İzmir, 26th February 2022

CONTAINER TRANSPORTATION EMISSION CALCULATION MODEL

for
Emissions
Accounting

shipsgo

Document writing

Version	Date	Writer	Modification
1.0	26.02.2022	O. Akdaş V. Çetinkaya	Document creation

shipsgo

General Contact

Dokuz Eylül University DEPARK Technology
Development Zone Doğuş Str.No:207/AG
Beta Building Buca, İzmir, Turkey

Responsibilities

Topic	Contact	Contact mail address
Coordination	Prof. Dr. Okan Tuna Soner Okur	okan.tuna@shipsgo.com soner.okur@shipsgo.com
Data Analysis	Efe Özcan Çelik Şule Çekiç	Efe.celik@shipsgo.com Sule.cekic@shipsgo.com
Methodology	Dr. Onur Akdaş Dr. Volkan Çetinkaya	onur@shipsgo.com volkan@shipsgo.com

ABOUT shipsgo ACADEMY

Since the beginning of our journey in the container transportation business, we have been trying to organize the shipping industry's information and make it universally accessible and helpful to all parties. So far, we have developed our well-known two pro-ducts in the digital container transportation market; container tracking and route finder. These two products attempt to solve the problem of "visibility" in container transport by supporting the information on the current position of containers and carriers' route per-formances (transit time and reliability). We have reached 5,000 daily searches on our website from 65+ countries and plan to reach 30,000 daily searches worldwide at the end of 2022.

In order to enhance our mission of making people happy with the information, we deve-loped Shipsgo Academy to produce case studies, instant learning packages, and rese-arch projects. Thanks to the powerful connection of Shipsgo with academia and industry, we design and pursue various projects with the participation of academia, uni-versity students, and our customers. Our case studies are produced with our customers' involvement and feedback to illustrate how their companies' visibility issues were solved. In addition to that, our team develops instant learning packages, including spe-cific matters from logistics/container transportation, aiming to decrease logistics costs and increase competitiveness. We also design and develop research projects by colla-borating with the research institutes and councils. The Shipsgo Academy team is also responsible for the project of emission calculation in container transportation.

CONTENTS

INTRODUCTION

The transportation sector emits more CO_2 than any other industry. Although shipping may seem like a clean form of transport- carrying more than 90% of the world's trade, ocean-going vessels produce around 3% of its greenhouse-gas emissions-, just 15 of the giant ships emit more of the noxious oxides of nitrogen and sulfur than all the wor-ld's cars put together. Global emissions from international maritime transportation are expected to reach 709 million metric tons of CO_2 in 2025. However, according to the IEA (International Energy Agency), CO_2 emissions from shipping could fall to 120 million metric tons of CO_2 by 2070. Container transportation is also in this process, and need-less to say, it is a long journey from 2021 to 2070. All related stakeholders expect "envi-ronmental sensitivity" from the carriers during this decarbonization process.

As mentioned earlier, the maritime transportation ecosystem has some significant responsibilities to decarbonize freight transportation considering the Paris Climate Agreement, European Green Deal, and other climate agreements to solve the climate problem. Container maritime transportation ecosystem participants, freight forwarders, BCOs, and other actors in the sector must track and report their freight emissions to contribute to reductions in global transport sourced emissions.

The aim of presenting this report is to explain how to calculate CO_2 emissions emitted during maritime container transportation. For this purpose, our API provider Shipsgo Methodology within the scope of the GLEC Framework has been referenced.

SHIPSGO METHODOLOGY

Shipsgo methodology is based on the methodology approved by the GLEC Framework. The method used to calculate emissions is based on the following references:

- Third IMO Greenhouse Gas Study 2014;
- Fourth IMO Greenhouse Gas Study 2020;
- EMEP/EEA air pollutant emission inventory guidebook 2019;
- GLEC Framework 2020.

CO_2e calculations are based on the estimation of fuel consumption for a specific vessel. Our modeling follows the publications of the IMO to estimate fuel consumptions based on:

- Distances
- Vessel characteristics
- Speeds

Distance

Distances come from the open-source databases. Our distance provider has developed proprietary algorithms to extract vessel routes from AIS, which allows having vessel-specific, draft-dependent, distances. Routes take into account traffic separation schemes, and port entries. Routes change on an ongoing basis, as vessel navigation patterns change.

Vessel Characteristics

The energy necessary to move the vessel (TTW) depends on the type of motors and fuel used. Most container vessels are equipped with a slow-speed diesel motor and generally use BFO (bunker fuel oil), also known as HFO (heavy fuel oil). Our API provider maintains and regularly updates a database of more than 6,000 vessels to extract power curves for various engine sizes and fuel types.

This includes auxiliary engines and boilers, which account for around 20% of fuel consumption for container ships, and, therefore, must be taken into account. Naturally, our API provider maintains a record of the vessel capacities (Twenty-Foot Equivalent Units, or TEU), so we can bring the emissions of the vessels down to the container level.

Speeds

Design speeds are used as a reference when computing the fuel consumption of an engine when compared to the actual sailing speeds. While design speeds are engine and vessel specifics, our API provider vary sailing speeds of our CO_2 calculation whether we are in the reporting or tendering use cases. Speeds can be obtained from AIS.

GLEC FRAMEWORK

The Global Logistics Emissions Council (GLEC), led by Smart Freight Centre, is a group of companies, associations, and programs backed by leading experts and other sta-keholders. GLEC Framework was formed in 2016.

The framework increases transparency, giving companies with smaller footprints a competitive advantage. Companies can also use emissions data for logistics business decisions, such as selecting more fuel-efficient modes, routes, and carriers and identif-ying ways to increase efficiency and reduce costs.

Basic Definitions and Terms

Greenhouse Gases

This framework includes guidance to calculate GHG emissions related to container transportation. The United Nations Framework Convention on Climate Change's Kyoto Protocol has identified the GHGs (CO_2 , CH_4 , N_2O) included in the framework. Carbon dioxide has the most significant share quantity of GHG emissions and is thus the stan-dard reference for measuring emissions.

CO_2 – equivalent (CO_2e) is the standard unit used to identify the global warming impact of the various GHGs. Black carbon is small, dark particles produced from the incomplete combustion of biomass and fossil fuels. The Black Carbon Methodology provides industry and stakeholders with a straightforward methodology to estimate black carbon emissions with sufficient accuracy for benchmarking, reporting, and sustainable decision-making.

Base Methodologies for Emission Calculation

Shipsgo methodology is based on the GLEC Framework that aligns global efforts on carbon accounting for logistics operations. It builds on individual modes, green freight programs, and government and harmonizes practices widely used by industry, experts, and practitioners worldwide. Beyond the high-level accounting protocols, the GLEC Framework adjusts numerous other existing methodologies.
The methodologies used as the basis for the framework are International Maritime Organization Ship Energy Efficiency Operation Index and Clean Cargo Working Group Carbon Emissions Accounting Methodology.

Scopes of Emission Calculation

The GLEC Framework classifies emissions into three categories following the principles of accounting put forward by the Greenhouse Gas Protocol as; Scope 1, 2 and 3.

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 purcha-sed 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 electri-city, 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 are indirect emissions from the reporting company's supply chain. Most notably, this includes transportation emissions required to move goods from supp-liers to the reporting company and from the reporting company to the end customer.

Fuel Life Cycle

In order to capture the full climate impact of fuel use, as required under the Greenhouse Gas Protocol, the GLEC Framework includes emissions from the full fuel life cycle, known as well-to-wheel (WTW) emission factors. WTW factors are comprised of two separa-te sub-categories: well-to-tank (WTT) and tank-to-wheel (TTW).

Fuel Emission Factor

The amount of fuel used can be converted to CO_2e using standard emission factors for each fuel type. Fuel emission factors are expressed as the mass of CO_2e released for fuel.

$$Fuel\ emission\ factor = \frac{kg\ CO_2e}{kg\ fuel}$$

Exceptions for Methodology

The following items may contribute additional climate impacts for transport activities but they have to be ignored for reasons of data availability, practicality or other issues.

- Direct emissions of GHGs resulting from fuel spills and leakages.
- Emissions from construction, maintenance and scrappage of vehicles or transport infrastructure.
- The production and maintenance of vehicles.

STEPS FOR CONTAINER TRANSPORTATION EMISSION CALCULATION

There are various steps that need to be carried out in order to generate a reliable and transparent container transportation emissions calculation output.

Calculate TEU-kilometers

It's essential to consider both the shipment weight and the distance for container transportation. As such, the TEU-kilometer is the critical unit for freight transport, repre-senting one TEU of cargo moving for one kilometer.

Weight

The actual shipment weight (mass) is the basis for quantifying the amount of goods being transported or processed is the actual shipment weight (mass). Volume and den-sity are also common freight attributes, but weight is selected due to its consistent app-lication across the supply chain. Weight information may be on invoices, bills of lading, within a Transport Management System, etc. However, the twenty-foot equivalent unit (TEU) is a standard unit used instead of mass or weight for containerized transport. For example, CCWG (Clean Container Working Group) trade lane emission intensity values are expressed as CO_2 per TEU. For a 40' standard container, the TEU values are multip-lied by 2. 40' high cube containers are multiplied by 2.25.

Distance

The distance a shipment is transported is measured from the point where the shipper hands it over to the carrier and ends with the hand-over of the shipment to another car-rier or the end receiver. Actual distance, Shortest feasible distance, Planned distance approaches may be applied for the emission calculation, but the reliable solution can be obtained by applying actual distance; however, it is difficult to reach actual distance for other emission calculation models. In our methodology, Shipsgo tracking data will state the exact actual distance and contribute to obtaining reliable emission results.

The TEU-kilometer calculation

Tonne-kilometers bring together weight and distance as the metric for freight transport activity. To calculate TEU-kilometers for a single consignment, TEU and distance are multiplied together.

$$TEU - km = TEU\ x\ kilometers$$

Find fuel efficiency factor

There are many different sources of data that can be used to estimate fuel and emissi-ons each with varying levels of accuracy and usefulness for different applications. Typi-cally, the data are classified into fuel efficiency factors.

Find Emission Factor

Emission factors are defined according to the ship types, trade-lanes, shipment load factor, and fuel type.

- Ships are well-cataloged, and public information on each vessel is available via theĂ MO's Global Integrated Shipping Information System.
- As load factor, CCWG(Clean Container Working Group) has calculated the average utilization of container ships to be 70% and recommends a corresponding load factor adjustment for container transportation emission calculations.
- Heavy fuel oil is currently assumed to be the standard fuel type; this may change as new technologies and regulations come online. Other potential fuel types include marine diesel oil, LNG, electricity, and biodiesel.

Convert activity data to emissions

The final calculation for transportation emissions brings together the tonnes, kilometers and efficiency factors.

$$kg\ \ CO_2 emissions\ =\ \ \ \ total\ TEU\ km\ x\ fuel\ emission\ factor$$

$$fuel\ efficiency\ factor = \frac{kg\ fuel}{tonne-km}$$

$$fuel\ emission\ factor = \frac{kg\ CO_2 e}{kg\ fuel}$$

An Example of how to calculate CO_2e emissions based on GLEC Framework

A shipment covering five 40 foot-equivalent high cube containers is transported from İzmir, Turkey, to Hamburg, Germany.

Carrier X is responsible for the shipment. The shipment is transported on the main servi-ce from İzmir to Hamburg operated by Carrier X. All vessels on the service are operated by Carrier X.

- Carrier X's trade lane emission factor is 99 g CO_2e / TEU km.
- Transport distance from İzmir to Hamburg = 6.141 km.
- Utilization factor is accepted as 70%, TEU conversion factor is 2.25

CO_2 calculation can be applied as follow:
(99 g CO_2e/TEU km x 5 x 2.25 TEU x 6,141 km) / 0.70 = 9.7 tonne CO_2e

NEXT PHASE IN PROGRESS: PORT INTEGRATED EMISSION MODEL

Climate Change is an environmental concern also for ports where important logistics activities are processed. In recent years several attempts have been made to control port emissions, and several methodologies have been developed to calculate emissions emitted by port-sourced operations. Many ports have started calculating their carbon footprint and reporting it; each authority or operator has used its method in recent years. Our port integrated emission model provides a standard methodology integra-ting route and port emissions to mitigate the methodology confusion.

It is recommended by WPCI (World Ports Climate Initiative) to calculate the emission of all three scopes as though in all logistics operations calculations supported by GLEC Methodology.

Scope 1 - Port Direct Sources: These sources are directly under the control and operati-on of the port administration entity and include port-owned fleet vehicles, port admi-nistration owned or leased vehicles, buildings (e.g., boilers, furnaces, etc.), port-owned and operated cargo handling equipment (to the extent the port is an operating port as described above), and any other emissions sources that are owned and operated by the port administrative authority.

Scope 2 - Port Indirect Sources: These sources include port purchased electricity for port administration-owned buildings and operations. Tenant power and energy purc-hases are not included in this Scope.

Scope 3 - Other Indirect Sources: These sources are typically associated with tenant operations and include ships, trucks, cargo handling equipment, rail locomotives, harbor craft, tenant buildings, tenant purchased electricity, and port and tenant employee commuting (train, personal car, public transportation, etc.).

CO_2 EMISSIONS CALCULATION PROJECT TEAM

Dr. Okan TUNA, Project Manager

Dr. Volkan ÇETİNKAYA, Academic Advisor

Dr. Onur AKDAŞ, Academic Advisor

Soner OKUR, Business Development Manager

Şule ÇEKİÇ, Data Analyst

METHODOLOGY PARTNER

This methodology is based on our CO_2 calculation partner GLEC framework. The current methodology includes the EN 16258 and ISO14083 compliant calculation. The core sources for the calculation are continuously monitored by our academic metho-dology developers. The current methodology is accredited by the Smart Freight Center - GLEC Framework.

GLOSSARY FOR CONTAINER TRANSPORTATION

- ***Beneficial Cargo Owner (BCO)*** is a owner of the cargo (Bosch, Henkel..etc).
- ***Bill of Lading (BL or BoL)*** is a legal document issued by a Carrier to a shipper that details the type, quantity and destination of the goods being carried.
- ***Carrier (Shipping Line)*** is a company that has ships and carry the containers(MSC, Maersk..etc)
- ***CH_4 (methane)*** is the second most important GHG for the enhanced greenhouse effect after carbon dioxide (CO_2).
- ***CO_2 (Carbon dioxide)*** is the primary greenhouse gas contributing to the enhanced greenhouse effect.
- ***Clean Container Working Group*** is a group of peers dedicated to accelerating sustai-nability in the container shipping industry.
- ***Container*** is a reusable metal box used to carry goods. Each container has unique number. Emission is an amount of a substance that is produced and sent out into the air that is harmful to the environment.
- ***Freight Forwarder*** is a broker company between cargo owners and carriers. (DHL, K+N..etc)
- ***Global Integrated Shipping Information System*** is aimed at allowing on-line access to the information and data supplied to the IMO Secretariat by Maritime Administrati-ons, its member states and port authorities, in compliance with IMO's instruments, regulations and guidelines.
- ***N_2O (Nitrous oxide)*** is the third most important GHG for the enhanced greenhouse effect after carbon dioxide (CO_2) and methane (CH_4).
- ***World Ports Climate Initiative*** is a global programme to provide ports worldwide with a framework to mitigate their impact on climate change.
- ***Well-to-Wheel (WTW)*** defines the emissions released into atmosphere during fuel production, transportation, and fuel use.
- ***Well-to-Tank (WTT)*** defines the emissions released into atmosphere during fuel pro-duction and transportation.
- ***Tank-to-Wheel (TTW)*** defines the emissions released into atmosphere during only fuel use.

REFERENCES

Clean Cargo Working Group Carbon Emissions Accounting Methodology *The Clean Cargo Working Group Standard Methodology for Credible and Comparable CO_2 Emissi-ons Calculations and Benchmarking in the Ocean Container Shipping Sector* (2015).

Clean Cargo Working Group *2019 Global Container Shipping Trade Lane Emissions Fac-tors* (2019).

EMEP/EEA *air pollutant emission inventory guidebook* 2019.

GLEC (Global Logistics Emissions Council Framework) for *Logistics Emissions Accoun-ting and Reporting Version 2.0* (2019).

Smart Freight Center, *Black carbon methodology for the logistics sector* (2017).
www.ghgprotocol.com
https://www.icos-cp.eu/science-and-impact/climate-change/ghgs

WPCI (World Ports Climate Initiative), *Carbon footprinting for ports* (2010).