

**IVE mbH -
Ingenieurgesellschaft für
Verkehrswesen mbH
Hannover**



**Infras AG -
Consulting,
Analysis and
Research**



**ifeu -
Institut für Energie-
und Umweltforschung
Heidelberg GmbH**



Ecological Transport Information Tool for Worldwide Transports

Methodology Report Short version Update 2019

**ifeu Heidelberg
INFRAS Berne
IVE Hannover**

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1 Introduction

This short version of the Methodology Report provides an overview for the industry user to enable easy access to the basic metrics and databases of ETW emission calculation.

It provides an overview of the basic tool functionalities in connection to the metrics and databases behind.

This short version focuses on carbon calculation. Most of the metrics also apply to pollutant calculation. However, pollutants differ in fuel and engine related emissions (sulphur, for example, is only related to the content in the fuel, which makes the consideration of fuel quality essential).

For details and literature references, please refer to the detailed Methodology Report: (available at: <https://ecotransit.org/methodology.en.html>).

As a starting point, the most basic questions of emission calculation shall be addressed.

What is calculated?

Table 1 gives an overview of the emissions within the scope of ETW.

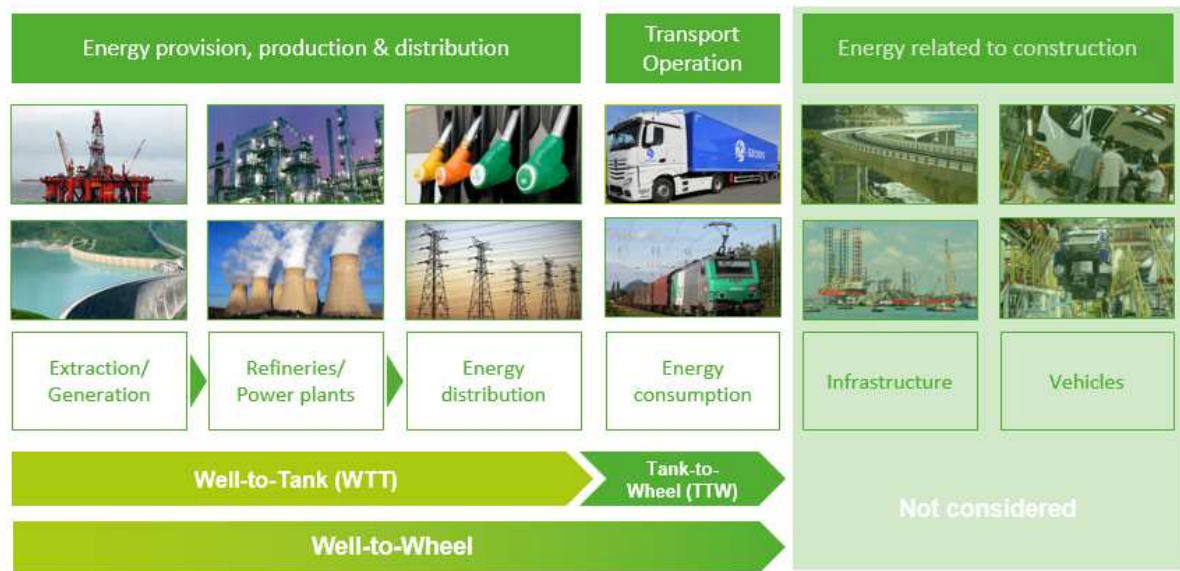
Table 1: Emissions within the scope of ETW.

Abbr.	Description	Reasons for inclusion
PEC	Primary energy consumption (= Well-to-Tank energy consumption)	Main indicator for resource consumption
CO ₂	Carbon dioxide emissions	Main indicator for greenhouse effect
CO _{2e}	Greenhouse gas emissions as CO ₂ -equivalent. CO _{2e} is calculated as follows (mass weighted): $CO_{2e} = CO_2 + 25 * CH_4 + 298 * N_2O$ CH ₄ : Methane N ₂ O: Nitrous Oxide For aircraft transport the additional impact of flights in high distances can optionally be included (based on RFI – Radiative Forcing Index factor)	Greenhouse effect
NO _x	Nitrogen oxide emissions	Acidification, eutrophication, eco-toxicity, human toxicity, summer smog
SO _x	Sulphur oxide emissions	Acidification, eco-toxicity, human toxicity
NMHC	Non-methane hydrocarbons	Human toxicity, summer smog
Particles	Exhaust particulate matter from vehicles and from energy production and provision (power plants, refineries, sea transport of primary energy carriers), in ETW particles are quantified as PM 10	Human toxicity, summer smog

What are the system boundaries for emission calculation?

Figure 1 illustrates the processes included.

Figure 1 System boundaries of processes /own figure adapted from Geodis/



In brief:

Energy	MJ TTW and WTW
CO2/e	metric tons TTW and WTW
SOx	metric tons TTW and WTW
NOx	metric tons TTW and WTW
NMHC	metric tons TTW and WTW
PM	metric tons TTW and WTW

Which transports are calculated?

Basically, all modes of transports are calculated, clustered into:

- Air freight – different aircraft types and sizes
- Ocean freight – container shipping, bulk shipping and liquids
- Inland ship freight – different ship types
- Road freight – truck types aggregated into size classes and emission standards, including/excluding ferry shares
- Rail freight – different rail sizes and types and emission standards

How detailed are transports calculated?

Basically, all transports can be split into different legs, either by the tool itself or by the user in a customized way. One leg is defined by a start and ending point of a specific mode of transport.

What is the input, what does the system do?

The input is flexible as to the “what is known by the user may be input by the user” logic. Basically, there are two modes of customer input options: The “standard” mode and the “extended” mode. The standard mode only requires starting and ending point input, type of cargo and metric weight and, optionally, the exact type of start and end point (port, zip code, geo data ...). The “extended” mode shows the user all default parameters of the back-end which he may accept or change at his discretion.

Chapter 2 will introduce the two modes more in detail, followed by the chapters for each transport mode which describe the specific metrics and databases.

How is energy consumption allocated and calculated for a single shipment?

The basic principle of calculation relies on the metric weight of the shipment and the distance travelled (tkm).

The principal calculation rule for the calculation of vehicle emissions is

$$\begin{aligned} & \text{WTW energy consumption or emissions per transport} = \\ & \quad \text{Transport Distance} \\ & \quad * \text{ mass of freight transported} \\ & * (\text{TTW energy consumption or vehicle emissions per net tonne km} \\ & \quad + \text{WTT energy consumption or emissions per net tonne km}) \end{aligned}$$

The corresponding formulas are

$$\begin{aligned} \text{EMT}_i &= D_i * M * (\text{EMV}_{\text{tkm},i} + \text{EMU}_{\text{tkm},i}) \\ \text{ECT}_i &= D_i * M * (\text{ECF}_{\text{tkm},i} + \text{ECU}_{\text{tkm},i}) \end{aligned}$$

Table 2: Parameters and units of the general calculation formula in EcoTransIT World.

Abbr.	Definition	Unit
EMTi	WTW emissions of transport	[kg]
ECTi	WTW energy consumption of transport	[MJ]
Di	Distance of transport performed for each energy carrier i	[km]
M	Mass of freight transported	[net tonne]
EMVtkm,i	TTW Vehicle emissions for each energy carrier i	[g/tkm]
ECFtkm,i	TTW energy consumption for each energy carrier i	[MJ/tkm]
EMUtkm,i	WTT (upstream) emissions factors for each energy carrier i	[g/tkm]
ECUtkm,i	WTT (upstream) energy consumption for each energy carrier i	[MJ/tkm]
i	Index for energy carrier (e.g. diesel, electricity, HS)	

The calculation rules for EMVtkm,i, ECFtkm,i, EMUtkm,i and ECUtkm,i include several parameters, to allocate vehicle related energy and emission data to the tonne-km related specific factors for the shipment. They can be different for each mode. The most important parameters are:

- Source of energy = fuel type
- Size and payload capacity of the vehicle/vessel type
- Load factor of the vehicle and for the shipment
- Empty trip factor for the shipment

As a shipment may be carried on a vehicle combined with other shipments, in the first step the energy consumption of the whole vehicle has to be considered. In general, the energy consumption of the vehicle is not known, therefore default values from acknowledged data sources are applied.

All calculation and allocation rules for each mode are described in chapters 3 to 7; further details can be found in the main Methodology Report.

Why and how is the calculation EN 16258 compliant?

The norm EN 16258 provides some basic principles of calculations, which are applied by EcoTransIT, such as

- Allocation of load and empty trips accruing during the whole loop of a vehicle's trip, i.e., from starting to the final re-location of the vehicle, to each single shipment, irrespective of the transport share of such shipment.
- No marginal calculation: The energy consumption of a vehicle's trip has to be equally shared by all shipments according to their metric weight (tons) or other specifications (shipment number, pallets etc.).
- Passenger weight in aircrafts is calculated assuming 100 kg including baggage. (The IATA RP 1678 applies 150 kg per PAX, including the seat weight. This leads to lower emissions of belly freight but is currently not (yet) a globally agreed methodology.)
- There are agreed emission factors for TTW/WTW (including biodiesel shares) per fuel type set out in Annex A of the standard.

Which WTT emission factors are used?

For the fuel supply the WTW emission factors for carbon dioxide, greenhouse gases and the energy demand are taken from EN 16258. These factors are complemented with factors for NO_x, SO_x, NMHC and PM from other data sources. The emission factors for fuel supply and the data sources are shown in the main Methodology Report.

The emission factors for the electricity depend on the average electricity split per year in each country. These emission factors were calculated by ifeu using data on regional electricity mixes, losses and plant efficiencies from EUROSTAT and IEA (reference year 2013). Further explanations on emission factor calculation and the values for the emission factors in different countries are also given in the main Methodology Report.

2 Application modes

This chapter introduces the 2 input modes of the ETW calculation front-end and the underlying parameters. Furthermore, the business solutions are briefly presented.

2.1 Standard input mode

In the Standard input mode, the user only needs to enter in the tons or TEUs of the shipment, click on the main mode of transport and type in the starting and ending point of his shipment (Figure 2).

Figure 2 GUI of EcoTransIT World in the Standard input mode

Freight: Choose the unit (tons or TEU) and the amount

Origin/destination: Choose the type of starting point

Table 3: Origin/destination types in EcoTransIT World.

Name	Attributes
City and District names	City name, District name, Country, Location classes, (Translations)
Zip codes	Country code/ Zip code, City name, Country code
Stations (UIC-Codes)	Station name, UIC-Code/ station code, Country code
UN-/LOCodes	UN-/LOCode, Location name, Country Code, Ports classes, Inland locations
Airports (IATA-Codes)	IATA-Code, Airport name, Country code, Airport classes
Longitude/ Latitude	No location layer or attributes are needed

Choose transport modes: You may click on several modes if you want to compare different modes on the same trip.

The starting / ending point specification decides whether the routing is applied to a single mode of transport, i.e., the chosen one, or whether pre- and on-carriage legs are added.

If the start and end match the mode of transport – airport for Airplane, harbour for Sea ship, rail station for train etc. – then no further leg is added. In case of no match EcoTransIT adds a truck delivery to the point of departure and from the respective modal node to the final point of destination.

In such case of pre-/on-carriage legs, ETW applies a 40 ton truck with a country/regional specific average emission factor and load factor.

The standard application calculates using average parameters which are set out in more detail in the mode specific sections.

2.2 Extended input mode

To see which parameters have been applied, one switches into the “extended” input mode where all parameters are visible (Figure 3).

Figure 3 GUI of EcoTransIT World in the Extended input mode.

The screenshot shows the 'CALCULATION PARAMETERS' interface. At the top, 'Input mode' is set to 'Extended'. The 'Freight' section includes 'Amount' (100), 'Weight' (Bulk and Unit Load (Tonnes)), 'Type' (average goods), and 't/TEU' (10). The 'Ferry' section has 'Ferry routing' set to 'normal'. The 'Origin' section includes a 'City district' dropdown, a confirmation field 'Please press ENTER to confirm', and a checked checkbox 'On-site rail track available'. There are two 'Transport service' sections: 'TS 1' and 'TS 2'. 'TS 1' is a truck with parameters: Transport mode (Truck), Vehicle type (26-40 t), Fuel type (diesel), Emission standard (EURO 5), Load factor (60%), and ETF (20%). 'TS 2' is a train with parameters: Transport mode (Train), Train type (-), Train weight (1000 t), Load factor (60.00%), and ETF (50.00%). Below 'TS 2' are 'Traction' (electrified) and 'Emission standard' (EU UIC 1) dropdowns. At the bottom, there is a 'Destination' section with a 'City district' dropdown, a confirmation field, and a checked checkbox 'On-site rail track available'. At the very bottom are 'CALCULATE' and 'RESET' buttons.

Such parameters with default values provide additional input/adjustment options:

- Freight: Type of goods to activate the freight type in the drop-down menu (heavy, average or light goods)
- t/TEU: 10 tons per TEU may be adjusted to the known weight per TEU
- Ferry: activate the resistance factor to route via ferry connections or completely avoid ferries in the drop-down menu (normal, preferred, avoid)

- Transport Service: TS1 = the first transport chain with defined modes and nodes (+ VIA). Additional transport service chains can be established to compare routes and modes on the same door-to-door trip.
- Transport mode: choose mode per leg by clicking on “+ VIA” to define a transfer node.
- Vehicle type: size class or type of vehicle in the drop-down menu (per mode)
- Emission standard (for road and rail)
- Fuel types (for road)
- Load factor: relation of metric freight weight and load capacity
- ETF = empty trip factor. Additional length of empty trips
- Speed reduction for sea ships: 25% default (IMO/research based) can be adjusted

All parameters are indicated in the default value (industry average for each mode) but may be adjusted optionally as far as known by the user.

2.3 Business Solutions

The ETW Business Solutions contain standardised interfaces (API) for automatic emission calculation of huge amounts of transport chains. Already today, several hundred million transports are calculated every year via the API. The use ranges from an individualised website to semi-automatic calculations of transport lists in CSV format to a fully automatic solution based on a SOAP XML Webservice (WSDL).

The ready-to-use standard solutions are extremely flexible and allow to calculate complex intermodal transport chains with little or much customer-specific transport information. If necessary, user-defined adaptations or extensions to the software are made available.

The interfaces are offered as Software-as-a-Service. The associated servers are provided by IVE mbH and are continuously monitored by specific monitoring software. Server costs and regular updates are included in the license fees. In addition to the API, the IVE mbH team offers to calculate, analyse and present customer-specific transports as consultation projects.

So far ETW provides the following products:

- SOAP XML Webservice (WSDL)
- CSV File Mass Calculation via website or sFTP up- and download
- Individualized calculation front-end on the customers' website

In addition to the API, the IVE mbH team offers to calculate, analyse and present customer-specific transports as consultation projects. Already now several shipper companies using this service of IVE to calculate their shipments on detailed level.

For more information about the Business Solutions, please visit <https://ecotransit.org>

3 Road emission calculation

3.1 Routing

EcoTransIT World comprises all streets in the world which are used for freight transports. In general, all transports are routed via a highway if available and a 40 ton truck with country specific average load factor and emission standard (Euro class).

For smaller streets, there are resistance factors, meaning that to a certain extent a detour via the highway is accepted to enable the quickest possible transport (Table 4).

Table 4: Road resistance factors.

Street category	Resistance
Highway (Category 0)	1.0
Large country road (Category 1)	1.3
Small country road (Category 2)	1.5
Large urban road (Category 3)	1.67
Urban road (Category 4)	2.5
Small urban road (Category 5-7)	3.33

Example: A routing via an urban road (Category 4) is only applied if the detour via a close by highway is longer than 2.5 times the distance of such transport.

Similarly, resistance factors have been defined for ferry inclusion in the road transport (Table 5).

Table 5: Ferry resistance factors for road transport.

Ferry handling	Resistance
Standard	5.0
Preferred	1.0
Avoid	100.0

In the standard mode, a ferry is only taken when it reduces the truck distance by >80%.

If the user knows the exact routing, he may set via points in the Extended Mode especially when he wants to make sure that certain streets or tunnels are used/avoided. (This may require a quite dense setting of via points. In the business solution it is always possible to define exact routings/schedules as well as changing the resistance factors for certain street categories.)

3.2 Emission factors

For road transport emission calculation, the parameters specified in **Fehler! Verweisquelle konnte nicht gefunden werden.** apply.

Table 6: Parameters for road emission calculation.

	Country/region specific parameters	Truck specific parameters
Road	Fuel specifications: - Sulphur content - Share biofuels Emission regulation Topography Available vehicles Default vehicles for long-distance/feeder	Truck types: - Final energy consumption - Emission factors (TTW): NO _x , NMVOC, PM

As in Europe the widely acknowledged database is HBEFA (current version 3.2), for each truck size class country-specific Euro class averages, the topography and the average traffic density is applied. For trucks outside Europe, size classes and emission standards are applied as set out in tables 18 to 20 of the main Methodology Report 2019.

To check the granularity of country specific default values, you may also refer to Table 3 of the main Methodology Report 2019.

The applicable truck sizes and weights (vehicle weight plus maximum payload and total weight) are listed in **Fehler! Verweisquelle konnte nicht gefunden werden.**

Table 7: Truck sizes and weights.

Vehicle/vessel	Vehicle/vessel type	Empty weight [tonnes]	Payload capacity [tonnes]	TEU capacity [TEU]	Max. total weight [tonnes]
Truck	<=7.5 tonnes	4	3.5	-	7.5
	>7.5-12 tonnes	6	6	-	12
	>-12-20 tonnes	9	11	-	20
	>20-26 tonnes	9	17	1	26
	>26-40 tonnes	14	26	2	40
	>40-60 tonnes	19	41	2	60

3.3 Capacity utilization

The capacity utilization combines the load factor with the empty trip factor. The load factor is derived from the metric weight loaded related to the total load capacity of the respective vehicle. The empty trip factor describes the additional distance for empty trips related to the transport distance between two nodes.

Example:

A 26-40 ton truck filled by 15.6 tons of freight weight has a load factor of

15.6 t / 26 t = 60%.

The empty trip factor is 20%. The resulting capacity utilization is:

$60\% / (100\% + 20\%) = 50\%$.

Table 8: Load factors, empty trip factors and capacity utilization for trucks.

	Load factor LF _{NC}	Empty trip factor ET	Capacity utilization CU _{NC}
Bulk	100%	60%	63%
Average	60%	20%	50%
Volume	30%	10%	27%

Examples for different cargo volume density would be:

- bulk goods (e.g. coal, ore, oil, fertilizer etc.)
- average goods: mixed cargo of different densities (based on statistics).
- volume goods (e.g. industrial parts, consumer goods such as furniture, clothes, etc.)

In the extended mode the user may adjust both the load factor as well as the empty trip factor to receive a capacity utilization which reflects his (round trip based) capacity utilization.

4 Rail emission calculation

4.1 Routing

EcoTransIT World comprises all rail tracks in the world on which cargo is transported.

Railways have the attributes of electrified or diesel line and dedicated freight corridor. If an electrified train is selected, diesel lines can also be used but they get a higher resistance than electrified lines. This is needed if there is no electrified line available or to circumnavigate possible data errors concerning the electrification of the railway network.

The attribute freight corridor is used as a railway highway. Lines with this attribute will be used with preference.

Table 9: Rail resistance factors.

Attribute	Resistance
Freight corridor	1.0
Non freight corridor	1.8
Diesel tracks at electrified calculation	4.0

Additionally, there are ferry routes within the rail network. These routes work like virtual tracks where the whole train is put on the ferry. ETW has different resistances for ferry routes included.

Table 10: Ferry resistance factors for railway transport.

Ferry handling	Resistance
Standard	5.0
Preferred	1.0
Obstruct	100.0

4.2 Emission factors

The parameters affecting rail transport emission calculation are listed in Table 11.

Table 11: Parameters for rail emission calculation.

	Country/region specific parameter	Rail specific parameters
Rail	Fuel specifications: - Sulphur content - Share biofuels Energy and emission factors of upstream processes (fuels and electricity) Topography Available train types Default vehicles for long-distance/feeder	Train type, weight and energy carrier: Final energy consumption (functions) Emission factors for diesel traction (TTW): NO _x , NMVOC, PM

In EcoTransIT World, several functions are used for the calculation of the final energy consumption of trains. Different train types are available. The default values for train sizes and weights (train weight plus maximum payload and total weight) listed in **Fehler! Verweisquelle konnte nicht gefunden werden.** apply.

Table 12: Default values for train sizes and weights.

Train Type	Gross tonne weight train	Empty weight wagon	Payload capacity wagon	TEU capacity wagon	Max. total weight wagon
General cargo					
Standard	1000 t	23 t	61 t	-	84 t
Dedicated cargo					
Car	700 t	28 t	21 t (10 cars)	-	59 t
Chemistry	1200 t	24 t	55 t	-	79 t
Container	1000 t	21 t	65 t	2,6 TEU	86 t
Coal and steel	1700 t	26 t	65t	-	91 t
Building material	1200 t	22 t	54 t	-	76 t
Manufactured product	1200 t	23 t	54 t	-	77 t
Cereals	1300 t	20 t	63 t	-	83 t

Beside the final energy consumption, the key driver for rail emissions with electric traction is the country specific electricity mix in the upstream (WTT) process. EcoTransIT World applies these mixes and also provides averages for whole regions, see detailed Methodology Report.

4.3 Capacity utilization

The capacity utilization combines the load factor with the empty trip factor. The load factor is derived from the metric weight loaded related to the total load capacity of the respective vehicle. The empty trip factor describes the additional distance for empty trips related to the transport distance between two nodes (see also example in chapter 3.3).

For specific cargo and related train types, the default values for capacity utilization listed in Table 13 apply. Load factor and empty trip factor can be changed in the extended mode.

Table 13: Load factors and empty trip factors.

Train Type	Load factor	Empty trip factor	Capacity utilization
General cargo			
Bulk	100%	80%	56%
Average	60%	50%	40%
Volume	30%	20%	25%
Dedicated cargo			
Car	85 %	50 %	57 %
Chemistry	100 %	100 %	50 %
Container	50 %	20 %	41 %
Coal and steel	100 %	100 %	50 %
Building materials	100 %	100 %	50 %
Manufactured products	75 %	60 %	47 %
Cereals	100 %	60 %	63 %

5 Sea ship emission calculation

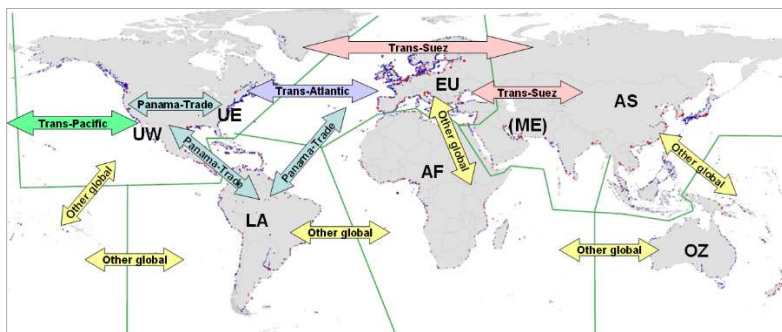
5.1 Routing

EcoTransIT World calculates direct port to port relations on actual sea routes. As most of these relations do not exist in reality because ship operators apply schedules with several port calls in a loop, the Clean Cargo Working Group, in which around 80% of the container vessel operators are represented, decided in 2014 to add a distance correction factor of 15% to each port-to-port connection.

EcoTransIT World does not apply such factor in its online version but integrates it into the business solution.

The main trade lanes represented in Figure 4 are considered and aggregated regarding average vessel size operations.

Figure 4: ETW division of the world oceans and definition of major trade lanes.



5.2 Emission factors

The emission factors used for sea transport are based on a bottom-up approach in which emissions are modelled for individual vessels by multiplying activity (days at sea at a given speed/days in port) with engine rating and load factor (the latter depending on speed) and associated fuel consumption and emission factors. Most of these inputs are based on the Third Greenhouse Gas study of the International Maritime Organization (IMO) from 2015. Further information can be obtained from the detailed Methodology Report.

From the individual vessel emissions, tkm-weighted averages have been calculated to obtain the parameter values required for each EcoTransIT input mode:

- for the standard input mode, in which the user only chooses origin, destination and type and amount of goods: default values by trade lane (average ship size, default speed, and associated emission factors; see Figure 4 and Table 1516);
- for the extended input mode, in which the user additionally chooses ship class and type (see also Table 1516): values by ship class and type.

In the extended input mode, the user can also choose the desired speed reduction and the cargo utilization factor (see below); the emission factors are accordingly modified. For details, refer to the detailed Methodology Report.

In addition, the so-called Emission Control Areas (ECAs) and regulations or incentives in certain ports determine the choice between Heavy Fuel Oil (HFO) and Marine Diesel Oil (MDO). MDO has a lower sulphur content and results in different emission factors.

The emissions of maritime vessels are averaged over the entire return journeys, taking the cargo utilization (including empty returns) and the days in port into account. All emissions are allocated to the freight carried.

In summary, the spatial/region-specific and vessel-specific parameters listed in Table 1415 determine the emissions calculated for maritime ship transports.

Table 14: Parameters for sea ship emission calculation.

	Region-specific/spatial parameters	Vessel-specific parameters
Sea Ship	<p>Origin and destination determine the route and thus:</p> <ul style="list-style-type: none"> - Distance within/outside Emission Control Area (ECA) determines fuel type (HFO/MDO) and respective set of emission factors at sea - Origin/destination port location (within ECA, or subject to other regulation/incentive) determines fuel type (HFO/MDO) and respective set of emission factors in port - In Standard Mode: Choice of trade lane determines emission factors at sea (based on the distribution of ship sizes on the respective trade lane) 	<ul style="list-style-type: none"> - In Extended Mode: chosen vessel type (liquid/dry bulk, container, general cargo, RoRo) and size class, determines emission factors at sea - Speed adjustment option - Cargo utilization rate adjustment option

5.3 Capacity utilization

To all vessel types and sizes a default average capacity utilization is applied in the Standard input mode. For container vessels an average capacity utilization of 70% on all trade lanes has been agreed by the Clean Cargo Working Group. The values for all ship types and size classes are summarized in Table 1516.

For container shipping, an average weight of 10.5 tons per TEU is applied, also agreed on by the Clean Cargo Working Group. If the user changes the weight per TEU in the application, actually the same amount of emissions and energy consumption per TEU is related to the lesser or larger amount of weight (tons per TEU) indicated. The reason is that the fuel consumption of the whole vessel is not sensitive to the filling rate of a container, as variations in capacity utilization are balanced by the amount of ballast water the vessel needs to carry to keep an optimized trim.

Table 15: Ship sizes/trade lanes and default cargo utilization by input mode and cargo type for sea transport emission calculation.

Input mode	Cargo type	Trade lane (Standard input mode) / Ship size (Extended input mode)	Size class	Default cargo utilization
Standard	Bulk	Suez trade	Aframax / Suezmax	55%
		Transatlantic trade	Handymax / Panamax	54%
		Transpacific trade	Handymax - Suezmax	54%
		Panama trade	Handymax / Panamax	54%
		Other global trade	Handysize - Aframax	52%
		Intra-continental trade	Feeder - Handymax	53%
		Great lakes	< 30,000 DWT	58%
	Container	Suez trade	> 4,700 TEU	70%
		Transatlantic trade	2,000 – 4,700 TEU	70%
		Transpacific trade	> 1,000 TEU	70%
		Panama trade	2,000 – 4,700 TEU	70%
		Other global trade	1,000 – 3,500 TEU	70%
		Intra-continental trade non EU	500 – 2,000 TEU	70%
		Intra-continental trade EU	500 – 2,000 TEU	70%
Extended	General cargo	Coastal	< 5,000 DWT	60%
	Bulk/general cargo (dry)	Feeder	5,000 – 15,000 DWT	56%
		Handysize	15,000 – 35,000 DWT	55%
	Bulk (dry)	Handymax	35,000 – 60,000 DWT	52%
		Panamax	60,000 – 80,000 DWT	52%
		Aframax	80,000 – 120,000 DWT	53%
		Suezmax	120,000 – 200,000 DWT	56%
	Bulk (liquid)	Feeder	5,000 – 15,000 DWT	62%
		Handysize	15,000 – 35,000 DWT	59%
		Handymax	35,000 – 60,000 DWT	62%
		Panamax	60,000 – 80,000 DWT	64%
		Aframax	80,000 – 120,000 DWT	58%
		Suezmax	120,000 – 200,000 DWT	57%
	Container	VLCC (+)	> 200,000 DWT	50%
		Feeder	<1,000 TEU	70%
		like Handysize	1,000 – 2,000 TEU	70%
		EU SECA like Handysize	1,000 – 2,000 TEU	70%
		like Handymax	2,000 – 3,500 TEU	70%
		like Panamax	3,500 – 4,700 TEU	70%
		like Aframax	4,700 – 7,000 TEU	70%
like Suezmax		7,000 – 14,500 TEU	70%	
ULCV		>14,500 TEU	70%	
RoRo	Global average	(all sizes)	70%	
	RoRo small	< 5000 DWT	70%	
	RoRo large	>= 5000 DWT	70%	
Abbreviations: RoRo = Roll-on/roll-off ship; VLCC = very large crude carrier; ULCV = ultra-large container vessel				

6 Inland waterway emission calculation

6.1 Routing

The majority of waterways available in ETW are located in Europe, but the largest waterways outside Europe (e.g. Yangtze, Mississippi or Amazon) are also included. The European waterways are classified by capacity using the CEMT classes (classification by the Conférence Européenne des Ministres des Transports in 1992); due to lack of information outside Europe, all non-European waterways are assigned CEMT class V by default. Each CEMT waterway type has an associated default ship type (see Table 1718) which will be chosen automatically in the Standard mode; in the Extended mode, the ship type can be chosen by the user but can only be applied on waterways of the associated CEMT class or above.

6.2 Emission factors

The emission factors of inland vessels (barges) are modelled in a bottom-up approach similar to ocean-going vessels. However, instead of applying tkm-weighted average fuel consumption and emission factors for aggregate ETW classes, three representative ship types are provided (see also Table 1718):

- The Europa ship, representative for ships with up to 1500 t capacity, and used by default on rivers of CEMT Classes I-IV;
- The Great Engine Vessel, representative for ships with 1500 – 3000 t capacity, and used by default on rivers of Class V;
- The Jowi class, representative for capacities >3000 t, used by default on rivers of Class VI and above.

In the extended input mode, additionally the emission standard can be chosen, which is set to “conventional” (engines without emission type approval) in the Standard input mode.

The direction of travel (up- or downstream) is not considered in order to treat all modes of transport similarly (compliant to EN 16258). Consequently, energy consumption and emission factors in flowing rivers, such as the Rhine, are averaged. A transport purchaser takes responsibility for the average performance regardless of the direction of the transport.

The same allocation rules as for ocean transport apply, with emissions being averaged over the entire return journeys, taking the cargo utilization (including empty returns) and the days in port into account.

The parameters affecting inland waterway transport emission calculation are summarized in Table 1617.

Table 16: Parameters for inland waterway transport (barge) emission calculation.

	Region-specific parameters	Vessel-specific parameters
Inland Ship	Fuel specifications: - Sulphur content - Share biofuels CEMT waterway class determines: - default ship type and thus emission factors in port and on-river - Optional ship types depending on waterway capacity Origin/destination determines default emission standard in Standard input mode	Ship type and Cargo type (container/bulk) - Final energy consumption Emission standard - Emission factors (TTW) NO _x , NMHC, PM

6.3 Capacity utilization

The default capacity utilization rates for inland waterway transport are listed in Table 1718.

Table 17: Inland vessels and associated parameter values.

Vessel type	Default for CEMT river class	Length [m]	Beam [m]	Installed power [kW]	Average speed [km/h]	Capacity		Default capacity utilization	
						DWT (bulk)	TEU (Container)	Bulk	Container
Europa ship	I - IV	85	9.5	737	10.5	1'350	100	60%	60%
Great Engine Vessel	V	110	11.4	1'178	10.5	2'500	200	50%	60%
JOWI class	VI+	135	17.34	2'097	10.5	5'300	450	50%	60%

7 Air emission calculation

7.1 Routing

EcoTransIT calculates airport to airport distances based on the Great Circle Distance (GCD) using the geographical coordinates of the airports and adding a supplement of 95 km for take-off and landing as provided by EN 16258.

For the selected airport pairs, a validation is performed whether selected airports are suitable for the flight. For this purpose, all airports are categorized according to their maximum reach (Table 1819).

Table 18: Airport size categories and associated reaches.

Airport size	Reach
Big size	over 5000 km
Middle size	Over 5000 km (but not oversea)
Small size	maximum 5000 km
Very small size	maximum 2500 km

After the selection of the airports, EcoTransIT calculates the GCD between the two airports. If the closest airport allows the distance of the flight, it will be selected. If the limit is exceeded, the next bigger airport will be suggested and so on.

7.2 Emission factors

Air transport emission calculation is influenced by the parameters specified in Table 1920.

Table 19: Parameters affecting air transport emission calculation.

	Region-specific parameter	Aircraft-specific parameters
	No region-specific parameters apply	Aircraft type: - Final energy consumption (TTW) - Emission factors (TTW): NO _x , NMVOC, PM

GHG and air pollutant emissions are depending on the aircraft type. The selected aircraft type determines capacity, turbine age and whether cargo is transported in a dedicated freighter aircraft or together with passengers (belly-freight).

EcoTransIT includes a wide range of aircraft types. For selected types the characteristics (design range, maximum payload, seat number) are shown in Table 2022. For the full list of available aircraft types in EcoTransIT refer to the annex of the main Methodology Report 2017 (Table 50).

The default aircraft applied in the different distance classes are listed in Table 2022.

Table 20: Characteristics of selected aircraft.

Type	Distance Group	Type of aircraft	IATA Aircraft code	Design Range (km)	Max. Payload (t)	Typical Seats (number)
Freighter	Short haul	Boeing 737-300SF	73Y	3,030	19.7	
Freighter	Medium Haul	Boeing 767-200F	76X	5,790	45.0	
Freighter	Long haul	Boeing 747-400F	74Y	8,250	113.0	
Belly Freight	Short haul	Embraer 190	E90	3,330	1.4	98
Belly Freight	Medium Haul	Airbus 320	320	5,700	2.4	150
Belly Freight	Long haul	Boeing 747-400	744	13,450	16.8	416

Sources: Lang 2007; Lang 2009; LCAG 2014.

Fuel consumption for different aircraft types is based on the data of the “Small Emitters Tool” by EUROCONTROL, which collects statistical data on fuel consumption for a wide range of aircraft types. Table 2123 gives an overview of the fuel consumption by distance used in EcoTransIT for selected aircraft types. CO₂, CO₂-equivalents and SO_x are directly derived from the fuel consumption whereas NO_x, NMHC and PM are based on the EMEP/EEA Guidebook. More details on fuel consumption and emission factors can be found in the main Methodology Report.

If selected, additional climate impacts of aircraft cruising at high altitude are taken into account. For details of the used weighting procedure refer to the main Methodology Report.

For freight transported together with passengers (belly-freight) the allocation principles according to EN 16258 are used. This allocation is based on the weight of freight and passengers, respectively, whereas for passengers a weight of 100 kg per passenger is assumed.

Table 21: TTW fuel consumption of selected freighter and passenger aircraft depending on flight distance.

Distance (km)	Dedicated freighter			Passenger aircrafts		
	Boeing 737-300SF (kg)	Boeing 767-200F (kg)	Boeing 747-400F (kg)	Embraer 190 (kg)	Airbus 320 (kg)	Boeing 747-400 (kg)
232	1,570	2,119	5,744	1,366	1,527	5,744
463	2,285	3,383	8,381	1,912	2,217	8,381
926	3,714	5,911	13,655	3,004	3,597	13,655
1,389	5,143	8,439	18,928	4,096	4,977	18,928
1,852	6,572	10,967	24,202	5,188	6,357	24,202
2,778	9,431	16,023	34,749	7,371	9,118	34,749
3,704	12,289	21,079	45,296	9,555	11,878	45,296
4,630		26,135	55,843		14,638	55,843
5,556		31,191	66,389		17,399	66,389
6,482		36,248	76,936		20,159	76,936
7,408			87,483			87,483
8,334			98,030			98,030
9,260						108,577
10,186						119,124
11,112						129,671
12,038						140,218
12,964						150,765
13,890						161,312

Source: EUROCONTROL Small Emitters Tool /EUROCONTROL 2015/

7.3 Capacity utilization

Capacity utilization refers to the ratio of the mass of the transported goods and the maximum payload capacity of an aircraft. In EcoTransIT it is assumed that only perishable, high volume goods are transported by air freight. Table 2224 shows the capacity utilization factors used in EcoTransIT by distance class and for freight and passengers (the latter are used for the allocation of energy consumption and emissions for belly-freight transports, see chapter 7.2).

Table 22: Capacity utilization of freight and passenger for aircraft.

	Freight (freighters and passenger aircrafts)	Passenger (only passenger aircrafts)
Short haul (up to 1,000 km)	50%	65%
Medium haul (1,001 – 3,700 km)	70%	70%
Long haul (more than 3,700 km)	70%	80%

Sources: BEIS 2016; Lufthansa 2014; EUROCONTROL 2013a; ICAO 2013.

8 Intermodal Transfer

Intermodal transfer can be relevant in a comparison of two transport variants, i.e. if one transport variant requires more transfer processes than the other. Therefore, the transshipping processes are classified in container, liquid, bulk and other cargo. On the basis of assumptions and previous IFEU-studies, the energy use of the different transfer processes is estimated. All processes are performed with electricity. In addition to final energy consumption stated below, country specific energy and emission factors for electricity generation are used to produce Well-to-Wheels-values.

The European standard EN 16258 doesn't consider up to now approaches for the calculations of energy consumption and GHG emission caused by intermodal transfers. This means that results for energy consumption and GHG emissions of transport services must not include intermodal transfers to be in accordance with EN 16258. Results for intermodal transfers are only additionally declared.

In the following the approaches for intermodal transfers of containers, liquid, bulk and other cargo are explained more in details:

- Container: The energy used by a handling container in a rail cargo transport centre was estimated by /IFEU°2000/ with 4.4 kWh/TEU and transfer process. In previous studies /ISV°1993, IFEU°1999/ a lower value (2.2°kWh/°TEU+transfer) for rail was assessed. For container transfer in ship cargo transport centres, these studies searched out an energy factor twice than rail /ISV°1993/. Because of high uncertainties, the value of 4.4 kWh/TEU+transfer is assumed for all carriers.
- Liquid cargo: In /ISV°1993/ a very detailed calculation of the energy demanded by transshipping diesel was carried out. For different carriers the values range from 0.3 to 0.5 kWh/t, for which is why 0.4 kWh/t as average energy use is assessed.
- Bulk cargo: The results of early IFEU-estimations searching out the energy use of unloading corn from different means of transport were used in /ISV°1993/. For bulk cargo transfer the previous value 1.3 kWh/t is also used in EcoTransIT.
- Other cargo: In this category all cargo, which is not container, liquid or bulk cargo is summarized. Thus, the value for energy use of transshipping cargo of this category has the highest uncertainty. On basis of /ISV°1993/ a factor of 0.6 kWh/t for this category is taken.