LOGISTIC AND TRANSPORT EMISSIONS **GUIDANCE**

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Catena-X
Your Automotive Network

Introduction

Purpose of this Document

This document provides guidance on accounting for logistics emissions in the context of Product Carbon Footprint (PCF) calculations, as required by the Catena-X PCF Rulebook v4 (5.2.3 Emissions from transportation). It aligns with the GLEC Framework V3.1, a recognized standard for logistics emissions accounting (GLEC Framework is based on ISO 14083 Quantification and reporting of greenhouse gas emissions arising from transport chain operations.)

Logistics includes all transportation activities of goods (external and internal), involving various carriers and modes of transport, as well as storage and handling operations.

Importance of Transport Emissions in PCF

Transport emissions contribute to the carbon footprint of products. It cannot be ensured that in any case the transport emissions are irrelevant / fall under the cutoff. A consistent and standardized approach to calculating these emissions ensures comparability, transparency, and credibility in PCF reporting across the supply chain.

Relationship Between Catena-X and GLEC Framework

The Catena-X PCF Rulebook references the GLEC Framework as the method for transport emissions accounting. This guidance document clarifies how to apply GLEC-aligned methods within the Catena-X PCF system, including:

- Establishing system boundaries for transport emissions
- Choosing appropriate emission factors and data sources
- Reporting logistics emissions in accordance with Catena-X requirements

Methodology for Logistic and Transport Emissions Accounting

Scope & Boundaries

- System Boundaries: Transport emissions shall be calculated considering the transport from supplier to the calculating company (inbound logistics) as well as internal transportation and include all transport chain elements (TCEs) as per the GLEC Framework.

Transport chain elements can be related to:

- Transportation
- Hub operation (distribution and storage activities)

As for the product carbon footprint, the cradle-to-gate boundaries end at the company's outbound gates (refer to Catena-X Rulebook Section 4.2 System Boundaries). This boundary applies independently from the responsibilities in economic or operative terms for transportation processes. Economic or operative responsibility' here refers to which party contracts or operates the transport, not to the physical location of the shipping site. Where the supplier operates a hub or distribution center, that hub is the supplier's outbound gate (see the hub case described later in this Scope & Boundaries section, and Catena-X Rulebook §5.2.3, Figure 8).

This means the inbound logistic activities are included in the product carbon footprint.

If distribution includes on supplier side a hub (operated by the supplier), the transportation from production plant to hub is seen as an internal transport and shall be included in the transportation emission.

If a supplier is responsible in economic or operative terms for the outbound logistics (i.e., transportation from the supplier to its customer), the supplier shall report the product carbon footprint from this transportation in addition to and separately from the product carbon footprint. In this case the customer shall aggregate the inbound transportation to his (customer-) product carbon footprint

- Emission Categories:
    - Tank-to-Wheel (TTW): Emissions from fuel combustion in transport vehicles
    - Well-to-Tank (WTT): Upstream emissions from fuel production, separate from TTW
    - Well-to-Wheel (WTW): TTW emissions plus upstream emissions from fuel production and distribution

In the Catena-X Rulebook the Well-to-Wheel Emission are considered for all logistics emissions. In other words, the system boundaries span from energy provision, production and distribution ending at the logistic / transportation operation itself. Emissions from the production of the transportation means (e.g. vehicles) and infrastructure, e.g., roads, vehicles, ships and railways, warehouses, shall not be included.

Data Sources and Hierarchy

The Catena-X PCF Rulebook establishes a hierarchy for data usage:

1. Primary Data: Measured e.g. fuel consumption, actual shipment data
2. Industry-Specific Secondary Data from associations (e.g. GLEC data from Chapter3)
3. Secondary Data from commercial databases

The GLEC framework allows logistic emissions estimates to be made using the best available data - from secondary data through primary data (following the same logic as Catena-X). Beside the PCF methodology the GLEC framework provides in addition secondary data sets, which can be classified as Industry-Specific Secondary Data from associations.

In this guidance the very basic methodology of GLEC framework based on secondary data is used (in GLEC Terminology default data). Advanced modeled data (see section Advanced emission calculation) or using primary data is beyond the scope of this document.

As primary data for transportation is normally not available, default data can be used to determine the transport emissions with a reasonable degree of accuracy. Using default data is also a good starting point to compare different modes of transportation in the screening analysis.

In order to achieve highest possible accuracy, primary data should always be used when available. Default data is considered the least accurate and should only be used as a last resort when no other data is accessible. If default data is used, this represents a more conservative approach for emissions estimation. It often results in higher reported emissions and should serve as a motivation to strive for ideally, primary data, to enhance accuracy and credibility in emissions reporting.

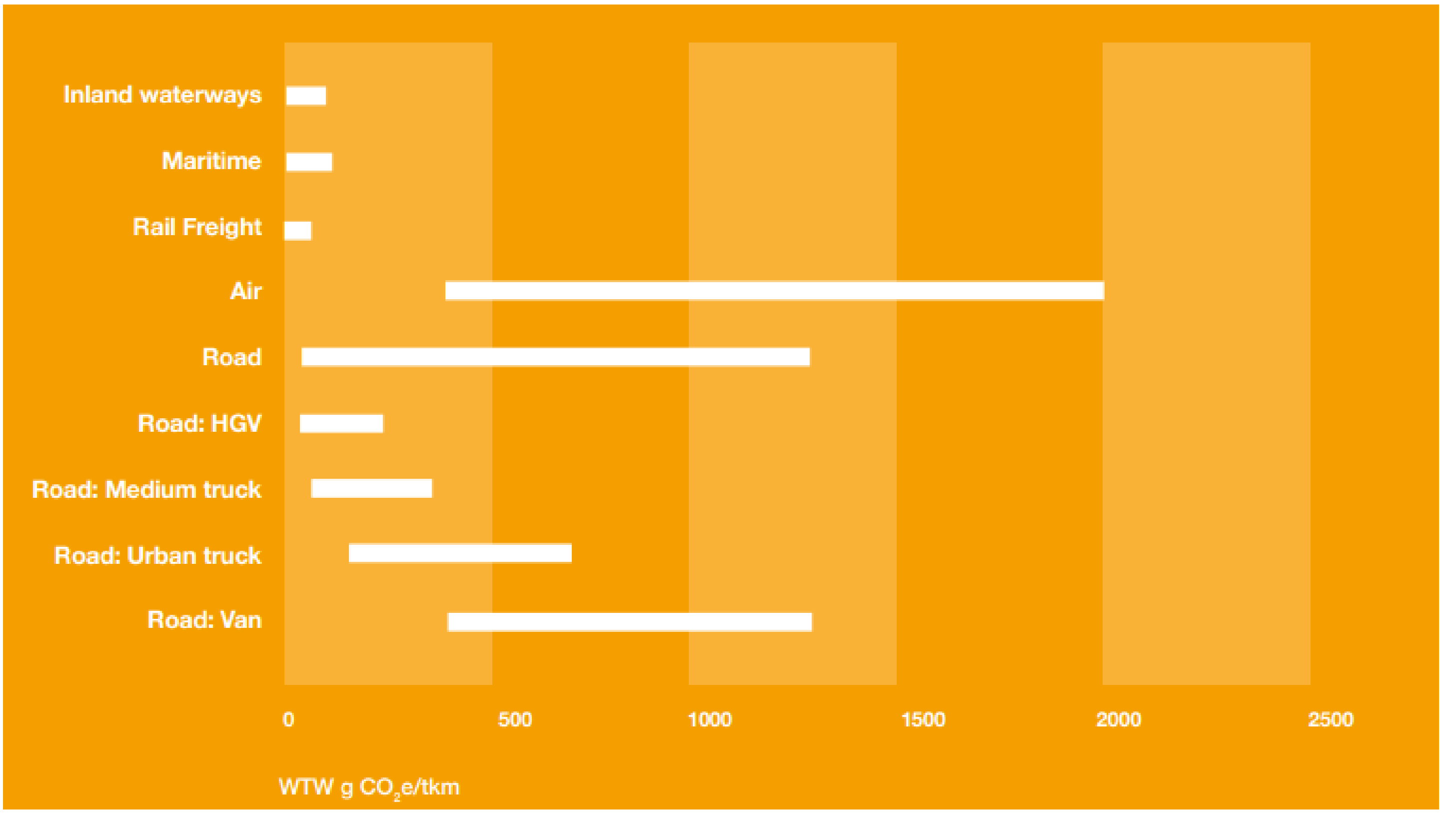

Figure 1: Examples of WTW emission intensity values for different types (Smart Freight Centre, 2023)

Emission Calculation Principles

Declared unit - Weight Definition:

- The transport weight is the product weight including its packaging (provided by the shipper).
- Handling auxiliaries, such as pallets and load carriers (from the transport operator), are excluded from the transport weight, as they are considered part of the transport infrastructure rather than the shipped product itself.

The GLEC Framework splits the transportation into TCE **T**ransport **C**hain **E**lement. For each of the TCE the emissions are evaluated separately:

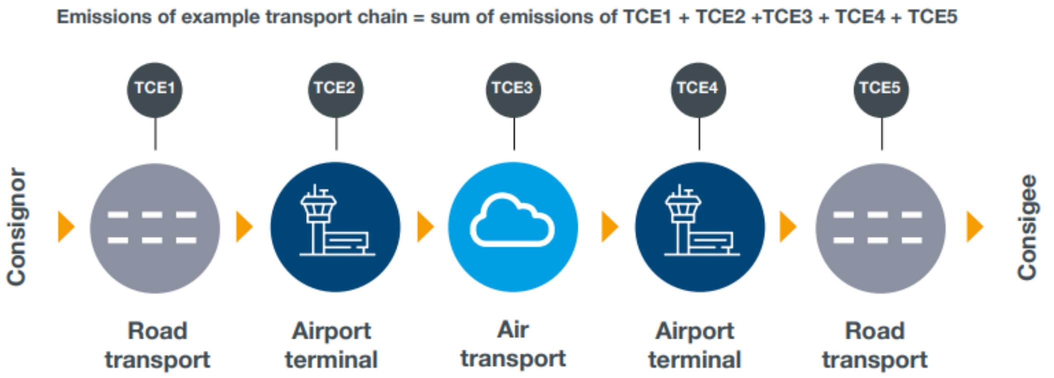

Figure 2: Emission calculation for an air transport chain, including an air transport TCE (Smart Freight Centre, 2023)

The **GLEC Framework** defines emissions as a function of **activity** multiplied by an **emission factor**:

Transportation Emissions:

- Calculated as ton-kilometers: $(tkm) \times WTW$ Emission factor
- The ton-kilometer represents the weight in tons of the declared unit multiplied by one km
- The WTW emission factor kg $\frac{CO2e}{tkm}$ is the emissions per ton-kilometer, including both direct fuel combustion and upstream fuel production emissions.

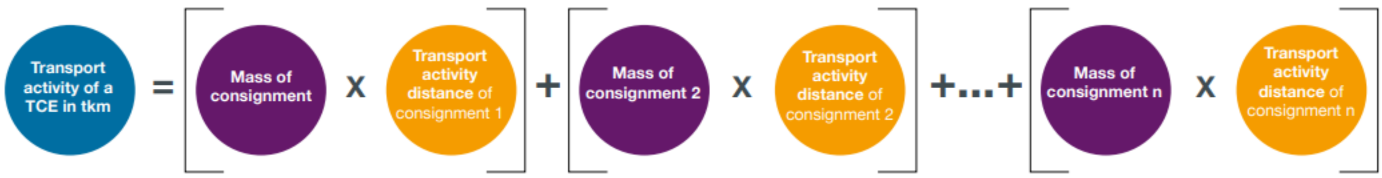

Figure 3: Transport Activity (Smart Freight Centre, 2023)

Hub Operations Emissions:

- Hub emissions arise from activities such as storage, loading, unloading, and transshipment of goods at logistics hubs (e.g., warehouses, ports, terminals).
- Calculated as hub operation activity × emission factor
- The hub operation activity is defined by the type of process occurring at the hub, such as:
  - Handling operations (e.g., loading/unloading containers, pallet handling)
  - Storage operations (e.g., climate-controlled warehouses, dry storage)
  - Transshipment operations (e.g., goods moved between transport modes)
- The emission factor for hub operations is typically expressed in kgCO2e per unit of activity, such as:
  - kgCO2e per ton handled
  - kgCO2e per square meter of storage per time
- The emissions are influenced by energy consumption (e.g., electricity, fuel for equipment like forklifts, heating/cooling needs for storage facilities) and the carbon intensity of the energy used.

Figure 4: Hub Operation activity (Smart Freight Centre, 2023)

Distance Calculation Methods

To ensure consistency in transport emissions calculations, standardized distance measures should be applied (in absence of primary measured distance data):

Shortest Feasible Distance (SFD) for Road Transport:

SFD represents the shortest practical route between two places considering 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.)

It can be determined by using tools like EcoTransIT World, which accounts for real-world transport conditions.

Great Circle Distance (GCD) for Air Transport:

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.

GCD values can also be determined by using tools like EcoTransIT World or other flight route calculation tools.

Measured Distance

In case of "measured" actual distance this distance must be corrected by the distance adjustment factor (DAF), to allow for systematic differences between actual distance and GCD or SFD:

Actual distance corrected by distance adjustment factor

The distance adjustment factor is DAF = 1.05 for road transport (i.e. actual distance is increased by 5 %) and DAF = (GCD + 95 km) / GCD for air transport, where 95 km represents the additional distance due to maneuvering, taxiing, etc. (GLEC Framework v3.1, Section on air transport). In other words, the actual distance is increased by multiplication with the factor DAF. Recommended values for DAF are listed in ISO 14083 Annex A–G.

Emission Factors and Secondary Data

When using secondary datasets for emissions from commercial databases (other than default data as offered by GLEC V3.1), the following factors must be considered and carefully checked in the relevant data set documentation.

Typical - but not complete – the following parameter must be considered:

- **Vehicle Categories**: vehicle type (size, powertrain type, trailer in/excluded, …)
- **Temperature Control**: Differentiation between ambient (standard) and cooled (temperature-controlled) vehicles is essential, as cooling systems significantly impact emissions. (In the examples ambient transport and storage are used)
- **Powertrain Type and Energy Source**: The type of powertrain (e.g., diesel, electric, hydrogen, biofuel) and the energy source's carbon intensity (e.g. provision of bio-based content, electricity mix) influence emission factors. (In the examples conventional powertrains and regional bio-based content is chosen.)
- **Load or Utilization Factor**: Reflects how much of a vehicle's total capacity (by weight) is being used. A lower utilization factor results in higher emissions per ton-kilometer. (In the examples of this guidance a 60% load factor is used)
- **Empty trip**:
    - Road transport typically operates as a round trip, meaning a vehicle does not always carry a load on the

return journey.

- The empty return trip is not equal to 100% of the distance from A to B, but rather a partial allocation of empty kilometers based on logistics efficiency. In this guidance 17% empty running is used as the default value for heavy-duty trucks in Europe. (Table 8 GLEC V3.1).

- **Infrastructure exclusion**: infrastructure (e.g. road infrastructure) shall be excluded (this is ensured when using GLEC datasets). Nevertheless, some commercial datasets include emissions related to road infrastructure construction and maintenance, which is not compliant with Catena-X
- **Vehicle Production and Maintenance**: while vehicle operation emissions shall be included, vehicle production and maintenance emissions shall be excluded (this is ensured when using GLEC datasets). Nevertheless, some commercial datasets include emissions related to production and maintenance emissions, which is not compliant with Catena-X.

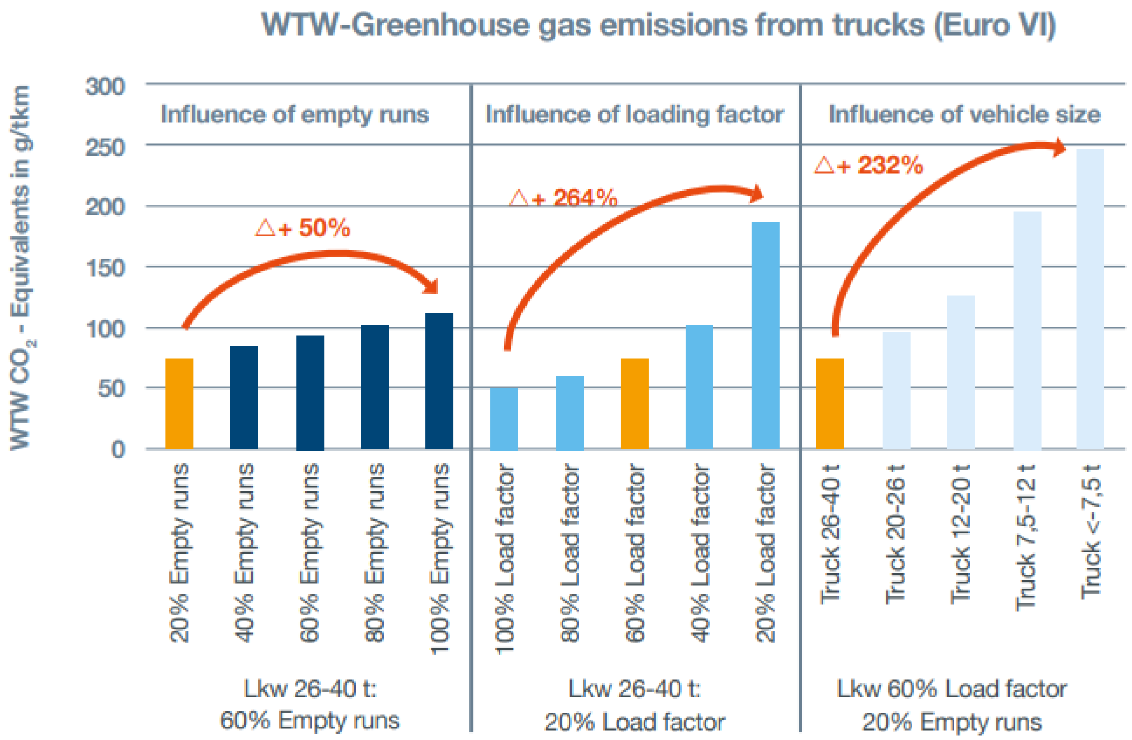

Figure 5: Impact of empty trip share, filling rate and vehicle size on emissions (Smart Freight Centre, 2023)

Exemplary calculation of emissions of transport chain activities

Example 1

Logistic of product P via road transport from supplier Company A to Company B. For Company B this is an inbound transport. The company B is responsible for providing (and including) the PCF for logistic in the product carbon footprint. Company B reports the PCF to its customer Company C. If company B is reporting the cradle to gate PCF to Company C, the logistic emissions (transport from company A to B) are included in the total PCF. There is only one Transport Chain Activity, the truck transport.

Shipment mass data:

- Mass of 1 article including package: $0{,}5kg = 0{,}0005t$

Transport activity (distance data):

- Hamburg – Madrid: SFD Shortest feasible distance: 2138.1 km (e.g. according to EcoTransIT)

Conversion to tonne kilometers:

- tonne - kilometers: $0{,}0005t * 2138km = 1{,}069\ tkm$

Emission factor truck transport (WTW):

- Rigid truck, 26–32 t GVW engine type diesel, load factor 60%, empty running 17%: $125\ \frac{gCO2eq}{tkm}$ (see GLEC V3.1 Framework: Section 3 Modul 2, Road transport, Region Europe and South America, Table 8)

Emissions of all transport chain activities:

$$GWP\ Emssions = 1{,}069tkm * 125\frac{gCO2eq}{tkm} = 133gCO2eq$$

Example 2

Logistic from supplier company A to customer Company B. For Company B this is an inbound transport. The company B is responsible for providing (and including) the PCF for logistic in the product carbon footprint.

Logistic chain: road transport - aircraft – road transport

Shanghai China, to Gdansk, Poland:

There are three transport chain activities:

1. Truck Transport Shanghai City to Shanghai Pudong International Airport

   $SFD\ distance: 46km$ (e.g. by EcoTransIT)

2. Airplane transport from Shanghai Pudong International Airport to Frankfurt Airport

   $GCD\ distance = 8851 + 95 = 8946km$ (e.g. by EcoTransIT)

3. Truck Transport Frankfurt, Germany to Gdansk, Poland

   $SFD\ distance = 1058km$ (e.g. by EcoTransIT)

Shipment mass data (applicable for all logistic activities):

- Mass of 1 article including package: $0{,}5kg = 0{,}0005t$

Emission factor, truck transport (China):

- Rigid Truck, HDV 16.0-20.0 t GVW: $152\ \frac{gCO2e}{tkm}$ (GLEC V3.1 Section 3 Module 2, Table 12)

Emission factor, airplane:

- Freighter (cargo only aircraft), long haul (<1500 km): $608\frac{gCO2e}{tkm}$ (GLEC V3.1 Section 3, Module 2, Table 1)

Emission factor, truck transport (EU):

- Same emission factor as in example 1: $125\ \frac{gCO2e}{tkm}$

Emission of all transport chain activities:

$$Emisson = 152 * 46 * 0{,}0005 + 608 * 8946 * 0{,}0005 + 1235 * 1058 * 0{,}0005 = 3376{,}94\ gCO2e$$

Example 3

Logistic activity for product P from supplier company A to customer Company B. Company B has a customer company C. For Company B this is an inbound transport, but since company A is contractual responsible for the logistics, company A reports the logistics emissions separately in the PCF (to company B). Meaning Company A reports cradle to gate PCF for product P and in addition the outbound logistic emissions (for logistics of product P between company A and Company B). The Catena-X data model provides a "separate" data field for this outbound logistic emissions reporting. Company B integrates the PCF received from company A, which includes already logistic emissions and therefore no extra efforts for company B to calculate inbound emissions for product P received from company A. Company C receives a PCF reporting / PCF data set as total PCF, outbound logistic was only separated in the PCF data transfer btw. company A and B. The transport chain activities are ambient container shipment per ship from Shanghai port to Rotterdam port and hub activity.

Shipment mass data (applicable for all logistic activities):

- Mass of 1 article including package: $0{,}5kg = 0{,}0005t$

Sea transport with container (non-temperature controlled) (GLEC V3.1 Section 3 Module 2, Table 14):

- Shanghai Pudong port (CNSHA) to Rotterdam port (NLRTM)
    - SFD distance: $25849km$ (EcoTransIT World, 2025)
- Asia to-from North Europe (Dry = non-temperature controlled)
    - Factor as given in TEU km: $44{,}1\ \frac{gCO2e}{TEU-km}$
    - Conversion to per-tonne intensity *): $44.1\ \frac{gCO2e}{TEU-km} * 10\ \frac{t}{TEU}$ = 4.41

Logistic hub activity (transshipment no storage) (GLEC V3.1 Section 3 Modul 2, Table 3):

- Logistic hub transshipment ambient: $1300\frac{gCO2e}{t}$

Emission of all transport chain activities:

$$Emission = 4{,}41 * 25849 * 0{,}0005 + 1300 * 0{,}0005 = 57{,}16\ gCO2e$$

**) As the GLEC sea factor is expressed per TEU-km but only piece weight is known, the standard GLEC conversion of 10 t per TEU is applied, giving an equivalent factor of 4.41 g CO_2e / t-km (GLEC v3.1, Section 3, Module 2, p. 50).*

Advanced emission calculation

For advanced emission calculations using the **modeled data** approach tools are available. EcoTransIT is such a tool, available also as Online-Tool and complying with GLEC V3.1 framework. Due to complexity in advanced modelling opportunities offered by GLECV3.1 framework this is not suitable to be explained the step-by-step approach. To give some idea of the used energy-based bottom-up approach implemented by the EcoTransITWorld tool, see Figure 6: Energy-based bottom-up approach

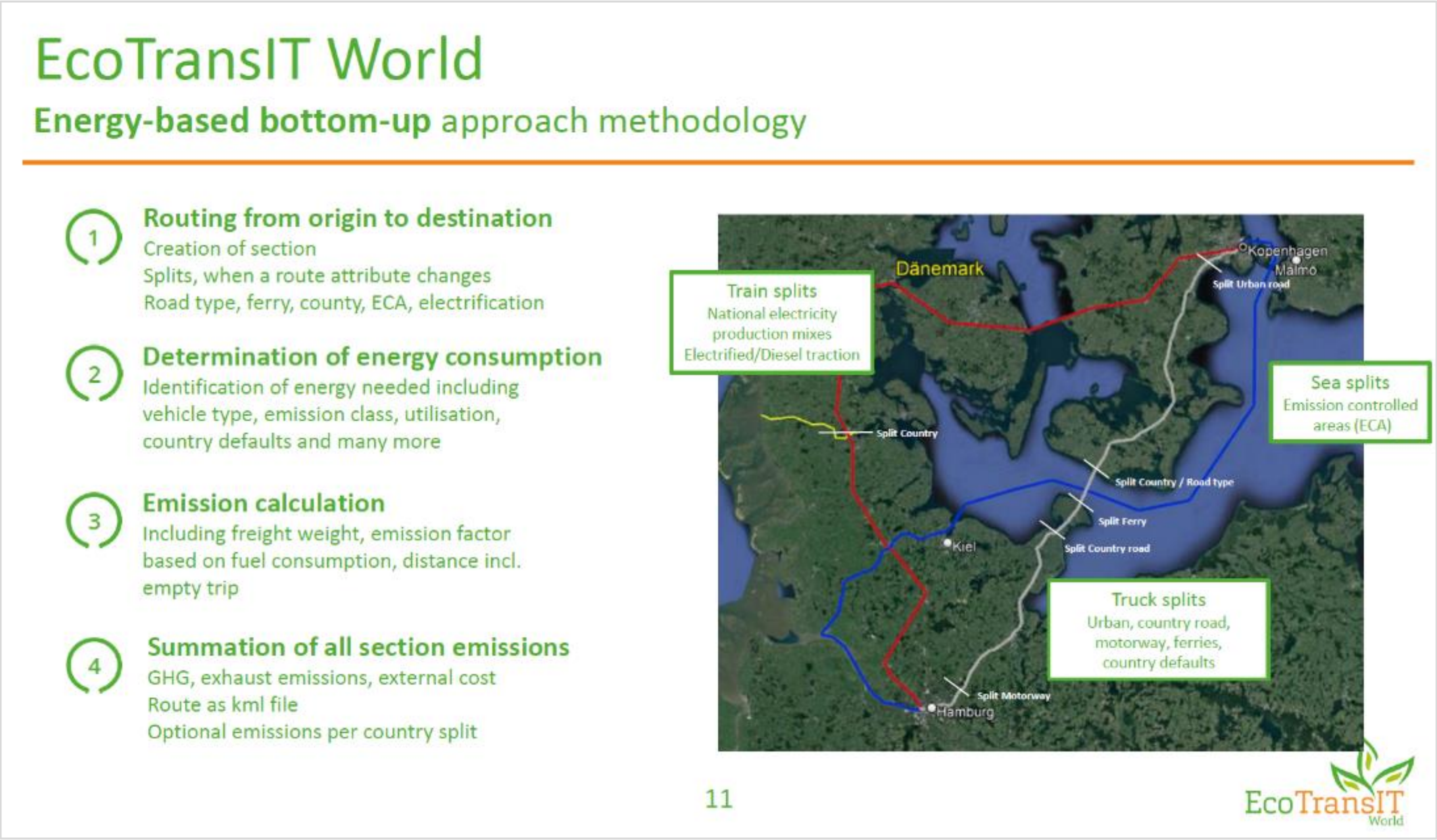

Figure 6: Energy-based bottom-up approach (EcoTransIT World, 2025)

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ANNEX

Glossary

Word	Description
Actual Distance	The actual distance traveled by a shipment based on odometer readings or knowledge of the actual route.
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.
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.
GLEC Framework	The Global Logistics Emissions Council (GLEC) Framework is a globally recognized standard for calculating and reporting logistics emissions, based on ISO 14083.
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.
Hub Operations	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.
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.
Round trip	group of sequential journeys that start and end in the same place.
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 considering real operating conditions and typical operational choices such as avoiding congestion hotspots or unsuitable, restricted roads.
Twenty-foot equivalent unit (TEU)	TEU is a standard unit of measurement for shipping container capacity of a 20 ft (6.10 m) container.
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 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. Well-to-Wheel (WTW)

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