GHG emission factors for IWT

Final report

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1 Introduction

In 2016 the first GLEC Framework for Logistics Emissions Methodologies has been released. Actions now are focused on adoption of the GLEC framework by companies and addressing gaps to refining modal default carbon footprint factors to further increase the accuracy of logistics emissions in global supply chains.

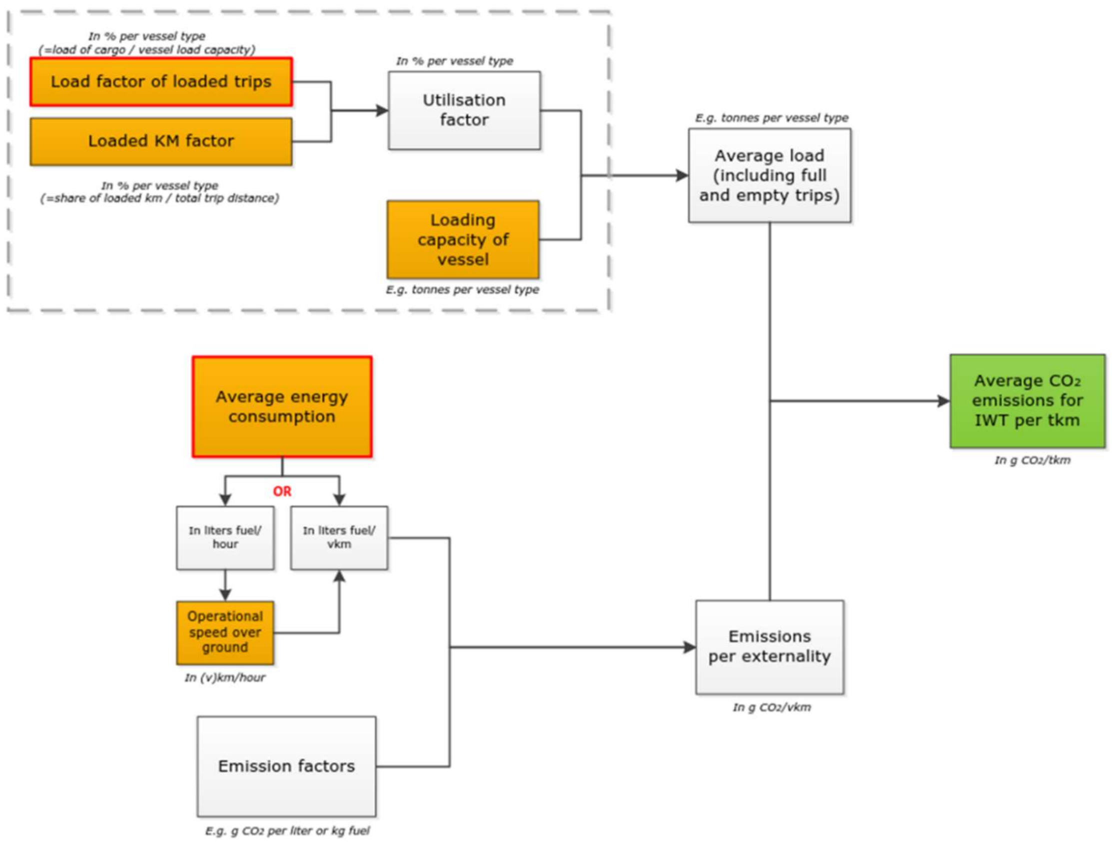
Concerning inland waterway freight transport, the existing framework provides a global default consumption factor with no further (regional) distinction between e.g. vessel types, sizes, (operational) power and load factors.

Therefore, SFC has the objective to integrate a more detailed methodology for inland waterways into the next update of the GLEC framework. This report provides the methodology used and process followed to establish updated GHG emission factors for Inland Water Transport, as planned, discussed and concluded within the GLEC IWW Action Group.

2 Methodology data collection

2.1 Framework for data collection

STC-NESTRA has developed a framework for estimating global GHG emissions for IWT, which has been the basis for collecting data on vessels types, operational characteristics, and fuel consumption. The framework has been broken down into multiple steps for collecting data by means of desk research, surveys and data analysis. See Annex I for a more detailed description of the data collection framework and required information.



Source: STC-NESTRA

2.2 Data collection process

The data collection process has been divided in two loops. In loop 1, the default emission and fuel consumption factors were reviewed by means of desk research, primarily based on the following studies:

For European waterways:

- H2020 – PROMINENT: As part of this project onboard measurements were carried out for 12 freight vessels. Data was collected on e.g. fuel consumption and emissions for representative vessels and journeys (related to selected vessel classes / "fleet families") – www.prominent-iwt.eu
- Connekt/TNO: report on comparison emission estimates with onboard monitoring data – 'Analyse synchromodale ketens met binnenvaart voor containertransporten ten aanzien van effectiviteit en duurzaamheid, met behulp van Lean and Green KPI's' (Connekt, 2014).
- Move-it: Report D7.3 Environmental Impact based on operational information of inland vessels operating in Europe - http://www.moveit-fp7.eu/
- STREAM Freight Transport 2016, CE Delft (January 2017): a handbook providing emission factors per tonne-kilometre for road, rail, inland-waterway and short-sea transport. For each of these transport modes the report gives representative average emission data suitable for exploratory (policy) analyses for which average data suffice.

For US waterways:

- SmartWay-Tool: collected data on fuel consumption and carbon footprint of inland barge operations. The Tool presents average GHG emissions per barge rather than for the complete convoy (e.g. push barge + 15 barges / 45 barges) - https://www.epa.gov/smartway

The outcome of Loop 1 confirmed the need for additional information on fuel consumption and load factors for inland vessels in order to establish (aggregated) global GHG emission for IWT. For Loop 2, a data collection template as distributed amongst GLEC IWW Action Group members with the object to provide specific input on global/regional representativeness of vessel classes and default GHG-emission values. Research institutes and operators in Europe and research institutes in China, Colombia and the US, were addressed to assist in this exercise.

2.3 Response to data inquiry

Europe:
Koninklijke BLN-Schuttevaer provided a dataset with characteristics and operational information of approx. 100 vessels operating in Western Europe. The data was collected between 2011 and 2015 and processed by Pierre Oom in order to validate model calculations carried out for the study STREAM Freight Transport 2016 (CE DELFT, 2017).

For the purpose of GLEC the dataset was processed to fit representative fleet families in Western Europe, following the analysis made in the H2020 PROMINENT project deliverable D1.1 'List of operational profiles and fleet families' (2016). Based on the dataset an overview has been conducted of the GHG emission performance for various vessel sizes. Unfortunately, it was not possible to distinguish information on cargo types transported.

Additionally, Contargo has collected data for 4 inland container vessels operating on the Rhine, of which 3 motor (container) vessels of 135m and 1 coupled convoy (container vessel + barge) of 185m.

China:
With a fleet of approx. 170.000 vessels and approx., China has the largest IWT fleet in World. IWT solutions in China play an import role play in hinterland transport, and therefore also in global supply chains. It would be of great added value to include data on energy consumptions factors / GHG emissions of Chinese IWT vessels as input for the GLEC Framework 2.0. The China Waterborne Transport Institute (WTI) has been requested to assist in the data collection for inland vessels operating on the most frequent used waterways in China. WTI is the principle institute to monitor and collect data on inland waterway transport in China. Because the institute is officially affiliated to the Ministry of Transport (MOT), it has to comply with the regulatory framework set by MoT. This means that if data has not been officially publicized, there is no mandate to distribute the information. The process of official approval is complicated and time-consuming. Therefore, WTI was unable to share information on energy consumption factors.

Colombia:
Contacts within Universidad del Norte (Barranquilla, Colombia) have filled in the data collection template based on information of barge operators operating on the Rio Magdalena.

US:
USEPA, member of the GLEC IWW Action Group, has been requested to try to collect more detailed data for IWT in the US. Based on the SmartWay-tool one single average value per barge is available for IWT. Additional information is beneficial in order to make a distinction of GHG emission factors related to the size of the barge configuration (push boat + 15/45 barges). Unfortunately, USEPA indicated they were not able to provide more detailed data for various barge configuration.

2.4 Final approach to achieve global coverage

Based on the information gathered in Data collection Loop 1 and 2, a pragmatic approach has been followed in order to update the global GHG emission factors for IWT as input for the GLEC Framework 2.0. On the basis of real-life data from barge operators for multiple trips or year-round navigation, based on H2020 – PROMINENT and P. Oom / Kon. BLN-Schuttevaer, GHG emission factors have been calculated for representative vessel classes in Europe. Due to limited information available for other continents, e.g. China and US, a pragmatic approach has to be followed in the objective to achieve global representativeness. Therefore, the European dataset of emission factors has been shared with WTI (China) to validate to what extent the results are representative for vessels operating in China. At this stage, feedback from China is still pending. Hopefully during the final consultation round of the GLEC IWW Action (feedback on this report), a response from China can be included. This approach may also be followed for other river basins/waterways.

Conclusively, based on the European dataset a distinction for various vessel sizes and cargo types can be made. Compared to the current single GHG emission value for IWT in the GLEC Framework 1.0, this should be seen as a step forward in the process to achieve global coverage.

3 IWT GHG Emission factors

3.1 Representative vessel classes

The European inland fleet consists of approximately 12,000 active vessels (see **Error! Reference source not found.** below).

Fleet families identified in PROMINENT	Total number of operational vessels in Europe	Operating fleet for Rhine and other waterway countries	Operating fleet for Danube countries
Passenger vessels (hotel/cruise vessels)	2,553	2,357	196
Push boats <500 kW (total engine power)	890	798	92
Push boats 500-2000 kW (total engine power)	520	332	188
Push boats ≥2000 kW (total engine power)	36	25	11
Motor vessels dry cargo ≥110m length	610	580	30
Motor vessels liquid cargo ≥110m length	602	599	3
Motor vessels dry cargo 80-109m length	1,802	1,713	89
Motor vessels liquid cargo 80-109m length	647	631	16
Motor vessels <80 m. length	4,463	4,285	178
Coupled convoy (mainly class Va+Europe II lighter)	140	140	*n/a**
Total**	**12,263**	**11,460**	**803**
** No detailed data available to estimate the number of coupled convoys for the Danube in a reliable way. The self-propelled units from coupled convoys are now included in the number of motor vessels. ** Excluding other type of vessels (e.g. dredgers, floating cranes, workboats, etc.)*			

Table 1: Main fleet families of the European inland fleet for 2013/2014, source PROMINENT D1.1

Error! Reference source not found. The table below presents the division of the active European fleet based on fuel consumption and estimated tonne-kilometre performance. The comparison reveals that larger vessels have a high share in the transport performance.

Fleet families identified in PROMINENT	Share in estimated tonne-kilometres transported in EU (in %)	Average fuel consumption per year (in m^3)
Push boats <500 kW (total engine power)	1%	32
Push boats 500-2000 kW (total engine power)	18%	158
Push boats ≥2000 kW (total engine power)	9%	2,070
Motor vessels dry cargo ≥110m length	19%	339
Motor vessels liquid cargo ≥110m length	14%	343
Motor vessels dry cargo 80-109m length	17%	162
Motor vessels liquid cargo 80-109m length	5%	237
Motor vessels <80 m. length	10%	49
Coupled convoys	7%	558

Table 2: Share in estimated tonne-kilometre performance and average fuel consumption of the main fleet families (based on detailed information from Western-European countries)

Looking specifically at the largest IWT corridor in Europe, the Rhine corridor, the following table provides the number of passages of inland vessels according to the vessel

classification used in the Netherlands (RWS classification system, RWS 2010[1]).
The most common motor vessel type on the Rhine is the M8 (reference dimension of 110x11.4 m according to RWS 2010 vessel categories), followed by the M6 (reference dimension of 80-85x9.5 m vessel). The large majority of coupled convoys are Class Va vessels sailing with a Europa II barge, sailing mainly in a long formation. The BII-4 (4 barges in a pushed convoy) formation is the most common push convoy on the Rhine.

Vessel type	Share in the number of passages Lobith
Motor vessels (reference dimensions)	
M1 (38.5*5.05m)	0,5%
M2 (50*6.6m)	3,7%
M3 (55*7.2m)	3,7%
M4 (67*8.2m)	4,5%
M5 (80*8.2m)	7,5%
M6 (85*9.5m)	15,9%
M7 (105*9.5m)	5,5%
M8 (110*11.4m)	31,9%
M9 (135*11.4m)	6,9%
M10 (110*13.5m)	1,0%
M11 (135*14.2m)	3,0%
M12 (135*17.0m)	2,2%
Coupled convoys	
C2l (Class IV+Europa I barge long)	0,4%
C3b (Class Va+Europa II barge wide)	0,3%
C3l (Class Va+Europa II barge long)	4,4%
C4 (Class Va+3 Europa II barges)	0,6%
Pushed convoys	
BII-1 (Europe II pushed convoy)	0,2%
BII-2b (2 Europe II barges in a wide pushed convoy)	0,2%
BII-4 (4 Europe II barges in a pushed convoy)	3,2%
BII-2L (2 Europe II barges in a long pushed convoy)	0,1%
BII-6b (6 Europe II barges in a wide pushed convoy)	0,9%
BII-6l (6 Europe II barges in a long pushed convoy)	1,0%

Table 3: Traffic counts for the year 2012 at Lobith (Source: Rijkswaterstaat, 'Toekomstige Ligplaatsbehoefte Overnachtingshaven Lobith 2013')

Although of key importance to provide transport solution for shippers on smaller waterways, relatively smaller vessels (≤80m) have a high share in terms of total number of vessels and relatively low share in terms of energy consumption and transport performance. Therefore, in order to limit the number of vessel categories for the purpose of the GLEC Framework 2.0, it is suggested to combine the smaller vessels into one vessel category and further distinguish larger vessel sizes and pushed/coupled convoy combinations. Based on the dataset available, the representative vessel types and share in passages, tonne-kilometer performance and fuel consumption (based on PROMINENT

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[1] Rijkswaterstaat developed a new and more detailed classification system (RWS 2010). This classification system provides a further specification of the CEMT classes with the current largest motor cargo vessels and includes the dimensions of coupled units. For more information, see: Rijkswaterstaat (2011). Waterway Guidelines 2011.

D1.1), the following vessel sizes and types have been distinguished to calculate GHG emission factors for the GLEC Framework 2.0:

General emission factors per vessel class:

- Motor vessels ≤ 80m
- Motor vessels 85 – 86m
- Motor vessels 87 – 109m, for which a representative vessel is selected with a length of 105m
- Motor vessels 110m
- Motor vessels 135m
- Coupled convoys, between 163 – 185m in length
- Pushed convoy – push boat + 2 barges
- Pushed convoy – push boat + 4/5 barges
- Pushed convoy – push boat + 6 barges

Specific information on liquid bulk vessels:

- Tanker vessels 110m
- Tanker vessels 135m

Specific information on container vessels:

- Container vessels 135m
- Container vessels – Coupled convoy (185m)

For the cargo categories liquid bulk and container vessels, information for other vessel sizes is currently not available. In case shippers use other vessel sizes to transport liquid bulk cargo or containers, it is suggested to use the GHG emission factors presented in Table 4.

3.2 GHG emission factors per cargo category

In the tables below an overview is given of the GHG emission factors per vessel class and cargo types. The emission factors are based on Well-to-Propeller CO2eq-emission factor for gasoil of 3240 gram per liter[2].

General GHG emission factors per vessel class:

General cargo, dry - and liquid bulk vessels	GHG Emission factor (in g/tkm)
Motor vessels ≤ 80m	29.5
Motor vessels 85 - 86m	20.7
Motor vessels 87 - 109m	18.4
Motor vessels 110m	18.4
Motor vessels 135m	19.0
Coupled convoys (163 - 185m)	17.0
Pushed convoy - push boat + 2 barges	17.3
Pushed convoy - push boat + 4/5 barges	9.7
Pushed convoy - push boat + 6 barges	7.4

Table 4: General GHG factors per vessel class.

[2] European standard EN16258 quotes 3.24 kg CO2e / litre Diesel (no blending of BioDiesel)

Source: P. Oom / Kon. BLN-Schuttevaer & H2020 – PROMINENT

Specific GHG emission factors for liquid bulk vessels:

Liquid bulk vessels	GHG Emission factor (in g/tkm)
Tanker vessels 110m	18.7
Tanker vessels 135m	22.0

Table 5: GHG factors for liquid bulk vessels

Source: P. Oom / Kon. BLN-Schuttevaer

Specific GHG emission factors for container vessels:

Container vessels	GHG Emission factor (in g/tkm)[3]
Container vessels 110m	25.5
Container vessels 135m	19.8
Container vessels - Coupled convoys	19.7

Table 6: GHG factors for container vessels

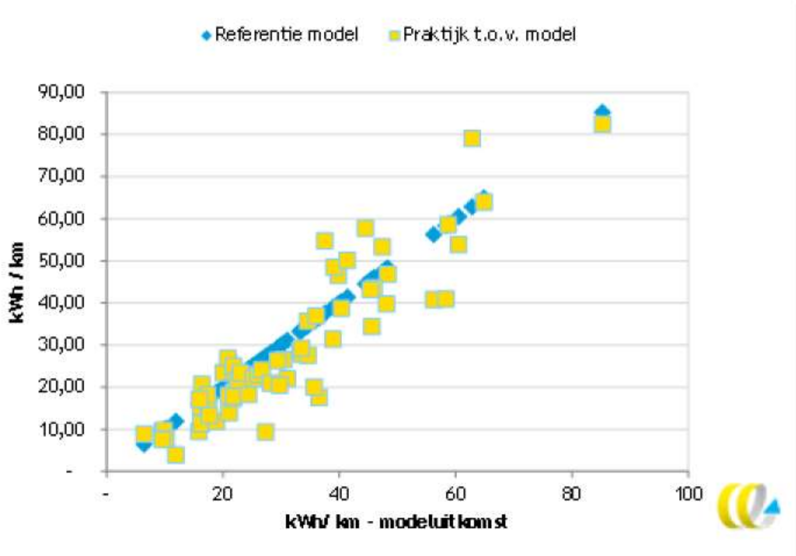
Source: P. Oom / Kon. BLN-Schuttevaer

A more detailed overview, including additional characteristics of vessel classes and operational information, is provided in Annex II.

3.3 Global coverage and validation

Europe:

In the STREAM study WTW CO_2eq-factors are distinguished for multiple vessel classes and cargo types, based on a transport model with conversion factors for various cargo types. The dataset from P. Oom / Kon. BLN-Schuttevaer has been used to validate the model calculations from the STREAM study, see below the results of the validation process. In general terms the model results are above the real-life fuel consumption factors as collected by barge operators.



Source: STREAM Goederenvervoer 2016 (CE DELFT, 2016).

[3] For container vessels the capacity and load factor is determined in TEUs. To express the GHG emission factors in g / tkm a coversion factor has been used of 10 tons / TEU.

Although the dataset of P. Oom / Kon. BLN-Schuttevaer is quite extensive in terms of trips and vessels, the dataset does not include information on cargo types transported. Furthermore, there is no information provided on push barges. Within the PROMINENT project, push barges on the Danube have been monitored. To calculate the emission factors the load factor was estimated to be 70%. This assumption is confirmed by data from the MoveIt-project, where an average load factors of 71% was registered (measured for 1 push barge combination only). Since no further updates from the PROMINENT project are expected regarding payloads, a load factor of 70% has been used to determine the GHG emission factors for pushed convoys.

Additionally, based on earlier CCNR[4] reports, CO2-emission factors) in inland navigation based on real fuel consumption for selected vessel types and shipping areas (including upstream services) are presented below (converted from Tank-to-Propeller to Well-to-Propeller emission factors):

- Pushed convoys consisting of 4 or 6 barges - Lower Rhine: **12 g / tkm**
- Johann Welker (80 m x 9.5 m x 2.5 m) / container transports - Rhine area: **25.7 – 41.3 g / tkm**
- Large motor vessel / container transports - Rhine area: **19.7 – 33.7 g / tkm**
- Jowi / container transports - Rhine area: **10.6 – 18.2 g / tkm**

Especially looking at the emission factors for container transport, similar GHG factors have been found based on the combined dataset from P. Oom / Kon. BLN-Schuttevaer and H2020-PROMINENT as presented in paragraph 3.2.

China:

From China, limited information is available on the energy consumption of typical inland vessels and related transport performance. Only for two vessel types, data was collected for vessels operating on the Grand Canal:

- DWT: 1600, HP: 660KW, from the Grand Canal to Yangzi River area, annual fuel consumption – 50 tons.
- DWT: 2500, HP: 952KW, from the Grand Canal to Yangzi River area, annual fuel consumption – 80 tons.

Based on the fuel consumption and very rough estimates for the transport performance (based on: a utilization factor of 60%; an average speed of 6 km/h; engine hours per year 1750 – 2000), the GHG emission factors would be between **18 – 21 g / tkm** (very rough estimate, considering GHG emission factor for MGO fuel – 3.49 kg CO2e / liter diesel fuel). These values, applicable to the Grand Canal, are in the same order of magnitude of similar vessel type operating on West-European waterways. Consumption factors for vessels operating on the Yangtze river are likely to be higher.

Colombia:

Typically, IWT in Colombia is carried out by means of pushed convoys consisting of a push boat and 6 to 8 barges. On average these barge configurations have a load capacity of 7,500 – 10,000 tons. The average load factor is 50% (empty return), the average fuel consumption is 21 liter / km.

[4] Source CCNR: Central Commission for the Navigation of the Rhine: http://www.ccr-zkr.org/

Based on the input parameters mentioned above, the average GHG emission factor lies between the 13.6 – 18.1 g / tonkm. This corresponds to emission factors found in Europe for barge configuration, considering that the average load factor in Europe is approx. 70%.

US:

The SmartWay-Tool has been used as source to validate the GHG emission factors from Europe with the US. The average factor per barge in the US is US 11.1 g / tkm. No further details were available per barge configuration (15 / 45 barges). The existing GHG factor lies within the range of GHG factors found in Europe per tonne-kilometre.

4 Main conclusion and recommendations

On the basis of real-life data from barge operators for multiple trips or year-round navigation, for which the H2020 – PROMINENT, P. Oom / Kon. BLN- Schuttevaer and Contargo were the primary source, GHG emission factors have been calculated for representative vessel classes in Europe. Since the aggregated dataset is based on actual data from inland barge operators and the majority of the input provided concerns information based on year-round navigation (and thereby levels out some seasonal effects), it is advised to use the GHG emission factors as indicated in Chapter 3.2 of this report for GLEC Framework 2.0.

Although, the GHG emission factors calculated for the GLEC Framework 2.0 are a large improvement in comparison to the existing value used in GLEC Framework 1.0, the GHG emission factors considered are still estimates rather than exact values. For example, in practice substantial differences can be experienced on similar trips carried out by similar vessels. This can be caused by differentiated water levels and currents, different load factors, operational profile and related power distribution, etc. The dataset to update the GHG emission factors for IWT is considered to be quite extensive in comparison to other studies in this field, however it still includes information on only approx. 1% of the vessels operating in Europe. Hence, in terms of consistency and representativeness of default GHG factors, it is recommended to continue expanding the dataset with annual information on transport performance (distance covered, load factor, tonnes transported) and fuel consumption per representative vessel class.

The existing data collection to establish updated GHG emission factors for IWT as input for the GLEC Framework 2.0, once again underlines the need for (accurate) data monitoring and consistent calculations, based on actual performance of inland vessels. The use of real-life data is important, since the data collected by barge owners / inland shipping lines has resulted in lower GHG emission factors in comparison to other recognized studies.

In order to reach global coverage, the conclusion is that more effort is needed. Validation of European GHG emission factors could be a first step, to be followed by onboard measurements on the most important river basins / waterways in the World. Considering the scale of IWT transport and the modal share in the overall national transport performance and thus global supply chains, it is recommended to strive for (more) detailed information on IWT emission factors for China and the US.

Annex I: Data collection framework

STEP 0: DEFINE REPRESENTATIVE CLASSES AND VESSELS

In Europe and China a wide range of vessel types and sizes can be distinguished, whereas in the US and Latin-America the preferred vessels used for inland navigation are large pushed convoys. STC-Nestra suggest to use to following vessel classes (incl. typical load capacity of representative vessel belonging to that vessel class):

- Motor vessels <80; 985 ton
- Motor vessels 80-109m; 1500 ton
- Motor vessels 110-134m; 3200 ton
- Motor vessels ≥ 135m (incl. motor vessels+1 barge = coupled convoy); 5500 ton
- Pushboat + 2 barges; 5680 ton
- Pushboat + 4-6 barges; 16680 ton
- Pushboat + up to 15 barges; 20250 ton (US configuration – barges with a capacity of 1350 metric tons)
- Pushboat + up to 30 barges; 40500 ton (US configuration – barges with a capacity of 1350 metric tons)
- Pushboat + up to 45 barges; 60750 (US configuration – barges with a capacity of 1350 metric tons)

NOTE: To be updated and validated by members of the GLEC IWW Action Group and other (research) institutes.

NOTE: Representative vessel classes may be changed according to availability and feedback from partners from other continents than Europe.

STEP 1: INFORMATION ON SELECTED REPRESENTATIVE VESSELS

In this first step, basic information is collected for a representative vessel per vessel class (see STEP 0) and per cargo category. The following data needs to be specified:

- GEOGRAPHIC REGION
  Select country / river basin / waterway where representative vessel is in operation.

- VESSEL TYPE
  Select type of representative vessel (Motor Vessel / pushed convoy / coupled convoy).

- CARGO TYPE
  Specify cargo type that is transported by representative vessel (Dry bulk / Liquid bulk / Containers / RoRo / General Cargo)

- DIMENSIONS
  Specify length, width and draught of representative vessel (in order to check the relevant vessel class for aggregating data)

- CONFIGURATION
  In case of convoy specify the configuration (motor vessel + barge / pushboat + no. of barges)

- LOAD CAPACITY OF VESSEL

Specify the load capacity (payload) of the representative vessel (in tons). For container vessels an average conversion factor for tons per TEU will be used.

- TOTAL ENGINE POWER
  Specify the total engine power (in HP or kW)

- TOTAL ENGINE POWER
  Specify the total engine power (in HP or kW)

- FUEL TYPE
  Specify the type of fuel used (Diesel / LNG / BioFuels)

STEP 2: OPERATIONAL CHARACTERSTICS REPRESENTATIVE VESSEL FOR 1 OR MORE ROUNDTRIP(S)

In STEP 2 information needs to be provided on representative roundtrip(s) for the representative vessels related to the vessel classes and the utilization of the vessels for the selected roundtrip(s).

The following data, to be provided for 1 or more roundtrips or year-round data (if available), is relevant:

- DESCRIPTION OF ROUNTRIP(S)
  Provide information on the selected roundtrip(s) (e.g. roundtrip Rotterdam – Basel; New Orleans – St. Louis; Shanghai - Wuhan) or indicated year-round navigation by inserting "per year".

- LOAD FACTOR as % of capacity (see Step 1)
  Provide information on the average load factor for the selected roundtrip(s). Insert of data may be distinguished in the load factor for both ***downstream*** *transport and* ***upstream*** *transport.*

STEP 3: AVERAGE ENERGY CONSUMPTION OF REPRESENTATIVE VESSEL FOR 1 OR MORE ROUNDTRIP(S)

Based on the previous steps, for the representative vessels and related roundtrip(s), detailed information is needed on the energy consumption, e.g. for 1 or more roundtrips or for year-round operations (if available).

Provide information on the fuel consumption for both the ***downstream*** *transport and* ***upstream*** *transport.*

The data can be provided in the following units:

- *Diesel - liter / km*
- *Diesel - liter / hour*
- *LNG - kg / km*
- *LNG - kg / hour*

A dropdown-list can be used to select the preferred unit to specify the fuel consumption.

Commonly inland vessels have auxiliary engines installed for living facilities and for special requirements to / conditioning of cargo on board (e.g. especially tankers, but also connections for reefer containers are increasingly installed). The total energy consumption provided in this step includes the use of auxiliary engines.

NOTE: information on energy consumption provided in liter / hour or kg / hour requires additional information on **AVERAGE OPERATIONAL SPEED OVER GROUND (SOG)**

Provide information on average SOG [km/h] for both ***downstream*** *transport and* ***upstream*** *transport.*

STEP 4: EMISSION FACTORS

For calculating the aggregated CO2-emissions per vessel class, emission factors for Gasoil / Diesel need to be applied. Following the GLEC Framework, the following Well-to-Propeller (WTP) emission factors are applied:

CO2-emission factor GASOIL/DIESEL (EN590):
3240 gram CO_2 per liter fuel

NOTE: The GLEC Framework aims to include the following GHGs: CO_2, CH4, N_2O, HFCs, PFCs, SF_6, NF_3, although not all GHGs are applicable to logistics services. In practice, CO_2, CH_4 and N_2O are the gases most commonly included within transport CO_2-equivalent (CO_2e) emissions factors. For engines operating on LNG (with the benefit of considerable lower air-pollutant emissions), the impact of unburnt methane (known as the 'methane slip') has to be considered due on the total GHGs emitted.

NOTE: Source: European standard EN16258 and https://co2emissiefactoren.nl/lijst-emissiefactoren/#totale_lijst

The collected data for the representative vessels and roundtrips on utilization (load factor) and energy consumption (fuel consumption), combined with application of the CO2-emission factor, will result in the average CO2-emission performance per vessel class per cargo type. Depending on the collected data, further distinction per continent / region / waterway might be possible.

Annex II: IWT GHG Emission factors

INFORMATION ON REPRESENTATIVE VESSELS			Motor vessels <80m	Motor vessels <80m	Motor vessels <80m	Motor vessels <80m	Motor vessels 85-86m	Motor vessels 87-109m	Motor vessels 110m	Motor vessels 135m		Coupled convoys	Pushed convoy		
GEOGRAPHIC REGION	country / river basin / waterway		Western Europe	Western Europe	Western Europe	Western Europe	Western Europe	Western Europe	Western Europe	Western Europe	ARA + Rhine	ARA + Rhine	Danube	Danube	Danube
CONFIGURATION	In case of convoy no. of barges											MVS + 1 barge	Pusher + 2 barges	Pusher + 4/5 barges	Pusher + 6 barges
DIMENSIONS	Length [m]		39	55-60	67-73	80	85-86	105	110	134-135	135	163-185			
	Width [m]		5.07	6,7-7,3	7,25-9	8,2-9,5	8,2-10	10,5-11,1	9,5-11,45	11,45-12,8	16.8	11/11,45-22,9			
	Draught [m]		2.5	2,4-2,6	2,5-3,0	2,5-3,0	2,7-3,6	3,2-3,5	3,2-3,7	3,5-4,2	4	3,2-3,6			
CARGO TYPE	Dry bulk / Liquid bulk / Containers / RoRo / General cargo												Dry bulk	Dry Bulk	Dry Bulk
LOAD CAPACITY OF VESSEL	[tons or TEU] *(average in case of multiple vessels)*		371	595	964	1207	1584	2403	3203	4116	6355	4746			
FUEL TYPE	Diesel / LNG / Biofuel (specify)		Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
DESCRIPTION OF ROUNTRIP(S) or YEAR-ROUND operation	e.g. roundtrip Rotterdam - Basel or Rhine/Danube		9 vessels; 214 trips	7 vessels; 435 trips	16 vessels; 1.288 trips	8 vessels; 511 trips	5 vessels; 283 trips	2 vessels, 106 trips	10 vessels; 1031 trips	5 vessels; 340 trips	1 vessel; 77 trips	10 vessel; 563 trips			
	Total distance covered [km]		134409	137954	411761	195669	109360	70280	584745	177131	16420	439657			
	For which period or year is the information provided?		2011 - 2015	2015	2015	2015	2014-2015	2015	2010 - 2015	2015	2015	2010 - 2015			
Average payload incl. empty km	% of load capacity or in tons	Average	55%	53%	54%	57%	60%	60%	50%	47%	69%	61%	70%	70%	70%
Fuel consumption		Total liter per year or per trip	265965	421939	1996331	1127877	668322	575706	5342678	2044389	365000	6692454			
Well-to-Propeller CO2e-emission factor GASOIL [g/l]		3240													
Well-to-Propeller - CO2e-emission factor LNG [g/kg]		3780													
Ton/TEU-factor		10													
Average payload incl. empty km		[ton]	206	317	519	687	956	1442	1605	1925	4406	2903	3000	8000	10000
Average fuel consumption		[l/km]	2.0	3.1	4.8	5.8	6.1	8.2	9.1	11.5	22.2	15.2	16.0	23.9	22.8
Average GHG-emission performance		**GHG (g/tkm)**	**31.2**	**31.2**	**30.3**	**27.2**	**20.7**	**18.4**	**18.4**	**19.4**	**16.3**	**17.0**	**17.3**	**9.7**	**7.4**
Weighted average		**GHG (g/tkm)**	**29.5**				**20.7**	**18.4**	**18.4**	**19.0**		**17.0**	**17.3**	**9.7**	**7.4**
		Source:	P. OOMS / KONINKLIJKE BLN-SCHUTTEVAER (2016)										H2020 - PROMINENT		

INFORMATION ON REPRESENTATIVE VESSELS		Tanker vessels 110m	Tanker vessels 135m	Container vessels 110m	Container vessels 135m					Container vessels - coupled convoy
GEOGRAPHIC REGION	country / river basin / waterway	Western Europe	ARA	ARA	Rhine/Main	Rhine	Rhine	Rhine	Rhine	Rhine
CONFIGURATION	In case of convoy no. of barges									MVS + 1 barge
DIMENSIONS	Length [m]	110	135	110	135	135	135	135	135	185
	Width [m]	11.4	14.2	11.4	11.4	14.2	14.2	14.2	17	11.4
	Draught [m]			3.7	3.25	3.3	3.8	4.01	3.9	3.7
CARGO TYPE	Dry bulk / Liquid bulk / Containers / RoRo / General cargo	Tanker	Tanker	Containers	Containers	Containers	Containers	Containers	Containers	Containers
LOAD CAPACITY OF VESSEL	[tons or TEU] *(average in case of multiple vessels)*			3200 (188 TEU)	268	334	5200 (421 TEU)	5558 (416 TEU)	606	368
FUEL TYPE	Diesel / LNG / Biofuel (specify)	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
DESCRIPTION OF ROUNTRIP(S) or YEAR-ROUND operation	e.g. roundtrip Rotterdam - Basel or Rhine/Danube	1 vessel, 11 trips	1 vessel, 92 trips	Antwerp - Rotterdam	Rotterdam-Frankfurt	Rotterdam-Mannheim	Rotterdam - Cologne	Antwerp - Mainz	Antwerpen-Karlsruhe	Rotterdam-Karlsruhe
	Total distance covered [km]	5480 loaded km	11841	11088	1130	1230	15249	21853	1430	1350
	For which period or year is the information provided?				2017	2017			2017	2017
Average payload incl. empty km	% of load capacity or in tons / Average	+/- 65%		75%	71%	80%	75%	75%	77%	68%
Fuel consumption	Total liter per year or per trip	65675	240025		16000	18000			22500	20500
Well-to-Propeller CO2e-emission factor GASOIL [g/l]	3240									
Well-to-Propeller - CO2e-emission factor LNG [g/kg]	3780									
Ton/TEU-factor	10									
Average payload incl. empty km	[ton]	2077	4725	1410	1903	2672	3158	3120	4666	2502
Average fuel consumption	[l/km]	12.0	32.1	11.1	14.2	14.6	25.9	15.1	15.7	15.2
Average GHG-emission performance	**GHG (g/tkm)**	**18.7**	**22.0**	**25.5**	**24.1**	**17.7**	**26.5**	**15.6**	**10.9**	**19.7**
Weighted average	**GHG (g/tkm)**	**18.7**	**22.0**	**25.5**	**19.8**					**19.7**
	Source:	P. OOMS / KONINKLIJKE BLN-SCHUTTEVAER (2016)		H2020 - PROMINENT	Contargo & H2020 - PROMINENT				Contargo	Contargo