depending on membership status. The highest aggregation is trade lane specific across all carriers in Clean Cargo. Such annually published data is designed for use by companies that need to calculate and report Scope 3 sea container transport emissions.

The challenges for a carrier in calculating its emission intensity from primary data inputs are:
- the distance between the loading and discharge ports within a loop (service), i.e., TCE based;
- the actual container load per TCE (excluding empty containers);
- the identification of a relevant TOC and its characteristics;
- the total transport activity for the TOC, quantified in TEU-km;
- the share of reefer containers loaded (i.e., capacity use of reefer slots between two ports) for the TOC;
- the actual fuel consumption of each type of fuel for the TOC;
- the energy consumption of the auxiliary engines for the TOC;
- the energy consumption of shore power while at berth in each port – which should be converted to GHG emissions and added to the emission total of the TOC;
- the refrigerant use for each vessel associated with the TOC.

Emission intensities need to be created per TEU-km and, alongside, per tkm (calculated using either actual TEU filling rates or a standard conversion of 10 tonnes per TEU). Alternatively, a value of 6 tonnes may be used for lightweight cargo or 14.5 tonnes for heavyweight cargo, if the use of these categories can be justified.

Useful aggregation levels may be derived from such data. These are all available to a carrier, but should not be combined in the same system:
- All port pair emissions, including the emissions while staying in the port, may be aggregated over a vessel's complete round trip with emission intensities in g/TEU-km and g/tkm, which apply to all port pairs within such a round trip, derived from it.
- Several vessels' emissions could be aggregated at an aggregated service level if the vessels in the service do not vary too much in engine design (fuel types) and size class.

Whatever the case, a carrier should deliver TOC and TCE based primary data which are fully ISO 14083 compliant.

4.3 Use of secondary (modeled) data

There are numerous tools which model ocean shipping data to a wide range of granularities, from tracking vessels via GPS, with detailed knowledge on engine power, filling rates by the measured draught and even fuel type compositions, through to calculators applying average parameters for distances, vessel size and filling rates, fuel type compositions, etc. The calculations produced by different tools with different granularity levels need to be examined in detail to secure comparability.

Any modeling needs to be conducted using a set of TOCs that follow the principles of ISO 14083. Distances used to calculate the TOC's emission intensity should use SFD, or where not available the TCE transport activity must be adjusted using an appropriate DAF. Any empty running also needs to be included within the TOC calculation. Although tempting, the use of the most granular modeling approaches can easily breach these conditions. As such the Scope 3 calculation would exclude a share of detours due to weather conditions, port congestion etc. which would breach the core principles of ISO 14083. (It is important to arrive at realistic emissions which the Scope 3 emitter needs to account for, especially given the carbon price tag and high investments needed to replace fossil marine fuels by non-fossil alternatives.)

4.4 Bulk Sea Transport

Bulk shipping, particularly in the form of short-term time charters, is one of the limited exceptions identified in ISO 14083 where a round trip logic to the TOC definition is not compulsory. Even here it is important to include any associated empty running into consideration as part of the TOC definition, so the emissions associated with a preceding ballast leg, if there is one, need to be included. (One option to help reduce emissions from shipping charters is to avoid chartering vessels that require a ballast leg to fulfil the contract.)

Example:
The following example focuses on the following fictitious scenario.

A shipping company charters a bulk vessel for a voyage from Asia to South America and subcharters space on the vessel out to two customers to transport freight from different locations in South America to Asia.

In this case the charterer agrees with its customers that the TOC is defined by the single trip. The transport chain consists of the following elements (see Table 9):

The TOC is defined as the sum of TCEs 1, 3, 5 and 7 and the emissions and intensity should be calculated for the TOC and applied to each of the TCEs. The emissions associated with each hub from the loading and unloading activity would be calculated according to the HOC associated with each of the hubs.

In this fictitious example the charterer has access to primary data for the transport TCEs but has to rely on default data for the hub TCEs as the hub operators do not yet calculate and report their emissions.

Developing the TOC Calculation

The operational characteristics known to the charterer are shown in Table 10. Cargo owner A's cargo is loaded first at location B and remains onboard until location D. Cargo owner B's cargo is then loaded at location C and remains onboard until location E.

Table 9
Example of transport chain elements of a bulk sea transport

Location	Leg description	Location	Leg description	Location	Leg description	Location	Leg description	Location
A (Asia)	A > B	B (S. Am.)	B > C	C (S. Am.)	C > D	D (Asia)	D > E	E (Asia)
	TCE 1	TCE 2	TCE 3	TCE 4	TCE 5	TCE 6	TCE 7	TCE 8
	Ballast leg	Hub (loading)	Laden leg 1	Hub (loading)	Laden leg 2	Hub (unloading)	Laden leg 3	Hub (unloading)

Table 10
Example of characteristics of TCEs of a bulk sea charter transport

	TCE1	TCE3	TCE5	TCE7	Total
Fuel (VLSFO) Cons (T)	381.27	83.75	780.20	82.26	Total
Fuel (MGO) Cons (T)	1.02	0.36	15.40	3.10	Total
Distance (km)	7565	1458	11844	1432	Total
Total Freight (T)	0	39,369	56,855	17,486	Total
Total Activity (tkm)	0	57,400,002	673,390,620	25,039,952	Total
Cargo owner A Cargo (T)	0	39,369	39,369	0	Total
Cargo owner A Transport Activity (tkm)	0	57,400,002	466,286,436	0	Total
Cargo owner B Cargo (T)			17,486	17,486	Total
Cargo owner B Transport Activity (tkm)	0	0	207,104,184	25,039,952	Total

The TOC emissions are based on the total of each fuel used, as follows:

Very Low Sulphur Fuel Oil (VLSFO)>
Energy production GHG emissions: 1327.48 × 1000 × 0.68 = 902,686 kg CO_2e
Operational GHG emissions: 1327.48 × 1000 × 3.16 = 4,194,837 kg CO_2e
Total GHG emissions: 1327.48 × 1000 × 3.84 = 5,097,523 kg CO_2e

Marine Gas Oil (MGO)
Energy production GHG emissions: 19.88 × 1000 × 0.61 = 12,127 kg CO_2e
Operational GHG emissions: 19.88 × 1000 × 3.26 = 64,809 kg CO_2e
Total GHG emissions: 19.88 × 1000 × 3.87 = 76,936 kg CO_2e

Emission factors for VLSFO and MGO taken from Module 1 for North America.

Total TOC energy production GHG emissions: 902,686 + 12,127 = 914,813 kg CO_2e
Total TOC operational GHG emissions: 4,194,837 + 64,809 = 4,259,646 kg CO_2e
Total TOC GHG emissions: 5,097,523 + 76,936 = 5,174,459 kg CO_2e

GHG emission intensity = total GHG emissions divided by the total transport activity.

TOC energy production GHG emission intensity: 914,813 / 755,830,574 = 0.00121 kg CO_2e / tkm
TOC operational GHG emission intensity: 4,259,646 / 755,830,574 = 0.00564 kg CO_2e / tkm
TOC overall GHG emission intensity: 5,174,459 / 755,830,574 = 0.00685 kg CO_2e / tkm

HOC Characteristics

Because the charterer has to rely on default data for the hub operations, and the hubs are all considered to be generic bulk terminals, they use a default value of 1.3 kg CO_2e / t.

Calculation for the Whole Transport Chain for Cargo Owner A

The calculation applies for the TCE's where Cargo Owner A's cargo was transported (TCEs 3 and 5) or handled (i.e. loaded TCE 2 and unloaded TCE 6).

Table 11
Example of characteristics of TCEs of a bulk sea charter transport

	TCE1	TCE 2	TCE 3	TCE 4	TCE 5	TCE 6	TCE 7	TCE 8
TOC Activity	0	0	57,400,002		466,286,436		0	
HOC Activity		39,369		0		39,369		0
Energy Production GHG Intensity (kg CO_2e / tkm)	0.00121	0	0.00121	0	0.00121	0	0.00121	0
Energy Production GHG Emissions (kg CO_2e)	0	0	69,474	0	564,366	0	0	0
Operational GHG Intensity (kg CO_2e / tkm)	0.00564	1.3	0.00564	1.3	0.00564	1.3	0.00564	1.3
Operational GHG Emissions (kg CO_2e)	0	51,180	323,490	0	2,627,857	51,180	0	0
Overall GHG Intensity (kg CO_2e / tkm)	0.00676	1.3	0.00676	1.3	0.00676	1.3	0.00676	1.3
Total GHG Emissions (kg CO_2e)	0	51,180	392,964	0	3,192,223	51,180	0	0

NOTE: GHG emissions are zero for TCE 1, the ballast leg, because the actual emissions for this leg are reallocated to the transport activity across the rest of the transport chain.

The total GHG emissions for the transport chain of Cargo Owner A is the sum of the GHG emissions for each TCE, i.e.,

Total TCE energy production GHG emissions: 633,839 kg CO_2e
Total TCE operational GHG emissions: 3,053,707 kg CO_2e
Total TCE GHG emissions: 3,687,546 kg CO_2e

The overall GHG emission intensity for the transport chain of Cargo Owner A is calculated as the total GHG emissions divided by the total transport activity:
3,687,546 / 523,686,438 = 0.00704 kg CO_2e / tkm.

4.5 RoPax Ferry Transport

The operator of a RoPax ferry line wishes to calculate and report the freight transport component of its GHG emissions from its ferry operations over a period of time.

Example:
During the period in question the ferry line uses 4000 t of VLSFO on a regular route with transport distance of 120km.

Energy production emissions: 4000 × 1000 × 0.68 = 2,720,000 kg CO_2e
Operational emissions: 4000 × 1000 × 3.16 = 12,640,000 kg CO_2e
Total emissions: 4000 × 1000 × 3.84 = 15,360,000 kg CO_2e

Emission factors for VLSFO taken from Module 1 for North America.

The observed usage data of the ferry was as shown in table 12.

Table 12
Example of different transport activities of a RoPax ferry

	Quantity	Passenger equivalents	Total peq	Transport Activity share (%)
Passenger & luggage	478500	1	478500	37.5
Passenger car	90000	1.3	117000	9.2
Bus	1000	10	10000	0.8
Caravan (Small)	500	1.1	550	0.0
Caravan (Medium)	500	2.3	1150	0.1
Caravan (Large)	500	3.5	1750	0.1
Motorcycle	1000	0.3	300	0.0
Unaccompanied HGV trail	4000	14	56000	4.4
HGV	34000	18	612000	47.9
Total			**1277250**	**100**

Using the calculated share of GHG emissions the breakdown of the freight component is as follows:

Unaccompanied Heavy Goods Vehicle (HGV) trailers:
Energy production GHG emissions: 0.044 x 2,720,000 = 119,256 kg CO_2e
Operational GHG emissions: 0.044 × 12,640,000 = 554,191 kg CO_2e
Total GHG emissions: 0.044 × 15,360,000 = 673,447 kg CO_2e

HGVs:
Energy production GHG emissions: 0.479 x 2,720,000 = 1,303,300 kg CO_2e
Operational GHG emissions: 0.479 × 12,640,000 = 6,056,512 kg CO_2e
Total GHG emissions: 0.479 × 15,360,000 = 7,359,812 kg CO_2e

Taking the average mass of a typical HGV to be 29.6t, comprising 14t for the unladen vehicle and 15.6 for the load then the GHG emission intensities for both the overall laden HGV and the load within would be as follows:

GHG emission intensities for the overall laden HGV:
Energy production GHG emission intensity: 1,303,300 / (34,000 x 120 x 29.6) = 0.0108 kg CO_2e/tkm
Operational GHG emission intensity: 6,056,512 / (34,000 x 120 x 29.6) = 0.0502 kg CO_2e/tkm
Total GHG emission intensity: 7,359,812 / (34,000 x 120 x 29.6) = 0.0610 kg CO_2e/tkm

GHG emission intensities for the cargo with the HGVs:
Energy production GHG emission intensity: 1,303,300 / (34,000 x 120 x 15.6) = 0.0205kg CO_2e/tkm
Operational GHG emission intensity: 6,056,512 / (34,000 x 120 x 15.6) = 0.0952 kg CO_2e/tkm
Total GHG emission intensity: 7,359,812 / (34,000 x 120 x 15.6) = 0.1156 kg CO_2e/tkm

Table 13

Emission factors used for hub calculation examples

Energy carrier (Region)	TTW (HEO)	WTT (HEEP)	Total	Source
Electricity (Germany)	**-**	**0.44 kg CO_2e/kWh**	**0.44 kg CO_2e/kWh**	**EcoTransIT World [24]**
Diesel (Europe)	**2.68 kg CO_2e/l**	**0.80 kg CO_2e/l**	**3.48 kg CO_2e/l**	**ecoinvent 3.9.1 cut-off**
Diesel, 5% biodiesel blend (Europe)	**2.54 kg CO_2e/l**	**0.82 kg CO_2e/l**	**3.36 kg CO_2e/l**	**Own calculation based on ecoinvent 3.9.1 cut-off and ETW 2022 EU Mix, amended**
Natural gas (Europe)	**0.21 kg CO_2e/kWh**	**0.08 kg CO_2e/kWh**	**0.29 kg CO_2e/kWh**	**ecoinvent 3.9.1 cut-off**

Table 14

Data for example: HOC with one hub and one average emission intensity value

Emission caused by ...	GHG activity data on ...		GHG emissions per activity
Handling containers	Electricity Diesel Diesel, 5% biodiesel blend	1,100,000 kWh 75,000 l 30,000 l	484,000kg CO_2e 261,000 kg CO_2e 100,800 kg CO_2e
General processes	Natural gas Electricity	32,000 kWh 160,000 kWh	9,319 kg CO_2e 70,400 kg CO_2e
Reefer station	Electricity	150,000 kWh	66,000 kg CO_2e
Total GHG emissions of the HOC			**991,519 kg CO_2e**

5. Calculation of GHG Emissions from Hub Operations

Hub operations usually occur where freight is transferred from one vehicle or mode of transport to another before, between, or after elements of a transport chain. The total GHG emissions of a HOC are the sum of the emissions of the hub equipment operations (TTW or HEO) and the related hub equipment energy provision (WTT or HEEP) of the HOC.

The following calculation examples start from the basic use case, and we assume that access is given to relevant GHG activity data (electricity use, fuel consumption etc.), so that the average emission intensity value can be calculated.
In our example we calculate two different scenarios:

- HOC with one hub and one average emission intensity value
- HOC with one hub and two emission intensity values

(We are aware that it is not always possible to access all relevant primary data. If no GHG emission intensities can be calculated, we recommend using the default values for logistics hubs (see Module 2) to get an approximation of the emissions for the hub operations.)

Table 13 gives you an overview of the emission factors we used for our example.

5.1 Freight transport hub - HOC with one hub and one average emission intensity value

This example refers to a container terminal in Germany, at which dry and reefer containers are handled. Only the total annual hub activity is known (4,250,000 t). Therefore, it is possible to derive one average emission factor.

First the total GHG emissions caused by container handling, general processes and the reefer station are calculated. Then the calculation of an average GHG emission intensity value for the hub operations.

For simplification, only the multiplication of GHG activity data and the total GHG emission factor is shown in this example. However, for further disaggregation the specific emissions factors for HOC (TTW) and HEEP (WTT) can also be used.

When dividing the total GHG emissions of the HOC by the total annual hub activity, the result is an average GHG emission intensity value for the hub operations.

Average GHG emission intensity value:
991,519 kg CO_2e / 4,250,000 t = 0.23 CO_2e/t

Due to the lack of data in finer granularity, a further breakdown of the hub activity is not possible. Therefore, in such a case of average emission intensity values, emissions of the ambient freight are somewhat overestimated, and emissions of refrigerated freight are underestimated. In such a case, it is advisable to collect further data at finer granularity to support a more differentiated analysis of the GHG emissions by the different hub operation activities

Nonetheless, this HOC GHG emission intensity factor can be provided to supply chain customers to apply to their own transport chains as it an approximate value based on the available primary data.

5.2 Freight transport hub - HOC with one hub and two emission intensity values

The second scenario refers again to the same container terminal in Germany, but now the difference is that more detailed data on the annual hub activities is available. The container terminal handles dry (4,200,000 t) and reefer (50,000 t) containers.

Two emission intensity values can be identified in this situation: one for the hub operations of ambient freight and one for hub operations of refrigerated freight. Therefore, a distinction is made between processes that are relevant to all types of freight (handing containers and general processes summarized as GHG emissions "unspecified group") and those that are only necessary for refrigerated freight (reefer station summarized as GHG emissions for "refrigerated freight") or that are only necessary for ambient freight.

For simplification, only the multiplication of GHG activity data and the total GHG emission factor is shown in this example. Nevertheless, for further disaggregation the specific emissions factors for HEO (TTW) and HEEP (WTT) can also be used.

Table 15

Data for example: HOC with one hub and two emission intensity values

Emission caused by ...	GHG activity data on ...		GHG emissions per activity
Handling containers	Electricity Diesel Diesel, 5% biodiesel blend	1,100,000 kWh 75,000 l 30,000 l	484,000 kg CO_2e 261,000 kg CO_2e 100,800 kg CO_2e
General processes	Natural gas Electricity	32,000 kWh 160,000 kWh	9,319 kg CO_2e 70,400 kg CO_2e
	GHG emissions "unspecified group" of the HOC		925,519 kg CO_2e
Reefer station	Electricity	150,000 kWh	66,000 kg CO_2e
GHG emissions specific group "refrigerated freight" of the HOC			66,000 kg CO_2e
Total GHG emissions of the HOC			**991,519 kg CO_2e**

The emissions resulting from handling containers and general processes applicable to both groups of freight, ambient and refrigerated freight (GHG emissions "general") can be calculated as follows:

GHG emission intensity "general":
925,519 kg CO_2e / 4,250,000 t =
0.218 kg CO_2e/t

The emissions of the reefer station (GHG emissions "refrigerated freight") are only associated with the hub operation activity of 50,000 t refrigerated weight and can therefore be calculated as follows:

GHG emission intensity "refrigerated freight":
66,000 kg CO_2e / 50,000 t = 1.32 kg CO_2e/t

Now the corresponding emission intensity values for handling of ambient freight and handling of refrigerated freight can be derived. As no specific, additional operations have been carried out for the ambient freight, the GHG emission intensity value is equal to the GHG emission intensity "general".

GHG emission intensity value for ambient freight:
0.218 kg CO_2e/t

For refrigerated freight the GHG emission intensity value is the sum of the GHG emission intensity for "general" plus the GHG emission intensity for "refrigerated freight".

GHG emission intensity value for refrigerated freight:
0.218 kg CO_2e/t + 1.32 kg CO_2e/t =
1.54 kg CO_2e/t

Again, these HOC GHG emission intensity values can be provided to supply chain customers to apply to their own transport chains or TCEs respectively. For example, to calculate a client-specific transfer of containerized dry goods freight (87 tonnes), the amount of freight must be multiplied by the GHG intensity value for ambient freight.

Client specific calculation for ambient freight:
87 t * 0.218 kg CO_2e/t = 19.0 kg CO_2e

In the same way, the emissions can be calculated for 100 tonnes of refrigerated freight using the corresponding GHG emissions intensity value for refrigerated freight:

Client specific calculation for refrigerated freight:
100 t * 1.54 kg CO_2e/t = 154 kg CO_2e

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Calculating GHG transport and logistics emissions for the European Chemical Industry

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4 Module 5
Calculating GHG transport and logistics emissions for the European Chemical Industry

September, 2021, updated August 2023

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1. Introduction

The members of Cefic, representing the majority of the chemical industry in Europe, recognize the importance of reducing the overall environmental impact of freight transport. Hence, knowledge about the GHG emissions that result from the transport of goods within their supply chain, both inbound to their production plants and outbound to their customers, is important to them. These guidelines support them in gaining this knowledge, so enabling them to take steps to reduce their impact.

Cefic and European Chemical Transport Association (ECTA), representing the specialist transport companies who work on behalf of the chemical producers, published a first guideline for the calculation of tank to wheel GHG emissions from freight transport operations applicable to the European chemical sector in March 2011. Since then there have been many developments in the field of GHG emission accounting, both in general and specifically for freight transport operations, including the EN16258 standard published in 2012, the GLEC Framework first published in 2016 and ISO 14083 published in 2023. A particular change worth noting is that the well-to-tank (WTT) emission factors of most fossil fuels have increased significantly since the September 2021 version of this guide. More information on this can be found in Module 1 of the GLEC Framework.

Nonetheless, the fundamentals of the process remain the same:

- Establish the amount and type of fuel used for the transport service in question
- Convert the fuel use to a well-to-wheel (WTW) GHG emission value, expressed as mass of CO_2e
- Relate the GHG emissions, including those from cleaning and warehousing, to the transport and logistics activity, expressed in tonne-kilometers, provided by the service
- Report both the total GHG emissions and the emission intensity, expressed as mass of CO_2e per tonne km

This process is set out in more detail Section 1, Chapters 1-4 of the GLEC Framework.

This updated report reflects changes that have occurred in the past 12 years and represents an opportunity for the sector to respond to increasing pressure from investors, legislation and customers to reduce GHG emissions from freight transport activities in particular, given its classification as a “hard to abate” sector. Implementing this guidance will show that the sector is adopting current best practice, adapted specifically for the chemical industry, and is preparing itself for the decarbonization challenge that will become increasingly apparent in the coming years.

The scope of the GHG emission calculation covered in this report includes the transport and logistics activities directly related to the chemical industry supply chain. The primary focus is the transport and logistics operations the companies are contractually responsible for, which are primarily the transport of finished goods to their customers. Estimates may also be made for transport operations within the supply chain that are the responsibility of other entities, for example inbound transport of raw materials, although any such estimates will inevitably be subject to greater uncertainty due to lack of knowledge of all parameters and hence greater reliance on estimation and assumptions. Therefore, it is highly recommended to request transport emission data to be included in the emission reporting of the contracting party.

The activities include:

- The transport itself, including associated vehicle repositioning needed to fulfil the service
- The handling of goods and short-term storage at logistics sites, including energy use associated with movement of goods within a logistics site or warehouse and the operation of the storage or handling facility
- Tank cleaning operations required to make vehicles available for their use in chemical transport
- Temperature control (whether heating or cooling) required for conditioning of the product during the transport chain

Items specifically excluded are:

- Activities associated with intermediate processing of a product, including where its nature is fundamentally changed
- Administrative functions of the transport company, even if they are co-located at a logistics site
- Maintenance of site or vehicles
- Vehicle or transport infrastructure

The report is structured as follows:

- Section 2 sets out some of the specific characteristics of chemical industry logistics operations that influence the way that GHG emissions are calculated as well as the resulting impacts.
- Section 3 sets out typical or representative values that may be used as default values by European chemical companies in cases where they are beginning to compute GHG emissions or where more specific carrier data is not available, for whatever reason.
- Section 4 provides guidance for carriers and logistics service providers (LSPs) when it comes to interpreting these guidelines.
- Section 5 provides guidance for chemical companies when it comes to implementing the GLEC Framework and the influence of these industry-specific guidelines.
- Section 6 acknowledges that knowledge about GHG emission impacts and calculations is continually evolving, as is the list of potential low emission solutions that are available to companies, including those in the chemical industry. This section also indicates areas where updates are most likely to be needed in the relatively near future and where this would be reflected in future versions of this guidance.
- A summary table of the default GHG emission intensities for road transport based on knowledge of load and empty running is presented in Annex 1, while Annex 2 presents additional information about intermodal transport.

2. Chemical industry specifics

This section describes specific characteristics of chemical industry transport and logistics operations that are not set out in detail in the existing GLEC Framework. The approach in terms of core methodology is unaffected, i.e., identify all the individual elements of the transport chain, including any associated empty running, and then collect the information necessary to calculate the emissions.

However, some of these characteristics do influence the way in which transport operation categories (TOCs) are defined for use in chemical transport operations. The result is a more detailed and specific set of transport categories than the general set defined in the main body of the GLEC Framework.

2.1 Nature of the cargo transported

The cargo transported for the chemical industry is a mixture of solids, liquids and gases that are either ingredients for or the result of chemical processes managed by the chemical industry. Consignment sizes tend to be greater than in the wider transport sector, which leads to a greater incidence of bulk transportation, the potential for higher payloads, especially when expressed in terms of cargo mass, and a greater potential for use of intermodal solutions and high-capacity modes such as rail, inland waterway and sea transport.

Some cargos have very specific storage or handling requirements that impact upon the way that transport chains in the chemical industry are arranged. This may also impact on the nature of the equipment used and on the business relationship, e.g., greater reliance on tankers or equipment that can withstand high pressures. These issues are reflected in some of the following subsections.

Analysis of data collected by ECTA suggested that the nature of the cargo, when classified as dry bulk, liquid bulk or cargo packed in smaller containers, does have an impact on both average load and the extent of empty running. This has been combined with information collected from chemical companies (Cefic members) to compile the input parameters used to define the default values presented in section 3 of this report.

2.2 Shared transport – definitions and use

Terminology can vary within the freight transport sector as a whole and even within a segment such as chemical transportation. The following terms have been used to establish the chemical sector default emission intensities:

- Full truckload (FTL): a chemical company has enough product for a consignment to fill a vehicle, by weight or other dimension, close to the vehicle's legal limits and that vehicle travels from a single point of origin to a single destination to deliver the single consignment.
- Less than truckload (LTL): a chemical company has one or more consignments that individually are not big enough to fill a vehicle, by weight or other dimension, to the vehicle's legal limits. An approximate boundary of 15 tonnes, i.e. ± 60% load by mass, has been used to differentiate full and less than truckload. LTL transport can be split into many different subcategories with widely differing characteristics. For the purposes of this document the following two categories have been used:
- Partial load: a single LTL consignment, which on its own is not big enough to fill a vehicle, by weight or other dimension, is transported on its own from a single point of origin to a single destination. The reason can be timing (rush order) or incompatibility with other products.
- Groupage: multiple LTL consignments, potentially originating from different chemical companies and different origins are consolidated by an LSP to achieve a main haul transport with higher load factor than would otherwise be the case. The consolidated consignments may be delivered to one or several end destinations. Consignment size, operating pattern, overall load factor can all vary considerably within this broad category of transport.

The use of groupage transport is commonplace, particularly for packed goods. The nature of the cargo may require specialist transport providers who are used to handling, or even licensed to handle, cargos with specific properties. The benefit of groupage services from a GHG emission perspective is that the transport provider should be able to achieve greater overall efficiency by carrying several consignments from different providers in one trip, so maximizing load factors and minimizing empty running. Sharing of operational information and actual GHG emission performance of groupage transport has been relatively uncommon; however, with the increased focus on transparency and reduction of GHG emissions we expect that may change in the future. The work required of the transport company should not be any greater than for dedicated transport, because all customers would be expected to share a network average emission intensity that reflects the overall benefit of the shared transport operation and the associated improved efficiency.

2.3 Dedicated transport

The use of dedicated transport services, where dedicated equipment is provided by the transport company for the use of a specific product (and company), is more common in the chemical sector than in general haulage, particularly due to the specialist nature of the equipment, cargos and cleaning requirements. This could lead to an increased incidence of empty running. Hence there is a trade-off between dedicated transport contracts and a lower overall system efficiency with higher GHG emissions.

This places a responsibility on chemical companies and their transport providers to investigate options to reduce the incidence of company-specific dedicated transport wherever the business model will allow it. For example, allowing transport of compatible loads or using cleaning facilities close to the point of unloading that would allow a backload would both avoid an empty return trip to base and improve overall transport system efficiency.

Data collected by ECTA suggested that there are significant variations reported in terms of average load and particularly empty running from transport operator to transport operator. Unfortunately, it has not been possible to isolate the nature of the transport operation to establish whether dedicated transport contracts were contributing to this variation. The assumption is that dedicated transport would result in higher level of empty running than for shared transport. However, it is likely that there is also a variation in the operating practices between differing transport companies which is a clear reason to advocate for the use of primary data as the basis for GHG calculations.

2.4 Payloads

As mentioned previously, the cargo tends to be relatively dense and consignments are larger, leading to payloads that are typically much closer to vehicle payload limits than the overall sector average. Nonetheless, consultation with individual chemical companies did reveal significant variations from company to company, around a relatively high average payload figure.

Although high payload does slightly increase vehicle fuel consumption and emissions when expressed on a per vehicle kilometer basis, the benefit of transporting more cargo in a single trip significantly outweighs this effect and leads to a much lower emission intensity, expressed in emissions per unit of transport activity (mass CO_2e / tonne km).

The variation from company to company emphasizes the importance of using primary data for the calculation of emissions at a company or even better at product level, and of monitoring factors such as the load factor and extent of empty running within a supply chain

1. To adhere to the basic principle of accuracy
2. To help identify where efficiency improvements and hence emission reductions can be achieved

It is through simple steps like these that short-term emission reductions can be easily achieved at relatively low cost and to the benefit of all parties involved and wider society.

The typical payloads used in generating the road transport default GHG emission intensities for chemical transport are as follows:

Table 1
Typical payloads used in generating default emission intensities

Market segment	Data source	Value (tonnes)
Overall sector average	Inferred from more detailed segments below	18
Packed goods transport		
Packed goods average	Inferred from more detailed segments below	15
Packed goods: FTL	Cefic project member data; confirmed ECTA member survey	21
Packed goods: part load	Cefic project member data	8
Packed goods: groupage	ECTA secretariat	15
Bulk transport		
Bulk goods average	ECTA member survey; confirmed Cefic project member data	22
Bulk goods: tank truck	ECTA member survey; confirmed Cefic project member data	21
Bulk goods: hopper/silo	ECTA member survey; confirmed Cefic project member data	26
Bulk goods: tank container	ECTA member survey; confirmed Cefic project member data	24

2.5 Empty running

Minimizing the extent of empty running is a way for all parties with an interest in freight transport to improve efficiency. At the same time a certain level of empty running is inevitable, especially for FTL transport, as it is unlikely that the next consignment will always be available at the point of unloading the previous one. Groupage allows an LSP to minimize empty running within the constraints of their network and the amount of business they are able to generate. The extent of empty running is an important influencing factor on GHG emission intensities. The values in Table 2 have been used in this document.

It is through simple steps like these that short-term emission reductions can be easily achieved at relatively low cost and to the benefit of all parties involved and wider society.

The typical payloads used in generating the road transport default GHG emission intensities for chemical transport are show in Table 1.

Higher values of empty running have been assumed for dedicated transport services based on discussions with Cefic members that are within the range reported in the ECTA survey.

Table 2

Typical empty running values used in generating default emission intensities

Market segment	Data source	Value % of total distance
Overall sector average	Inferred from more detailed segments below	22
Packed goods transport		
Packed goods average	Inferred from more detailed segments below	22
Packed goods: FTL	ECTA member survey	22
Packed goods: part load	ECTA member survey	22
Packed goods: groupage	GLEC LTL average	17
Bulk transport		
Bulk goods average	Inferred from more detailed segments below	22
Bulk goods: tank truck	ECTA member survey	19
Bulk goods: hopper/silo	ECTA member survey	22
Bulk goods: tank container	ECTA member survey (assumed same as tank truck)	19

2.6 Cleaning operations

In many cases the purity of the cargo is important to meet strict product standards. Where such a restriction applies it is essential that the transport equipment is thoroughly cleaned between the successive transport operations conducted by a vehicle to avoid cross contamination. The required cleaning operations are carried out to industry standards at facilities that may or may not be present at, or close to, the location where a particular cargo is unloaded or the next cargo is to be loaded. If no cleaning station is present the result may be additional empty running between point of unloading and the next loaded journey. In extreme cases, if a cleaning facility is not available in the locality of the unloading location, this may necessitate a return to base for cleaning before the next journey can be undertaken.

The impact of cleaning on empty running has been factored into the default values based on feedback and data received from Cefic and ECTA members.

Where a cleaning operation is known to take place the calculation of transport GHG emissions should be based on a combination of the transport emissions and the GHG emissions associated with a cleaning operation. A default value for the GHG emissions from cleaning is provided in section 3.10. However, that value depends heavily on the local electricity emission factor and the efficiency and energy source of the steam generator. This information may support emission reduction through re-evaluating options for compatible loads, potentially moving away from dedicated company transport.

Because the choice of cleaning versus dedicated transport is part of the operational model of the transport provider, and may change depending on volumes and business developments, it is important for the chemical company to ensure the service provider considers this option. Given high the variability of cleaning emissions it is recommended that the provider of the cleaning operations uses a specific value for the GHG emission per cleaning operation for their specific situation, wherever possible. Further guidance can be found at: https://www.eftco.org/safe-cleaning/emission-guideline.

2.7 Tank container transport

From a GHG calculation methodology perspective, the use of tank containers to transport fluids is not per se a significant deviation from other truck body types, i.e., the standard trailer used in generic road transport calculations. What is important to note is that, as for all other transport, it is the net weight of the load that should be used when calculating the transport activity, i.e. excluding the weight of the container. If there is any uncertainty, please confirm with the carrier that the weight of the container has not been included in the calculation of the GHG emission intensity.

2.8 Pipeline transport

Pipeline transport is a form of transport that is highly specific to the chemical sector and is not currently reflected in the main body of the GLEC Framework, except in passing in the introduction. Hence, information for pipeline transport has been developed specifically for this report. This has highlighted that, although information is known to pipeline operators, until now sharing and calculation of GHG emissions from this transport mode has been limited.

Discussion among the project group suggested that there are several factors that influence the emission intensity of pipeline transport, including:

- Pipeline length
- Pipeline diameter
- Nature of the product (liquid or gas)
- Viscosity of the product
- Pressure within the pipeline system, which may be varied depending on required flow rate

Some products, particularly gases, may come out of the production plant in a highly pressurized form. If that pressure can be captured then the product may, in some cases, flow due to the original pressurization without requiring extra energy for transportation. In order to ensure consistency with the overall project scope, and boundaries used for the emissions for production plants and logistics sites, the following boundaries were agreed:

- Do not include the energy used by pumps “within the boundaries of a production site” meaning that only the energy used by pumps when the product is in transit contribute to the pipeline transport emissions

- If the product is already in transit, and being transferred from a ship or barge, any pumps on board the ship or barge would be accounted for by the ship, whereas any pumps linked to the pipeline would be included in the pipeline emissions

This is shown in figure 1.

Given the potential variability of pipeline emission intensity it is recommended that chemical companies request emission intensity data from the operator of the pipeline expressed in GHG emissions per tonne km of product throughput, averaged on an annual basis in order to calculate representative emissions in a comparable way to other transport modes.

Figure 1
Where to include pumping station energy use and emissions

Where	Factory	Transit	Half-way station	Transit	Destination
What	Pump	Pump	Pump	Pump	Pump
In/out	No	Yes	Yes	Yes	No

Where	Ship	Transit	Half-way station	Transit	Destination
What	Pump	Pump	Pump	Pump	Pump
In/out	No	Yes	Yes	Yes	No

3. Impact of chemical industry specifics on default values

3.1 Sector-specific TOCs

This section presents the result of the discussions within the project group on how the individual different TOCs should be set out on a mode-by-mode basis and the resulting default GHG emission intensities.

Similar to the presentation of default values in the main body of the GLEC Framework, defaults are presented in a hierarchy of three levels, starting from a highly generic situation where the chemical company knows little about the consignment or how it is transported, through a situation of partial knowledge through to a more detailed knowledge of the goods and the detailed means of transport. Through this progression the assumptions become more specific to the transport in question and the values more representative of the actual transport.

All emission intensities are presented as WTW values in g CO_2e/tkm.

Table 3
Road transport TOC characteristics

Transport operation category		Empty running (% of total distance)	Typical load (tonnes)	Emission intensity (g CO_2e/t-km)		
				WTT	TTW	WTW
Level 1						
	Overall sector average	22	18	21	66	87
Packed goods – Level 2						
	Average, ambient	22	15	24	76	100
	Average, temperature controlled	22	15	27	85	112
Packed goods – Level 3						
FTL	Ambient	22	21	19	58	77
	Temperature controlled	22	21	21	65	86
Partial load	Ambient	22	8	41	127	168
	Temperature controlled	22	8	46	142	188
Groupage	Ambient	17	15	23	72	95
	Temperature controlled	17	15	26	80	106
Bulk goods – Level 2						
	Average, ambient	22	22	18	57	75
	Average, temperature controlled	22	22	20	64	84
Bulk goods – Level 3						
Tank truck	Ambient	19	21	18	57	75
	Temperature controlled	19	21	20	64	84
	Dedicated, ambient	50	21	27	82	109
	Dedicated, temperature controlled	50	21	30	92	122
Hopper/silo	Ambient	22	26	16	51	67
	Temperature controlled	22	26	18	57	75
	Dedicated, ambient	50	26	22	70	92
	Dedicated, temperature controlled	50	26	25	78	103
Tank container	Ambient	19	24	17	52	69
	Temperature controlled	19	24	19	58	77
	Dedicated, ambient	50	24	24	74	98
	Dedicated, temperature controlled	50	24	27	83	110

3.2 Road transport

Following the approach taken in Module 2 of the main GLEC Framework three levels of default GHG emission intensity are provided for road transport:

Level 1: to be used by the chemical company only in exceptional circumstances when there is no knowledge of the product type or how the transport service is organized.

Level 2: to be used by the chemical company when there is knowledge of the product type but no knowledge of how the transport service is organized.

Level 3: to be used by the chemical company when there is knowledge of the product type and the general nature of the transport service but the carrier has not provided the data required for calculation of the GHG emissions based on their primary data.

The default road transport GHG emission intensities are calculated on the basis of using vehicles in the class "articulated truck up to 40 tonne gross vehicle weight" using "Diesel, 5% biodiesel blend," which industry data shows to be the predominant vehicle class.

The values for dedicated transport are at the extreme, conservative end of the possible range with 50% empty running, assuming dedicated transport at the company level. For a more accurate value, specific to your service, please consult with your service provider.

For non-dedicated transport where a cleaning operation is required to facilitate operation with a lower level of empty running as compared to returning to base for cleaning then an additional 86.6 kg CO_2e per cleaning operation should be added (see section 3.10).

3.3 Rail transport

Notes:
Single wagon rail transport includes allowance for extra short distance transport to origin main haul site to assemble full train and from destination site for final distribution.

Electric traction energy is assumed only for main haul traction. Any shunting within site or short distance transport to/from site to assemble single wagon trains is assumed to be by diesel traction.

Electric main haul assumes EU average electricity factor of 356 g CO_2e/kWh. Use of individual country mixes may give significantly different values, especially in countries with a highly decarbonized electricity supply.

3.4 Inland waterways transport

Inland waterways transport is well-suited to the generally larger consignments that are typical of the chemical sector and so the inland waterway default intensities in the main GLEC Framework are directly applicable to the chemical sector as follows:

Table 4
Rail transport TOC characteristics

Transport operation category	Empty running (% of total distance)	Load factor (%)	Traction energy	WTW GHG emission intensity (g CO_2e/tkm)
Level 1				
Overall sector average	33	40	Average	23
Level 2 : Container train (intermodal)				
Average	17	50	Average	17
Diesel train	17	50	Diesel	28
Electric train	17	50	Electric	10
Level 2 : Blocktrain (RTC)				
Average	50	100	Average	16
Diesel train	50	100	Diesel	26
Electric train	50	100	Electric	10
Level 2 : Single Wagon train (RTC)				
Average	50	100	Average	22
Diesel train	50	100	Diesel	36
Electric train	50	100	Electric	14

Table 5
Inland Waterway TOC characteristics

Transport operation category	Overall utilization (%)	GHG emission intensity (g CO_2e/tkm)		
		WTT	TTW	WTW
Bulk tanker (average)	65	5.7	19	24.7
Tanker barge (liquid)	65	5.7	19	24.7
Tanker barge (gas)	65	5.7	19	24.7
Container vessel (average)	75	6.8	22.5	29.3
Container vessel 110m	75	6.8	22.5	29.3
Container vessel 135m	75	5.2	17.4	22.6
Dry barge (average)	50	4.9	16.74	21.4

3.5 Short and deep sea transport

The framing of international sea transport, whether deep sea or short sea (coastal) shipping is currently set by the International Maritime Organisation (IMO) 4th GHG Study,[1] which focuses on categorization of vessels by general type size categories. This approach has been used to provide short sea and deep sea shipping values for chemical tankers, gas tankers and general cargo. The values are based on the median fuel consumption for each size category with the addition of 10% of the range between lower and upper quartile values to avoid a risk of underestimation and adhere to the principle of taking a cautious approach to the use of default GHG emission intensities. Although shown in the same table below it is worth noting that short sea shipping within Europe is likely to be performed by the smaller vessel sizes whereas deep sea transport will more likely use the larger vessel sizes.

Care should be taken when calculating emissions from sea transport that distances are converted from nautical miles to kilometers to avoid systematic errors.

Table 6
Sea Transport TOC characteristics

Vessel category	Overall utilization (%)		GHG emission intensity (g CO_2e/tkm)		
			WTT	TTW	WTW
Chemical tanker	0-4999	dwt	9.3	49.6	58.9
	5000-9999	dwt	4.1	22.0	26.1
	10000-19999	dwt	2.8	15.0	17.8
	20000-39999	dwt	1.7	9.1	10.9
	40000-+	dwt	1.3	7.0	8.3
General cargo	0-4999	dwt	4.1	21.7	25.8
	5000-9999	dwt	3.3	17.5	20.8
	10000-19999	dwt	2.9	15.6	18.5
	20000-+	dwt	1.5	8.1	9.6
Gas tanker	0-49999	m3	7.3	39.0	46.3
	50000-99999	m3	2.1	11.3	13.4
	100000-199999	m3	1.7	8.9	10.6
	200000-+	m3	1.8	9.4	11.2

dwt = deadweight tonnes

3.5.1 Sea container transport

The latest data from the Clean Cargo initiative has been used for containerized shipping. Clean Cargo provides industry average data on a trade lane basis and this has been converted to a per tonne kilometer basis using indicative payload values for ISO tank, 20' and 40' containers.

Table 7
Sea container transport TOC characteristics

Transport operation category		Temperature condition	GHG emission intensity (g CO_2e/tkm)		
			WTT	TTW	WTW
Level 1					
Sector Average	ISO Tank	Ambient	0.5	2.6	3
		Temp controlled	0.9	5.2	6.2
	20'	Ambient	0.5	2.8	3.3
		Temp controlled	1	5.8	6.8
	40'	Ambient	0.8	4.6	5.4
		Temp controlled	1.7	9.4	11.1
Level 2					
Intra NW Europe	ISO Tank	Ambient	1	5.7	6.7
		Temp controlled	1.7	9.5	11.2
	20'	Ambient	1.1	6.3	7.4
		Temp controlled	1.9	10.5	12.3
	40'	Ambient	1.8	10.2	12.1
		Temp controlled	3	17	20.1
Intra Mediterranean	ISO Tank	Ambient	1	5.5	6.5
		Temp controlled	1.7	9.7	11.4
	20'	Ambient	1.1	6.1	7.2
		Temp controlled	1.9	10.7	12.6
	40'	Ambient	1.8	10	11.8
		Temp controlled	3.1	17.4	20.5
NW Europe - Mediterranean	ISO Tank	Ambient	0.5	2.6	3.1
		Temp controlled	0.9	5.3	6.2
	20'	Ambient	0.5	2.9	3.4
		Temp controlled	1	5.8	8.1
	40'	Ambient	0.9	6	6.9
		Temp controlled	1.7	9.5	11.2
NW Europe - Asia	ISO Tank	Ambient	0.3	1.6	1.8
		Temp controlled	0.7	4.1	4.8
	20'	Ambient	0.3	1.7	2
		Temp controlled	0.8	4.5	5.3
	40'	Ambient	0.5	2.8	3.3
		Temp controlled	1.3	7.3	8.6
NW Europe - Africa	ISO Tank	Ambient	0.6	3.6	4.2
		Temp controlled	1.2	6.6	7.8
	20'	Ambient	0.7	4	4.7
		Temp controlled	1.3	7.3	8.6
	40'	Ambient	1.2	6.5	7.6
		Temp controlled	2.1	11.9	14

Continued on next page

Table 8

Sea container transport TOC characteristics (continued)

Transport operation category		Temperature condition	GHG emission intensity (g CO_2e/tkm)		
			WTT	TTW	WTW
NW Europe – South & Central America	ISO Tank	Ambient	0.5	2.9	3.4
		Temp controlled	1	5.6	6.6
	20'	Ambient	0.6	3.2	3.8
		Temp controlled	1.1	6.2	7.3
	40'	Ambient	0.9	5.2	6.1
		Temp controlled	1.8	10	11.8
NW Europe – Middle East/India	ISO Tank	Ambient	0.4	2.2	2.6
		Temp controlled	0.9	4.9	5.8
	20'	Ambient	0.4	2.4	2.9
		Temp controlled	1	5.4	6.4
	40'	Ambient	0.7	4	4.7
		Temp controlled	1.6	8.8	10.3
NW Europe - Oceania	ISO Tank	Ambient	0.6	3.2	3.7
		Temp controlled	1	5.6	6.6
	20'	Ambient	0.6	3.5	4.1
		Temp controlled	1.1	6.2	7.3
	40'	Ambient	1	5.7	6.7
		Temp controlled	1.8	10.1	11.9

Transport operation category		Temperature condition	GHG emission intensity (g CO_2e/tkm)		
			WTT	TTW	WTW
NW Europe – North America East Coast/Gulf	ISO Tank	Ambient	0.6	3.1	3.7
		Temp controlled	1	5.8	6.8
	20'	Ambient	0.6	3.5	4.1
		Temp controlled	1.1	6.4	7.5
	40'	Ambient	1	5.7	6.7
		Temp controlled	1.9	10.4	12.3

3.6 Air transport

Air transport is a relatively uncommon mode of transport for the chemical sector; hence, the guidance is to use the general values specified in the GLEC Framework.

3.7 Pipeline transport

The current data available suggests that the characteristics and performance of pipelines is highly variable making it difficult to represent reliably using a default GHG emission intensity.

As many pipelines are owned by chemical companies, it is expected that emissions can easily be calculated from the energy consumption available to the pipeline owner, as follows (see also section 2.8):

Total emissions = electricity consumption outside site boundaries x electricity emission factor (country specific, or EU average of 349 kgCO_2e/kWh) where the total tonne km = total tonnes transported in the latest year multiplied by the length of pipeline in km.

Most pipelines have been shown to operate in the range 1 to 50 g CO_2e/tkm, although instances of up to 360 g CO_2e/tkm have been found in extreme circumstances (e.g. combination of short distance, uphill etc.).

Table 9
Intermodal transport TOC characteristics

Main Carriage	Total Distance (km)	% distance by main carriage	GHG emission intensity (g CO2e/tkm)
Rail	1000	85	32.5
Inland waterway	110	85	53.2
Short sea containerized	1100	85	16.9
Deep sea containerized	7600	90	9.7

3.8 Intermodal transport

Intermodal transport involves the transport of a consignment by at least two transport modes, which necessarily have different operating characteristics, as well as a handling operation at a logistics site each time there is a change of mode. As such, assigning a default GHG emission intensity to an intermodal transport is subject to a greater degree of uncertainty than to an individual transport mode - not only does it depend on the uncertainty associated with the assumptions for each individual transport element, but also the assumed length, and hence relative contribution, of each leg. Hence, the following scenarios should be seen as indicative; pre- and on- carriage are assumed to be by road transport. These values also include the default values from the GLEC Framework of 1.3 kg CO_2e / t or 10.7 kg CO_2e per container moved.

Notes:
Total distances in the above table are for Europe and based on Cefic survey data; deep sea based on transatlantic intermodal example.

Includes GHG emissions associated with two transshipment actions, one at each end of the main haul.

Additional information is provided in Annex 2 (Intermodal GHG emission intensity by distance) which shows the variability according to total distance, distance share as well as an equation that sets out the impact on GHG emission intensity of varying these two distance parameters, keeping all other assumptions fixed.

A worked example using different levels of information to show how a more detailed and accurate calculation can be achieved with better data and by calculating the emissions for every step in the intermodal chain including transshipment is provided in Annex 3. This would also allow the calculation of other modal combinations such as road + rail / barge + deep sea, for example in addition to the four default combinations.

3.9 Logistics Sites

Information regarding GHG emissions from logistics sites in general remains relatively limited. Hence, provision of default GHG emission values specifically for the chemical industry (including tank storage as well as transshipment and warehousing) is not possible and the guidance is to use the general values specified in Module 2 of the GLEC Framework. (Efforts will continue with GLEC members and partner organizations to add depth to the data regarding GHG emissions from logistics sites with a view to revising the data in future versions of the Framework.) It is recommended that companies request a value from the operator of the logistics site that represents the GHG emission per tonne of product throughput for their specific situation.

Table 10
Indicative Tank Cleaning Calculation based on data provided by the European Federation of Tank Cleaning Organizations (EFTCO) (see www.eftco.org/emission-guideline)

Electricity (kg CO_2e/KWh)	Gasoil (g CO_2e/MJ)
0.349	95.4

Per tank cleaning	Consumption	Production kg CO_2e
Energy consumption gas (MJ)	881.6	68.6
Energy consumption gasoil (MJ)	12.77	1.2
Total electrictiy consumption (kWh)	48.0	16.8
Total per tank cleaning	-	**86.6**

3.10 Cleaning Operations

The above table sets out the calculation used to determine a representative value for tank cleaning. The value of 86.6 kg CO_2e per cleaning operation conducted has been used in several of the worked examples later in this document.

Note: according to the transport chain boundaries, electricity consumption included only relates directly to cleaning operation.

Note: The heating efficiency of the steam generator in the above example is assumed to be 90%. (For other assumptions see the EFTCO webpage above.)

4. General guidelines for transport operators and logistics service providers

This section briefly describes the steps a carrier, or LSP that operates transport equipment, must take in order to align with requirements of the GLEC Framework. The main focus is guidance to be used by transport operators in the collection and processing of operational data. Additional information is also provided for situations where operations are subcontracted, as is often the case for integrated, intermodal and specialist transport.

4.1 Operational data collection and processing

As set out in Chapter 2 of the GLEC Framework, the expectation is that the operator of the transport, irrespective of mode, will have access to the energy/fuel consumption information necessary to calculate their total emissions, based on the equation:

GHG emission (mass of CO_2e) = fuel / electricity consumption (per amount of energy used) x WTW emission factor (kg CO_2e per amount of fuel used)

So that a carrier can report information to their customer, which may be an LSP, in a way that is meaningful, it makes sense for the carrier to tailor the information to the customer's needs by following some simple steps, as outlined below. The intention is to provide transparency about the GHG emissions which the carrier produces while conducting transport on their behalf, so reducing:

- the risk of incorrect reporting;
- wasted time linked to incorrect or incomplete reports

and improving opportunities:
- to identify emission hotspots
- to make joint decisions to improve efficiency / reduce emissions

STEP 1: Break up your total transport into categories

For the information to be as relevant as possible it is important to break up your overall transport activities into different categories and then base your customer report on the category relevant to them. The idea is that the characteristics of the trips within one category are as similar as possible (e.g. same type of truck, lanes, distances, type of load, etc.), so that the performance is clustered around a representative value.

To perform the calculation you need to be able to identify the net tonnes of product transported and kilometers driven (both loaded and empty) associated with each category and specify the total fuel consumption for that category.

In this step it is also good practice to engage with your customer to see if the categories you intend to use match their needs. In the worst case you can combine everything together into one category for the whole business and decide how you could create more specific categories for the next reporting period.

The breakdown of the default GHG emission intensities follow a suggests structure for the transport operation categories as follows:

Road transport:

Level 1:
- Overall average

Level 2:
- Packed goods average, ambient
- Packed goods average, temperature controlled
- Bulk goods average, ambient
- Bulk goods average, temperature controlled

Level 3:
- Packed goods: FTL, ambient
- Packed goods: FTL, temperature controlled
- Packed goods: partial load, ambient
- Packed goods: partial load, temperature controlled
- Packed goods: groupage, ambient
- Packed goods: groupage, temperature controlled
- Bulk goods: tank truck, ambient
- Bulk goods: tank truck, temperature controlled
- Bulk goods: tank truck, dedicated, ambient
- Bulk goods: tank truck, dedicated, temperature controlled
- Bulk goods: hopper/silo, ambient
- Bulk goods: hopper/silo, temperature controlled
- Bulk goods: hopper/silo, dedicated, ambient
- Bulk goods: hopper/silo, dedicated, temperature controlled
- Bulk goods: tank container, ambient
- Bulk goods: tank container, temperature controlled
- Bulk goods: tank container, dedicated, ambient
- Bulk goods: tank container, dedicated, temperature controlled

Intermodal transport
- Road + rail main carriage
- Road + inland waterway main carriage
- Road + short sea containerized main carriage
- Road + deep sea containerized main carriage

Rail transport

Level 1:
- Overall sector average

Level 2:
- Track Container
- Track RTC blocktrain
- Track RTC (single wagon)

Inland waterway transport
- Bulk tanker
- Container vessel
- Tanker barge (liquid)
- Tanker barge (gas)
- Dry barge
- Container vessel 110m
- Container vessel 135

Sea transport
- Chemical tanker
- General cargo
- Gas tanker
- RoRo
- Container transport: sector average
- Container transport: by trade lane

STEP 2: Calculate fuel consumption by category

To determine the total GHG emissions for each category that is relevant to you and your customer, it is important that you know the fuel consumed in each category over the requested time period.

The approach taken will depend on the maturity level of your organization, and may be based on the total amount of liters purchased, the average fuel consumption by type of truck in the fleet, or actual consumption monitored through telematics systems or refueling records.

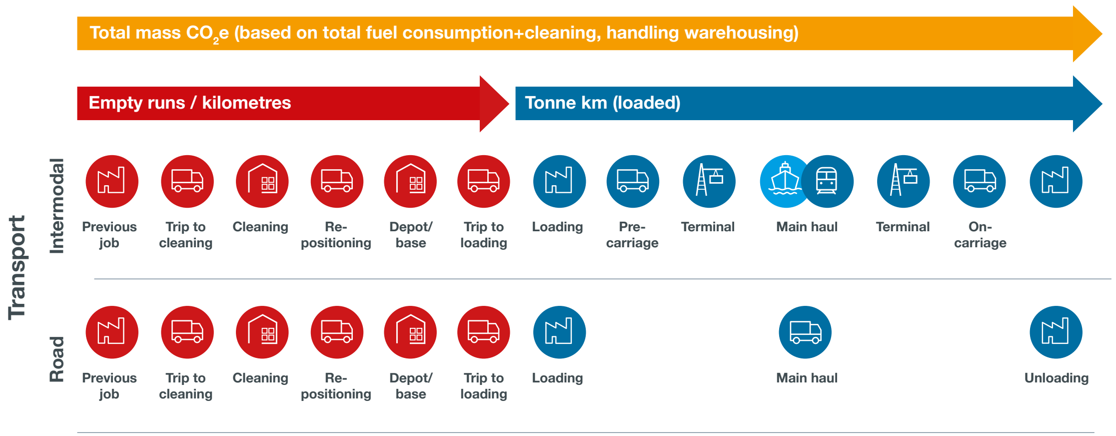
Ideally, the fuel data will be available as actual liters consumed per vehicle and it will be possible to assign the distance traveled, the amount of product transported and the associated fuel consumption by category from the bottom up. In many cases individual vehicles will only operate in one category, but where that is not the case the operations should be assigned by category according to use. Remember, you must include fuel used when the vehicle is empty and returning to base, transporting empty containers, traveling to cleaning, or to its next place of loading.

Figure 2

Examples of empty running and its relation to the calculation of emissions

Blue bar represents the tonnes loaded from the loading place to the unloading place multiplied by the loaded km. Yellow bar represents Total tonnes CO_2 emitted by all modes and activities in that chain.

Emission intensity is yellow divided by blue
Red line are 'empty runs / kilometres



If primary fuel data is not available at the ideal, disaggregated level then you will either have to

- work with averages of fuel consumption for the different vehicle types. In that case you need to know the actual total kilometers (empty and full) driven by the different vehicle types in each operation category. For example see Table 11.
- or make top-down assumptions; for example, it could be that you make an estimate of the share of the total fuel consumption for the different operation categories based on your knowledge of the proportions of vehicle activity within your business. For example see table 12.

When you use either of these approximations it is important to check that when you add together the consumption of all the categories this matches the total consumption of your operation, so you are sure that all consumption has been accounted for.

You may be consuming different fuel types (e.g. diesel, biodiesel blend, liquefied natural gas (LNG)) within one operation category. In this case you would need to determine the consumption of the individual fuel types separately in order to calculate the emissions correctly at Step 3.

STEP 3: Calculate total GHG emissions

Once you know the actual fuel consumption for the operation category, you can now calculate the related GHG emissions for each fuel using the emission factor for that fuel. The emission factors will depend on the type of fuel and may vary by region. The GLEC Framework contains standard factors for most common fuels; these may be updated occasionally, so always check the latest version of the GLEC Framework (Module 1). For some more innovative fuels such as high blend biofuels your fuel supplier probably has its own certified value for the emission factor linked to the fuel that they are supplying.

For example, if three different fuel grades are used within a single operation category as follows, the total GHG emissions would be calculated as shown on Table 13.

Table 11
Calculation based on average fuel consumption

Category: Bulk truck	Total km driven per type	Avg consumption l/km	Consumption per truck type
Truck type A	10,000,000	0.26	2,600,000
Truck type B	5,000,000	0.30	1,500,000
Total fuel consumption in category			**4,100,000**

Table 12
Calculation based on share of fuel consumption

Transport Category	Percentage of total fuel consumption	Liters fuel consumed
Total company fuel consumption		**200,000,000**
Bulk truck (liquid/solid)	40%	80,000,000
Container carrying trucks	30%	60,000,000
Refrigerated trucks	30%	60,000,000

Table 13

Fuel type	Consumption (l)	Well to Wheel emission factor (kg CO_2e/l fuel)	Total emissions (t) CO_2e
Diesel	**80,000,000**	3.48	**278,400**
Diesel (5% biodiesel blend)	**20,000,000**	3.36	**67,200**
100% Biodiesel	**1,000,000**	1.17	**1,170**
Total emissions for category			**346,770**

STEP 4: Calculate the emission intensity

When sharing information with your customer you may be happy to collect and share your primary data (fuel used and resulting emissions) with them so that they can see the full calculation shown in Step 3. This is most likely to be relevant for dedicated transport contracts where their volumes can more easily be identified. Alternatively, you may prefer to share the emission intensity of the transport operation that you provide on their behalf. To calculate the emission intensity you need to know the total GHG emissions (from Step 3) and the amount of transport activity expressed in tonne kilometers.

In this step you must calculate the transport activity for all the loaded trips in each category and add up the tonne kilometer values for each trip. This gives the total tkm of the category and can also accurately identify the tkm for your individual customers. More detailed guidance on calculating transport activity is presented in Section 1 Chapter 2.

For a short example of the correct approach to calculate the transport activity, see Table 14.

The emission intensity is easily calculated by dividing the total emissions in a transport operation category by the tkm in that category. Using this information you can calculate emissions for each category, for example see Table 15.

By assigning total emissions to a transport operation category, and dividing it by the loaded tonne km, the calculated GHG intensity factor includes emissions linked with empty runs, cleanings, repositioning etc, for that transport category. Additional calculation examples are provided in Annex 3.

Table 14

Calculation of transport activity

Trip	Customer	Loaded weight (t) per trip	Loaded distance traveled (km) per trip	Metric ton kilometers (tkm)
1	Customer A	20	150	3,000
2	Customer B	19	100	1,900
3	Customer B	22	200	4,400
Total tkm for this category over the requested time period				**9,300**

Table 15

Category	Total emissions (kg CO_2e)	Total transport activity (tkm)	GHG intensity kg CO_2e /tkm
Bulk truck	**7,680**	**128,000**	**0.060**
Container carrying truck	**5,280**	**6,0000**	**0.088**

STEP 5: Carrier reporting to direct customer

Follow the guidance in Section 2 Chapter 1 on reporting. You should report the activities that you provide directly to each customer. This example shows your Bulk truck category and your Container carrying truck category.

Table 16

Example report from carrier to customer

Item	GHG intensity (WTW) CO_2e kg/tkm	Customer specific tkm****	WTW GHG emission (kg CO_2e)
Bulk truck category	**0.060**	**50,000**	**3,000**
Container carrying truck category	**0.088**	**10,000**	**880**
Total emissions kg CO_2e			**3,880**
Input data type**	**100% primary data**		
Mode coverage*	**Road**		
Data verification statement***	**Data has not been independently verified by a 3rd party**		
Period covered	**1/1/2020 – 31/12/2020**		

*) In this case the emission calculations only cover road transport.
**) Since you used your own actual fuel consumption and tonne kilometers, this calculation is considered based on primary data. Had you received information from sub-contractors, that would need to be specified. You could then list their total emissions as a separate line item in this overview. Likewise, if you had used default values for a part of your business for which you have no actual consumption figures, you would have to state the percentage or which part of the business these defaults were used for.
***) For extra confidence you could ask an independent 3rd party to verify the data and calculations, but this is not common yet.
****) Please specify if actual or planned kms have been used

Note: if you provide a transport service with the same characteristics for multiple customers (e.g. a groupage service) it is acceptable to calculate the emission intensity for the combined service and report the same emission intensity to all customers that receive that service. See the examples provided in Annex 3 for more information.

4.2 Managing data from subcontracted services

It is often the case that for some elements of a transport service the carrier is providing the service to an intermediary that integrates the individual transport and logistics operations to provide the overall contracted service i.e. (some of) the actual operations are subcontracted. This often has an influence on the visibility of data within the contract chain and the way in which the final calculation is presented to the chemical company as the final customer. Three general situations are possible:

- the transport provider does not operate any transport services directly, instead subcontracting all aspects to one or more transport operators, possibly across different modes of transport
- the transport provider operates transport services only in one mode and subcontracts other modes where they are necessary in order to complete the full transport operation, e.g., for intermodal transport services.
- the transport provider operates transport services only in one mode but sometimes subcontracts some operations in order to manage overall fluctuations in demand or where a special vehicle is needed as part of a broader contract.

The main contractor should request the information from the transport operators in the format as set out in Section 4.1 and to use this information within its own reporting. To date this has not been common but is expected to become more so in the future as data and IT systems improve. In cases where this data is not shared then the main contractor will need to rely on either detailed modeling (Section 5.3.2) or the industry defaults (Section 3) for those elements of the service that are subcontracted.

For intermodal transport the main contractor is expected to report the total GHG emissions and the emission intensity of the full intermodal service, as set out in Section 2, Chapter 1.

LSP reporting to chemical company

Again this follows the guidance in the GLEC Framework on reporting, the so called “GLEC Declaration”. The LSP should report the activities that within the overall contract, whether provided using its own assets or those of subcontracted transport and logistics operators. The example report below is for an intermodal transport service as set out in more detail in Annex 3.

Table 17

Example intermodal report from main contractor to customer

Category	GHG intensity (WTW) CO_2e kg/tkm	Customer specific tkm	WTW GHG emission (kg CO_2e)
Intermodal rail transport Dormagen to Italy	0.0181	222,000	4,007
Total emissions kg CO_2e			4,007
Input data type*	primary data for road transport; default data for rail, transhipment and tank cleaning		
Mode coverage	Road (pre- and on-carriage), transshipment, rail (main carriage) tank cleaning		
	GHG intensity (WTW) CO_2e kg/tkm	Customer specific tkm	WTW GHG emission (kg CO_2e)
Rail	0.0100		2,109
Road	0.0883		980
Data verification statement	Data has not been independently verified by a 3rd party		
Period covered	1/1/2020 – 31/12/2020		

* primary data for operations using owned trucks; default data used for subcontracted operations

5. Guidelines for chemical companies per mode

The intention is that the contracted transport provider will provide a report, as set out in Section 4 Step 5, presenting the results of GHG emission calculations aggregated for the transport they provide in each of the transport operation categories set out in Section 3.

The reports provided should contain the information required for a chemical company to calculate its freight transport GHG emissions for each transport operation category by summing up the declared emissions across all carriers and all transport operation categories.

In cases where a logistics service provider fails to report, or does not report fully then the following procedures would apply:

1. No data reported: Request the data in the format set out in Section 4 Step 5.

2. If the logistics service provider presents only the total GHG emission (i.e. total CO_2 or CO_2e) covering all TOCs:

a. Request the data as set out in Section 4 Step 5, split out for each TOC;
b. If step 2a fails, perform your own GHG emission calculation for each TOC according to 5.1.

3. If the logistics service provider presents only the total GHG emission (i.e. total CO2 or CO2e) for each TOC:

a. Request the emission intensity and transport activity data for each TOC, as set out in Section 4 step 5;
b. If Step 3a fails, calculate the GHG emissions according to 5.1 in order to sense-check the total GHG emission value provided by the carrier for each TOC. If in doubt, use your own calculation results and engage with the carrier to try to establish the reasons why they struggled to report fully.

4. If the logistics service provider presents only a GHG emission intensity for each TOC:

a. Request the emission intensity and transport activity data as set out in Section 4 Step 5;
b. If step 4a fails, compare the GHG emission intensity provided with the default emission intensity for that TOC. If you are satisfied that the GHG emission intensity provided by the carrier is credible then calculate the GHG emissions according to 5.1 using the GHG emission intensity provided carrier. If in doubt, calculate the GHG emissions according to 5.1 using the default GHG emission intensity for the TOC and engage with the carrier to try to establish the reasons why they struggled to report fully.

5.1 Chemical company calculation

In cases where the data provided by the logistics service provider is incomplete the chemical company should calculate the GHG emissions for each TOC using the following formula:

GHG emission (mass of CO_2e) = GHG emission intensity (mass of CO_2e / tonne km) x transport activity (tonne kilometers)

Use the GHG emission intensity provided by the carrier if you have confidence in it; otherwise use the default industry emission intensity for that TOC

If the carrier provides a GHG emission intensity but not the associated tonne km there is a risk of underestimating the total emissions. In such cases an additional distance adjustment factor of 5% should be applied to allow for the typical extra actual distance traveled by the vehicle compared to the planned distance calculated by a route planner.

GHG emission (mass of CO_2e) = GHG emission intensity x chemical company estimate of transport activity x 1.05

The factor of 1.05 should also be applied for groupage transport to allow for the additional distance that can result from the operator's network or from diversions to pick up or drop off intermediate loads.

5.2 Data checks

Because reporting of GHG emissions between carrier and their customer is not yet common it is likely that in the early stages there will be errors in the data reported. Common errors that could impact the carrier's calculation that the customer should be aware of include:

- Incomplete reporting. This is one reason why it is useful to include the tonne km value as part of the carrier report – because the chemical company knows the amount of transport contracted it should become clear quickly if some of the transport activity has been missed out.

- Incorrect calculation of the transport activity can lead to calculation of an incorrect emission intensity. Follow the detailed guidance in Chapter 2 of the GLEC Framework.

  Note: it is normal for the carrier's transport activity to be slightly higher than the chemical company's expectation, partly because actual distance traveled is almost always greater than the planned distance, even when the origin, destination and route are known; however, for groupage or LTL transport the difference may be considerably higher because the chemical company is unlikely to know precise details of the carrier's network and the position of intermediate transfer locations and depots can have a significant influence on the total distance traveled.

- Use of incorrect emission factors – most likely substituting a tank-to-wheel rather than a well-to-wheel value. This would be apparent through incorrect, probably lower, total emission and emission intensities than expected.

- Failure to include the emissions from empty running within the calculation. This would result in a systematically lower, total emission and emission intensities than expected and would be more noticeable for dedicated transport where the level of empty running is higher.

- Inclusion of the weight of transport equipment, such as containers or tank containers, within the weight of the load and hence the transport activity (tonne-km). This would result in a systematically lower, total emission and emission intensities than expected.

In the future, as this type of data sharing becomes more common it is likely that cost-effective, commercial data verification services will become available.

5.3 Alternative Calculation approaches

In addition to the use of aggregated data provided by the carrier, which is presented above as the standard approach to reporting, and the backup provided by the chemical sector default emission intensities presented in this report, other approaches are possible.

5.3.1 Shipment level data

As noted in Section 4 Step 4, your carrier may be willing to share primary information with you so that you can see the full calculation. This would probably help to remove uncertainty regarding the approach taken and data used in the calculation. Access to data at this level is most likely for dedicated transport where long-term contracts support a truly collaborative approach to operational efficiency. In contrast, this approach is unlikely for shared transport options where it might reveal commercially confidential information.

This level of data transparency can be useful to understand the underlying issues that influence GHG performance; however, as corporate reporting generally occurs at annual level it is more useful for proactively identifying opportunities for operational efficiency and emission reduction through gain sharing

If you do have access to shipment level data in collaboration with your carrier, it is important to resist the temptation to exclude emissions linked to empty running. For road transport the most widely accepted way to include the impact of empty running is to calculate the average level of empty running across the whole transport operation category and then apply this value to the emissions due to the loaded trips in proportion to the tonne-kms.

5.3.2 Modeled Emissions

Modeling of GHG emissions is a well-established option – Smart Freight Centre has reviewed and accredited several such calculation tools as being in conformance to the GLEC Framework – see www.smartfreightcentre.org for more current details. The use of such models may be beneficial in that it should be possible to tailor the calculated values to match the specific characteristics of the transport that is being provided, rather than relying on the default values, which are, by their very nature, only generally representative. Modeling is also useful to assess the potential of different options to reduce emissions as a first step prior to investing in actual trials.

6. Recommendations for updating the defaults.

Given the increasing focus on the severity of the global climate crisis and the importance that accurate and transparent GHG reporting has in tracking progress against sector and company emission reduction targets, the whole topic of GHG calculation and reporting is subject to ongoing technical and process updates. Therefore, future updates to the GLEC Framework and these guidelines can be expected that might affect both methodology and approach to default emission intensities.

Some examples of this may include:

- Revision of the levels of empty running and typical load factors as better access to primary data and changes to standard industry practices become apparent

- Revision of default GHG emission intensities as updated emission factors for diesel are published, new, lower emission fuels become more commonplace for chemicals transport in some or all modes

- More detailed reporting requirements may be put in place for carriers and/or shippers, for example to split up the well-to-tank and tank-to-wheel components of the overall emission values.

- Improvements in the way that baseline data for specific modes are managed by the legislative bodies. For example, the IMO is aware of some overlap between the different vessel categories, particularly regarding chemical and oil tankers which use different size classifications even though some vessels may be used interchangeably; there are also calls to move from the use of vessel size classes to a continuous relationship between vessel size and expected emissions. These issues are being reviewed at IMO level, and the outcome of the discussions may result in a revised approach to calculating default emission intensities.

Annex 1:
Road transport: Full default table

Table 18
Emission intensities for standard articulated truck (i.e. no special equipment) with B5 diesel/biodiesel blend.

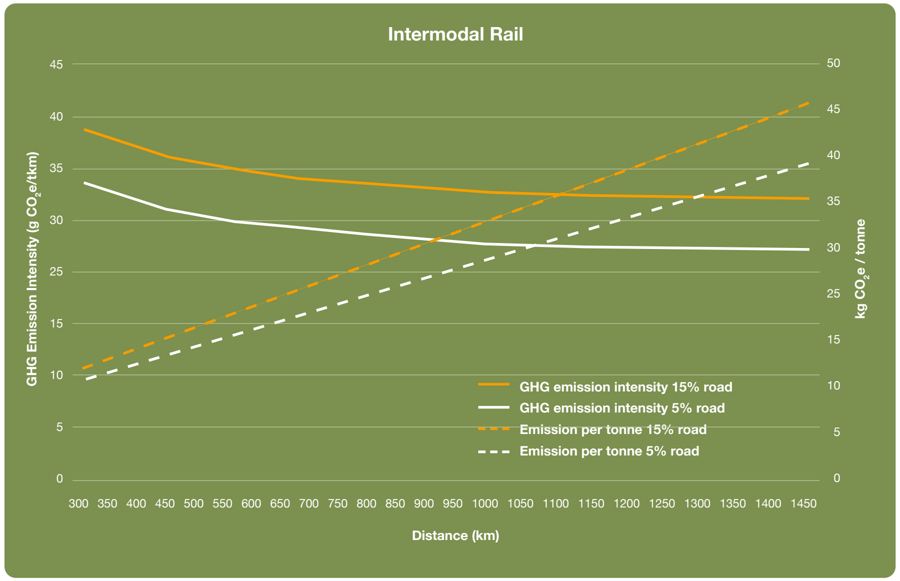
% truck kms empty	Default Emission intensity g CO_2e / tonne-km on a well to wheels basis										
	Payload (tonnes)										
	8	10	12	14	16	18	20	22	24	26	28
0%	136	113	98	87	79	62	67	63	60	57	54
2%	138	115	99	88	80	63	68	64	60	57	55
4%	141	117	101	90	81	64	69	65	61	58	56
6%	143	119	103	91	82	65	70	66	62	59	56
8%	146	121	104	93	84	66	71	67	63	60	57
10%	149	123	106	94	85	67	72	68	64	61	58
12%	152	126	108	96	87	68	74	69	65	62	59
14%	155	128	110	98	88	69	75	70	66	62	60
16%	158	131	112	99	90	70	76	71	67	63	60
18%	161	133	115	101	91	72	77	72	68	64	61
20%	165	136	117	103	93	73	79	74	69	66	62
22%	168	139	119	105	95	74	80	75	70	67	63
24%	172	142	122	108	97	76	82	76	72	68	65
26%	176	145	125	110	99	77	83	78	73	69	66
28%	180	149	127	112	101	79	85	79	74	70	67
30%	185	152	131	115	103	81	87	81	76	72	68
32%	190	156	134	118	106	83	89	83	78	73	70
34%	195	160	137	121	108	84	91	85	79	75	71
36%	200	165	141	124	111	87	93	87	81	77	73
38%	206	169	145	127	114	89	95	89	83	78	74
40%	212	174	149	131	117	91	98	91	85	80	76
42%	219	179	153	134	120	94	100	93	87	82	78
44%	226	185	158	138	124	96	103	96	90	84	80
46%	233	191	163	143	127	99	106	99	92	87	82
48%	242	198	168	147	132	102	110	102	95	89	84
50%	250	205	174	152	136	106	113	105	98	92	87

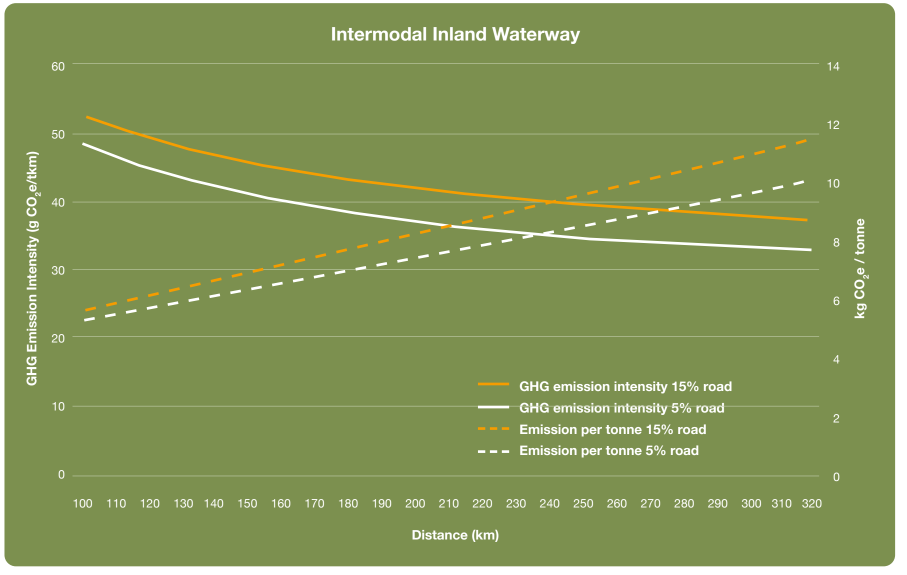
Annex 2:
Intermodal GHG emission intensity by distance

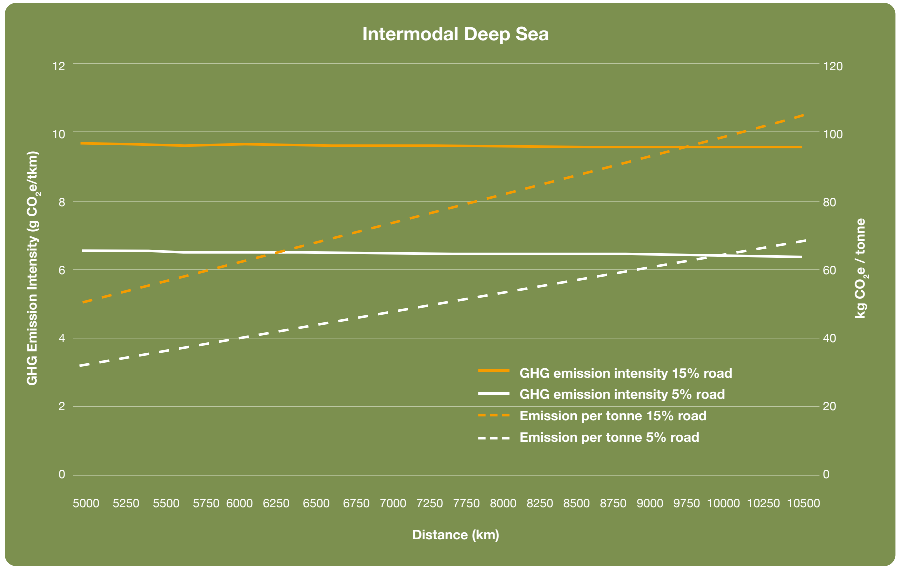
The following graphs show the relationships between GHG emission intensity and distance for the four examples of intermodal transport presented in Section 3.8. As noted there, assigning a default GHG emission intensity to an intermodal transport is subject to a greater degree of uncertainty than to an individual mode due to the greater number of variables. Hence, it must be noted that the graphs show the relationship only for a combination of one example loading and empty running for each of the pre-carriage, main transport and on-carriage; however, it is instructive to show that the emission intensity does decrease marginally as the logistics site emissions are spread over a greater transport activity. At the same time the increase in total emissions per tonne of product moved has a close to linear relationship with distance, showing the impact of increasing supply chain distances on total GHG emissions, even when using an intermodal option. The graphs also show how reducing the proportion of distance by road impacts on each of these intermodal combinations.

The distance ranges shown are indicative of what might be expected of each intermodal combination but could be extended in either direction in exceptional circumstances.

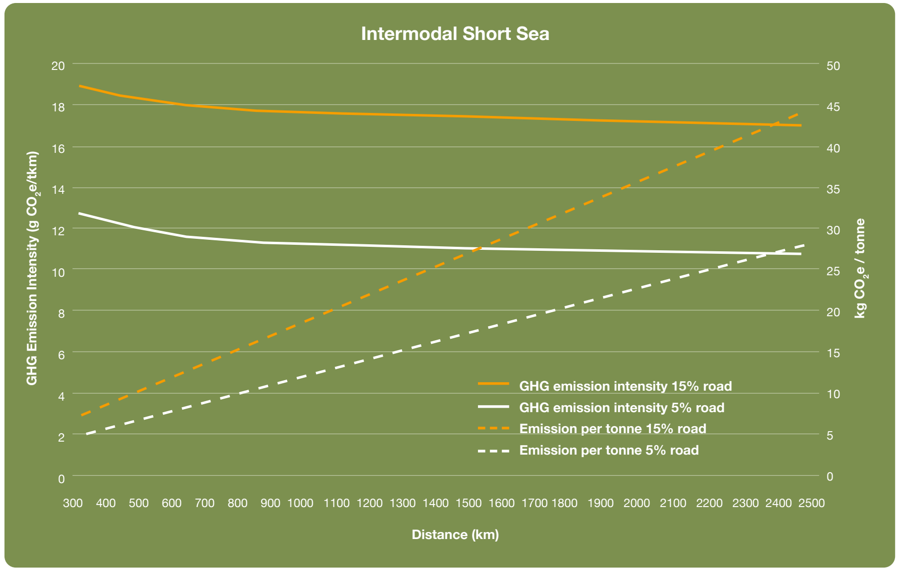
The relationship in each case is:
Overall emission intensity = (% main mode distance x main mode emission intensity) + (% road distance x road emission intensity) + (2 x handling site intensity / total distance)

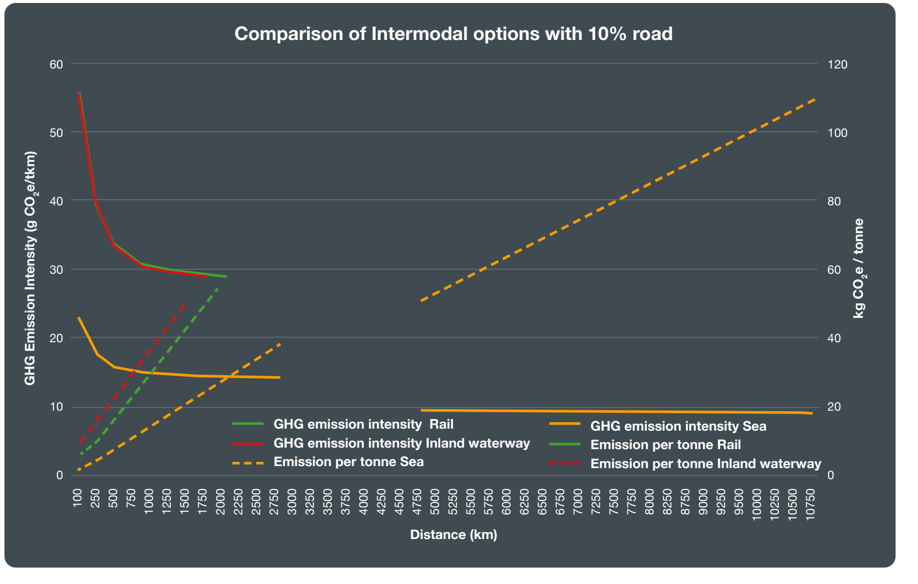






The following graph then shows how the modes compare with each other for a standard 10% pre- and on-carriage element by road. It is worth noting that short sea distances can be considerably longer than rail or inland waterway depending on the exact route meaning that it is important to consider the exact options rather than relying solely on general emission intensities.





Annex 3: Example calculations

Road Transport

Chemical Company Calculations

Road Example 1

Level 3 Calculation

Calculation of GHG emissions for groupage transport to move 10 tonnes of packed goods between two points that are 250 km apart according to the shortest feasible distance by road.

Given that the customer knows that the goods are being transported via a groupage transport then the starting point is the level 3 WTW GHG emission intensity of 95 g CO_2e/tkm from the table in Section 3.2.

Using the equation from Section 5.1 the GHG emissions can be estimated to be:

GHG emission (mass of CO_2e) = GHG emission intensity x customer estimate of transport activity x 1.05

(The distance adjustment factor is applied due to the lack of information about the actual distance that the goods are transported for this groupage transport.)

GHG emission = 95 g CO_2e/tkm x 10 t x 250 km x 1.05 = 249.38 kg CO_2e

Calculation using information provided by the carrier/LSP

The transport service provider has been able to provide the following information that relates to this transport:

Table 19
Example of road transport reporting

Item	GHG intensity (WTW) CO_2e kg/tkm	Customer specific tkm	WTW GHG emission (kg CO_2e)
Ambient groupage transport	0.0617	28,600	160.42
Total emissions kg CO_2e			160.42
Input data type	100% primary data		
Mode coverage	Road		
Data verification statement	Data has not been independently verified by a 3rd party		
Period covered	March 2021		

The report covers the whole of the month's operations for its groupage operations for all customers. The transport activity value is the amount of transport activity for this particular customer. Without confirmation of the tonne km linked to this specific consignment the calculation would be:

GHG emission = 61.7 g CO_2e/tkm x 10 t x 250 km x 1.05 = 161.96 kg CO_2e

(The distance adjustment factor of 1.05 is applied as the provided GHG intensity is assumed to be based on actual distances if not stated otherwise)

However, if the transport operator confirms that the actual transport activity of this consignment was 2600 tkm then the calculation can be refined to be:

GHG emission = 61.7 g CO_2e/tkm x 2600 tkm = 160.42 kg CO_2e

Road Example 2

Level 3 Calculation

Calculation of GHG emissions for groupage transport to move 8 tonnes of packed goods between two points that are 510 km apart according to the shortest feasible distance by road.

Given that the customer knows that the goods are being transported via a groupage transport then the starting point is again the level 3 WTW GHG emission intensity of 95 g CO_2e/tkm from the table in Section 3.2.

Using the equation from Section 5.1 the GHG emissions can be estimated to be:

GHG emission (mass of CO_2e) = GHG emission intensity x customer estimate of transport activity x 1.05

(The distance adjustment factor is applied due to the lack of information about the actual distance that the goods are transported for this groupage transport.)

GHG emission = 95 g CO_2e/tkm x 8 t x 510 km x 1.05 = 406.98 kg CO_2e

Calculation using information provided by the carrier/LSP

The transport service provider has been able to provide the following information that relates to this transport:

The report covers the whole of the quarter's operations for its groupage operations for all customers. The transport activity value is the amount of transport activity for this particular customer. Without confirmation of the tonne km linked to this specific consignment the calculation would be:

GHG emission = 54.9 g CO_2e/tkm x 8 t x 510 km x 1.05 = 235.19 kg CO_2e

If the transport operator is unable to confirm the actual transport activity of this consignment then the above is the best calculation available to the customer.

Table 20

Example of road transport reporting

Item	GHG intensity (WTW) CO_2e kg/tkm	Customer specific tkm	WTW GHG emission (kg CO_2e)
Ambient groupage transport	0.0549	4,284	235.19
Total emissions kg CO_2e			235.19
Input data type	100% primary data		
Mode coverage	Road		
Data verification statement	Data has not been independently verified by a 3rd party		
Period covered	Q1 2021		

Table 21
Example of a multi-element transport chain

Start point	End point	Load (t)	Distance (km)	Activity (tkm)	Fuel (l)
Depot	A	0	30	0	8
A	B	10	20	200	6
B	C	23	240	5520	79
C	Depot	0	260	0	65
Depot	A	0	30	0	8
A	B	10	20	200	6
B	C	23	240	5520	79
C	Depot	18	260	4680	83
Depot	E	18	40	720	13
E	Depot	12	40	480	12
Depot	A	12	30	360	9
A	C	25	255	6375	87
C	Depot	18	260	4680	83
Depot	E	18	40	720	13
E	Depot	0	40	0	10
Total				**29455**	**561**
Overall fuel intensity					**0.0190 l/tkm**
Overall GHG emission intensity (based on Diesel fuel emission factor of 3.48 kg CO_2e /liter)					**66.12 g CO_2e/tkm**

Transport Company Calculations

Road Example 1

This provides a simplified worked example of the procedure for a transport company to calculate its GHG emission intensity for its groupage operations. It is recognized that a full, real-life network calculation would include a lot more data and hence may need a specialist software solution.

Vehicle operations included for each element of the transport chain, see Table 21.

Transport activity for a 10t consignment from A to C via B = 10 t x (20 + 240) km = 2600 tkm

Transport activity for a 18t consignment from C to E via depot = 18 t x (260 + 40) km = 5400 tkm

Table 22
Example of a complex multi-element transport chain

Start point	End point	Load (t)	Distance (km)	Activity (tkm)	Fuel (l)
Hub A	O	24	20	480	8
O	P	18	4	72	1
P	Q	6	15	90	4
Q	R	14	20	280	6
R	S	8	4	32	1
S	T	12	18	216	5
T	U	18	16	288	5
U	Hub A	22	9	198	3
Handling emissions at Hub A: 1.3 kg CO_2e/t = 1.3 x 22 = 28.6 kg					
Hub A	Hub B	22	485	10670	160
Handling emissions at Hub B: 1.3 kg CO_2e/t = 1.3 x 22 = 28.6 kg					
Hub B	C	22	12	264	4
C	D	14	16	224	5
D	E	17	5	85	1
E	F	11	14	154	4
F	G	16	23	368	7
G	H	8	8	64	2
H	I	12	20	240	2
I	Hub B	20	8	160	3
Hub B	Hub A	20	485	9700	158
Total				**23585**	**379**
Overall fuel intensity					**0.0161 l/tkm**
Overall transport emissions					379 x 3.48 = **1318.92 kg CO_2e**
Total emissions					1318.92 + 2 x 13.2 = **1376.12 kg CO_2e**
Overall GHG emission intensity					**1376.12 / 23585 = 58.3 g CO_2e/tkm**

Transport Company Calculations

Road Example 2

This provides a simplified worked example of the procedure for a transport company to calculate its GHG emission intensity from hub and spoke groupage operations. It is recognized that a full, real-life network calculation would include a lot more data and hence may need a specialist software solution.

Vehicle operations included for each element of the transport chain, see Table 22.

The optimal calculation for a hub and spoke groupage operation is to separate the calculation of the collection and delivery element from the trunking element and for the collection and delivery element to use the direct distances between each of the collection and delivery points and the hub to allocate the emissions to each consignment. This removes the variability of the detailed emission calculation depending on where the consignment happens to be within the order of a particular round.

In practice the above network value can be used to communicate the overall GHG emission intensity from the transport provider to their customer, with the customer using the 5% distance adjustment factor to allow for this variation.

Intermodal Transport

Calculation of GHG emissions for ISO container on road/rail intermodal combination from Dormagen to Italy with a total distance of 1850 km. The order consists of 7 consignments totalling 120 tonnes.

Chemical Company Calculations

The chemical company has various options depending on the amount of data available. These follow the levels introduced, along with the default values in Section 3 and reflect the amount of information available to them.

Level 1: limited information

With the bare minimum of information the chemical company should consult the table in Section 3.8 and combine the generic default value for intermodal rail transport of 32.5 g CO_2e/tkm (based on 15% road transport by distance) with the total transport activity of the 7 consignments which is 120 x 1850 = 222000 tkm.

Additionally 7 lots of tank cleaning emissions should be added using the standard factor of 86.6 kg CO_2e .

Hence the level 1 total GHG emission is estimated to be 32.5 g CO_2e/tkm x 222000 tkm + 7 tank cleaning lots x 86600 g CO_2e/tank cleaning = 7821200 g CO_2e or 7.82 t CO_2e.

Level 2: intermediate information

With additional information the chemical company can refine the calculation and use the equation from Annex 2 with some of the modal default values from Section 3. For example:

- The chemical company may know that road transport is only 5% of the total distance.
- The chemical company may choose to use the average value for an ambient tank container of 75 g CO_2e/tkm for the road legs
- The chemical company may choose to use the average GHG emission intensity for a track container of 17 g CO_2e/tkm for the rail leg
- The chemical company can use the average transshipment emission intensity of 1300 g/t from the GLEC Framework for the transfer between road and rail at each end of the main haul.

With these parameters the overall emission intensity = 0.95 x 17 + 0.05 x 75 + (2 x 1300 / 1850) = 21.305 g CO_2e/tkm.

Additionally 7 lots of tank cleaning emissions should be added using the standard factor of 86.6 kg CO_2e.

Hence the level 2 total GHG emission is estimated to be 21.305 x 222000 + 7 x 86600 = 5336000 g CO_2e or 5.34 t CO_2e.

Level 3: detailed information

The chemical company may be able to use more detailed information regarding each leg to further refine the calculation as follows:

Road leg 1 (pre-carriage)
Distance is known to be 40 km
Total product mass is 120 t across 7 consignments, so average consignment weight is 17.1 t

Tailored emission intensity for a payload of 17.1 t and an average tank container empty running value of 19% is between these 4 values from the table in Annex 1:

91	84
93	85

Leading to an approximate emission intensity of 88.3 g CO_2e/tkm.

Total transport GHG emissions for road leg 1 = 120 t x 40 km x 88.3 g CO_2e/tkm = 823840 g CO_2e.

Transshipment 1
The average transshipment emission intensity for the transfer between road and rail is 1300 g/t.

Emissions between road leg 1 and rail transport = 1300 g/t x 120 t = 156000 g CO_2e.

Rail leg (main carriage)
Distance is known to be 1757.5 km
Main carriage traction is known to be electric.

From the table in Section 3.3 the GHG emission intensity for a track container with electric traction is 10 g CO_2e/tkm

Total transport GHG emissions for rail leg 1 = 120 t x 1757.5 km x 10 g CO_2e/tkm = 2109000 g CO_2e

Transshipment 2
The emissions for transshipment 2 are estimated to be the same as for transshipment 1.

Road leg 2 (on-carriage)
Distance is known to be 52.5 km
In the absence of carrier specific data the emission intensity for road leg 2 is taken to be the same as for road leg 1, i.e. 88.3 g CO_2e/tkm.

Total transport GHG emissions for road leg 2 = 120 t x 52.5 km x 88.3 g CO_2e/tkm = 556290 g CO_2e.

Total for the Intermodal Journey
The level 3 total GHG emission is the sum of the emissions from the individual journey legs.

Journey Leg	Total GHG emission (t CO_2e)
Road Leg 1	0.42
Transshipment 1	0.16
Rail leg	2.11
Transshipment 2	0.16
Road Leg 2	0.56
Tank cleaning	0.61
Total	4.01

With Data input from the Logistics Service Provider

The LSP report for the above example would be (as shown in section 4.2):

Table 23
Example intermodal report from main contractor to customer

Item	GHG intensity (WTW) CO_2e kg/tkm	Customer specific tkm	WTW GHG emission (kg CO_2e)
Intermodal rail transport Dormagen to Italy	**0.0181**	**222,000**	**4,007**
Total emissions kg CO2e			**4,007**
Input data type	**Primary data for road transport; default data for rail, transshipment and tank cleaning**		
Mode coverage	**Road (pre- and on-carriage), transshipment, rail (main carriage) tank cleaning**		
	GHG intensity (WTW) CO_2e kg/tkm	**Customer specific tkm**	**WTW GHG emission (kg CO_2e)**
Rail	**0.0100**	**210,900**	**2,109**
Road	**0.0883**	**11,100**	**980**
Data verification statement	**Data has not been independently verified by a 3rd party**		
Period covered	**1/1/2020 – 31/12/2020**		

Annex 4: Partners

4 Annex unit conversions

Click here to go back to **Section 4** *contents page*

Table 1
Distances

To convert from	To	Multiply by
Foot (ft)	Meter (m)	0.304 8
Yard (yd)	m	0.914 4
International Mile (mi)	m	1.609 344
Nautical Mile (nmi)	Kilometer (km)	1.852

Table 2
Weight

To convert from	To	Multiply by
Short ton (2000 lb)	Metric ton (t)	0.907 184 74
Long or imperial ton (2240 lb)	t	1.016 047
US pound (lb)	t	0.000 453 592
Kilogram (kg)	t	0.001
US Gallon	Liter (l)	3.785 411 784
Short ton-mile (ton-mi)	t-km	1.46

Conversions specific to container shipping

(Source for the following: ISO 14083:2023, Originally sourced from IMO and EcoTransIT.)

Table 3
Twenty-foot equivalent unit (TEU)

Cargo type	Tonnes per TEU
Lightweight cargo	6
Average cargo	10
Heavyweight cargo	14.5
Empty container	2

Table 4
Alternative container types

Cargo type	TEU conversion factor (TEU equivalents)
20’ standard and high cube container	1.0
40’ standard	2.0
40’ high cube	2.25

List of abbreviations

CCAC	Climate and Clean Air Coalition
CC	Clean Cargo
CDP	Carbon Disclosure Project
CH^4	Methane
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
COVID-19	Coronavirus Disease 2019
CSR	Corporate Sustainability Reporting
DQA	Data Quality Assurance
DAF	Distance Adjustment Factor
DJSI	Dow Jones Sustainability Index
EC	European Commission
EEDI	Energy Efficiency Design Index
EEOI	Energy Efficiency Operational Indicator
eGRID	Emissions & Generation Resource Integrated Database
ERTAC	Eastern Regional Technical Advisory Committee
EU	European Union
EU ETS	European Union Emissions Trading System
FTL	Full Truck Load
GCD	Great Circle Distance
GHG	Greenhouse Gas
GIS	Geographic Information System
GLEC	Global Logistics Emissions Council
GPS	Global Positioning System
GVW	Gross Vehicle Weight
GWP	Global Warming Potential
HBEFA	HBEFA: Handbook of Emission Factors (“Emissionsfaktorhandbuch”)
HFCs	Hydrofluoro-Carbons
HFO	Heavy Fuel Oil
HGV	Heavy Goods Vehicle
HOC	Hub Operation Category
HPDI	High-Pressure Direct Injection
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ICC	International Chamber of Commerce
ICT	Information and Communications Technology
IEA	International Energy Agency
IMO	International Maritime Organization

List of abbreviations

IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
ITF	International Transport Forum
kg	Kilogram
kJ	Kilojoule
KPI	Key Performance Indicator
kWh	Kilowatt-hour
LEARN	Logistics Emissions Accounting & Reduction Network
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LSP	Logistics Service Provider
LTL	Less than Truck Load
MDO	Marine Diesel Oil
MIT	Massachusetts Institute of Technology
N_2O	Nitrous Oxide
NDCs	Nationally Determined Contributions
NF^3	Nitrogen Triflouride
NGO	Non-Government Organization
NOx	Nitrogen Oxides
NTM	Network for Transport Measures
OECD	Organization for Economic Co-operation and Development
peq	Passenger equivalent
PFCs	Perfluoro-Carbons
RAILISA	RAIL Information System and Analyses
RED2	Renewable Energy Directive (EU)
REff Tool®	Resource Efficiency Tool
RP	Recommended Practice
SAF	SAF: Sustainable Aviation Fuel
SBTi	Science-Based Targets initiative
SDA	Sustainable Development Agenda
SF6	Sulphur Hexafluoride
SFC	Smart Freight Centre
SFD	Shortest Feasible Distance
SI engine	Spark Ignition engine
t	Tonne = 1000 kg
T&D	Transmission and Distribution
TCE	Transport Chain Element
TEU	Twenty-foot Equivalent Unit
t-km	Tonne-kilometer
TMS	Transport Management System

List of abbreviations

TOC	Transport Operation Category
TSC	Transport Service Category
TTW	Tank-to-Wheel/Wake
UIC	Union Internationale des Chemins de Fer (International Union of Railways)
UN	United Nations
UNGC	United Nations Global Compact
US EPA	United States Environmental Protection Agency
VLSFO	Very Low Sulfur Fuel Oil
WBCSD	World Business Council for Sustainable Development
WRI	World Resources Institute
WTT	Well-to-Tank
WTW	Well-to-Wheel/Wake
WWF	World Wildlife Fund for Nature

Glossary

Actual distance — The actual distance traveled by a shipment based on odometer readings or knowledge of the actual route.

Belly cargo — Cargo transported in a passenger aircraft but distinct from passengers' luggage.

Calendar year — Calendar year is a timeframe spanning from January 1st to December 31st. In contrast, a twelve-month period consists of twelve consecutive months and does not necessarily commence on January 1st.

Compressed Natural Gas (CNG) — CNG is an energy carrier made by compressing natural gas to less than 1% of its volume at standard atmospheric pressure, used primarily as an alternative to gasoline.

Consignment — Refers to a quantifiable quantity of cargo that can be distinctly identified as a single unit. It is transported from a sender or consignor to a receiver or consignee, irrespective of the mode of transportation employed.

CO_2 — Carbon dioxide is a colorless, odorless gas naturally present in the Earth's atmosphere and a major contributor to the greenhouse effect.

CO_2e — Carbon dioxide equivalent is a unit that describes the collective impact of different greenhouse gases as a single measure related to the overall global radiative forcing caused by carbon dioxide.

CO_2e intensity — A way to express the CO_2e intensity of freight transport; expressed as the total CO_2e emissions divided by the total transport activity, expressed in tonne-kilometers.

Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) — CORSIA is an aviation industry program developed by the International Civil Aviation Organization (ICAO) to reduce and offset carbon emissions from international flights.

Coronavirus Disease 2019 (COVID-19) — COVID-19 is a highly contagious respiratory illness caused by the novel coronavirus SARS-CoV-2, first identified in 2019.

Distance Adjustment Factor (DAF) — The DAF is the factor expressing the difference between the actual distance and the transport activity distance. It is introduced to ensure that where different types of distance are used at different stages of an emission calculation the resulting calculation errors can be eliminated or minimized.

Fuel efficiency factor — Fuel efficiency factor is a metric used to quantify the effectiveness of fuel use in transporting goods. It is determined by dividing the total fuel consumption by the transport activity conducted.

Embedded emissions — The emissions related to the manufacturing and production of a product or structure. Also known as embodied emissions.

Empty trip — Empty trip refers to a transportation operation in which no cargo is being conveyed. It's important to note that the transportation of empty containers, pallets, or other load carriers is not considered an empty trip. In these instances, the load carriers assume the role of the carried freight or transported commodity.

Energy — Electricity, fuels, steam, heat, compressed air and other similar mediums.

Energy carrier — Any substance that can be used to generate mechanical movement or heat and to generate chemical or physical processes.

Energy consumption — Energy consumption refers to the use of energy.

European Union Emissions Trading System (EU ETS) — EU ETS is a carbon emissions trading system implemented by the European Union to regulate greenhouse gas emissions from industries.

Fleet — Fleet refers to the complete collection of a transport operator's vehicles, which can be further categorized into sub-fleets.

Freighter — An aircraft dedicated solely to the transportation of cargo which does not carry passengers.

Glossary

Fuel life cycle	The various stages from the production to the use phase of fossil and alternative fuels.
Fugitive or evaporative emissions	Pollutants released to air from leaks in equipment, pipelines, seals, valves, power conversion stations, etc.
Great circle distance (GCD)	GCD is defined as the shortest distance between any two points on the surface of the earth, respecting its spherical surface.
Greenhouse gas (GHG)	Greenhouse gases, defined as those indicated by the latest IPCC Assessment Report
Greenhouse gas activity	Any activity that results in the emission of GHGs
Greenhouse gas emission intensity	A factor expressing the quantity of greenhouse gas emissions in relation to the specific greenhouse gas activity that caused those emissions.
Global Warming Potential (GWP)	GWP is an index that measures the radiative forcing potential of greenhouse gasses over a specific time and in relation to carbon dioxide. It measures how much a given amount of a greenhouse gas is estimated to contribute to global warming over a specific timeframe.
Hub	A hub is any location within a transport chain where freight is transferred, potentially involving a switch between transport modes or vehicles, regardless of further operations carried out at that location. Hubs include depots, nodes, stations, ports, airports, logistics sites, etc.
Hub activity	The operations carried out at a hub, measured in the hub's throughput.
Hub equipment energy provision GHG emission	The GHG emissions linked to the production, storage, processing and distribution of energy carriers used for carrying out hub operations.
Hub equipment operation GHG emissions	The GHG emissions linked to the operation of hub equipment.
Hub Operation Category (HOC)	Represents a grouping of hub operations that share similar characteristics.
Intermodal freight transport	Multimodal transport of goods by successive modes of transport, in one intermodal transport unit, without handling of the goods themselves when changing modes. The intermodal transport unit can be a container, swap body or a road or rail vehicle or a vessel.
International Organization for Standardization (ISO)	ISO is an international standard-setting body that develops and publishes standards for various industries.
Liquefied Natural Gas (LNG)	LNG is an energy carrier formed by natural gas that has been cooled to a liquid state for easier storage and transportation.
Liquefied Petroleum Gas (LPG)	LPG is a flammable hydrocarbon used as an energy carrier in heating appliances, cooking equipment and vehicles.
Load factor	Load factor is the ratio of the total cargo mass carried by a vehicle to the legally maximum payload capacity of a vehicle or vessel.
Logistics Service Provider (LSP)	An LSP is a company that offers logistics and supply chain management services.
Marginal accounting Modes	Method of allocation based on assigning only the additional emissions to an extra load rather than its full, proportional share.
Multimodal freight transport	Means of transport or type of transport (e.g., rail, sea, road, etc.). Transport of goods by at least two different modes of transport. Intermodal transport is a particular type of multimodal transport, often based on a contract regulating the full multimodal transport.
Network distance	Effectively a variation of planned distance, network distance is used where the route options that can be taken are limited, for example rail or inland waterway networks.

Glossary

Nitrogen Oxides (NOx) NOx refers collectively to the various oxides of nitrogen that contribute to air pollution and smog.

One way trip Travel without a return trip.

Planned distance Generally found using route planning software, the planned distance represents the distance that is intended for a vehicle to complete its journey. It is generally, but not exclusively, the same as the shortest feasible distance.

Pre-carriage An inland movement that takes place prior to the container being delivered to the port/terminal.

Primary data Otherwise known as actual or measured data; it is the "quantified value of a process or an activity from a direct measurement or a calculation based on direct measurements." (source: ISO 14083:2023)

Program data Data from e.g., green freight programs such as SmartWay or CCWG carrier data.

Ro-Ro Roll-on/Roll-off (Ro-Ro) ships are vessels designed to carry wheeled cargo.

Round trip A group of sequential journeys that start and end in the same place.

Secondary Data Any data that is not primary data. For further details, please see Section 1.

Sustainable Aviation Fuel (SAF) SAF is an aviation fuel made from renewable resources with lower carbon emissions compared to traditional jet fuel.

Shipment Refers to the goods in a commercial transaction between a seller and a buyer. It encompasses the consignments transported as part of this transaction via a transport chain from the consignor to the consignee.

Shipper Individual or entity that sends goods for transport.

Shortest feasible distance (SFD) Generally found using route planning software, the shortest feasible distance tends to be the shortest distance taking into account real operating conditions and typical operational choices such as avoiding congestion hotspots or unsuitable, restricted roads.

Spark Ignition engine An internal combustion engine that ignites fuel-air mixtures with a spark plug.

Subcontractors Company or individual that carries out the transportation service for the contractor.

Tank-to-wheel (TTW) Tank-to-wheel (or tank-to-wake for air and sea transport) refers to the section of the energy carrier's life cycle where the energy carrier is converted to propulsion energy.

Throughput The throughput is the amount of freight handled at a hub. It can be best measured as the amount of freight or goods departing from the hub.

Tonne Metric unit of mass equal to 1000 kilograms.

Tonne-kilometer The unit of measure for freight transport, representing the transport of one tonne of goods over the distance of one kilometer.

Trade lanes Heavily trafficked transport corridors where vehicle movements are heavily concentrated between multiple locations at the start and end point.

Transshipment Transshipment involves the shifting of freight or goods from one transport vehicle to another, irrespective of whether this entails a shift in transport mode.

Transport activity Transport activity is the quantification of freight or cargo moved by transport; it is usually expressed in tkm (tonne-kilometers), it characterizes the mass (tonnes) transported over a certain distance (km).

Transport chain Sequence of transport modes used to move the goods from their origin to their destination. A transport chain is therefore built of two or more transport chain elements (TCEs). Along the chain, one or more transshipments take place. The goods may not necessarily stay in the same loading unit along the full transport chain.

Glossary

Transport chain element (TCE)	A TCE is one element of the transport chain. It can consist of a transport activity or a hub activity.
Transport distance	Refers to the distance covered from the consignor to the consignee during the transportation of the freight.
Transport network	The full set of transport-related activities when all transport chains are aggregated.
Transport operation	Operation of any vehicle with the purpose to move freight, including the movement of freight in pipelines.
Transport operation category (TOC)	TOC is a grouping of transport categories sharing similar characteristics.
Twenty-foot equivalent unit (TEU)	TEU is a standard unit of measurement for shipping container capacity of a 20 ft (6.10 m) container.
Value chain	While supply chains refer to systems that move a resource or products to a consumer, the value chain refers to the manner in which value is added to a product along the chain.
Vehicle energy provision GHG emissions	These are the GHG emissions linked to the production, storage, processing and distribution of energy carriers used for carrying out vehicle operations.
Vehicle operation	A vehicle operation is any transport operation providing deployment of a vehicle, regardless of whether it is autonomous, manned, piloted, or remotely controlled.
Vehicle operation GHG emissions	The GHG emissions linked to the operation of vehicles.
Well-to-tank (WTT)	The section of the energy carrier's life cycle from the start of the initial process to generate the input feedstocks to the moment to the moment is supplied to the vehicle (at the recharging or refueling station.)
Well-to-wheel (WTW)	Well-to-wheel (or well-to-wake for air and sea transport) refers to the full energy carrier life cycle; i.e. the summation of the WTT and TTW phases.
Year-on-Year (YOY)	YOY analysis compares data or performance metrics over consecutive years to identify trends and changes.

Version history

Version	Year	Summary of changes
1.0	2016	Initial version
2.0	2019	Major revision of v1.0 with updates on design; Alignment with the Greenhouse Gas Protocol; Inclusion of logistics sites, updated treatment of inland waterways, data collection and reporting guidelines; Additional information on reporting of emissions; Specific guidance for the mail and parcels sector.
3.0	2023	Updated design, language alignment with ISO 14083, updated emission factors implemented in Section 3, Module 1.
3.1	2024	Updated Data Module 3 with latest sources, added new China values, integrated EV accounting whitepaper, and made minor amendments

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