

Background report – waterborne transport

Update 13.9.2026 (R1.03): Minor value adjustment and renaming.

Update 15.4.2025 (R1.02): Minor text and value corrections. JEC v4 replaced with JEC v5.

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Original 2020 (R1.00)

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1. Background information

Waterborne transport's technological progress has been relatively slow, and the lifetime of vessels is long contributing to slow turnover rate of the fleet. However, in recent years engine technologies and improved use efficiencies have decreased fuel consumption and emissions. (LIPASTO Unit Emissions: Methodology: Waterborne transport).

Many fuels such as crude oil and biofuels are transported mainly by ship. The type of ship used for transportation depends on the distance needed to be traveled. Crude oil from the Arab Gulf is mainly transported in very or ultra large crude carrier ships holding between 200-500 kilotons of fuel. For shorter trips, such as for the North Sea, smaller crude carriers are used carrying typically 100 kilotons of fuel. Transportation of LNG uses dedicated ships. (JEC v.5a.)

In waterborne transport, alternative fuels and propulsion have not yet become widespread. Liquefied natural gas is the cleanest fossil fuel available. In Finland, ships can use Pori's and Tornio's (and Hamina in 2020) LNG-terminals and many operators deliver LNG by trucks to harbors. Biofuels still have a limited availability for shipping operations. (Liikennefakta 2021)

2. Sources utilized

LIPASTO emission factors for shipping are based on the MEERI-calculation system for shipping for the year 2016. Here, the average emissions and energy use of maritime freight transport is used. MEERI-calculation values have been cross checked together with shipping companies. LIPASTO unit emissions are shown per ship kilometer, per transport unit, per net ton kilometer and passenger kilometer. The LIPASTO emission database includes different pollutants as well as fuel and energy consumption. It also contains further information about ship classes such as average speed, usage, distance, dead weight tonnage, and main and auxiliary engine power. LIPASTO unit emissions consider real capacity usage of two-way round trips, which is why emission factors might be higher than by assuming more theoretical loading factors. Port emissions are included in the emission factors. (LIPASTO Unit emission database: Methodology: Waterborne transport)

JEC-reports versions 4 and 5 (JRC) present the well-to-tank emissions of fuels of which many are transported by ship. Published data have been used for a type of ship, consistent with the length of the envisaged trip and the material being carried. Usually, ships return empty, and JEC considers the corresponding fuel consumption. For biofuel shipping, the ships, however, are known to be partially loaded on the return trip. (Edwards et al 2014)

3. Selected typical values

Emission data was collected from relevant sources.

Following table shows sources considered from LIPASTO:

LIPASTO Unit Emissions 2016 [g/tkm]	Emissions [CO₂ g/tkm]	Emissions [CO₂e g/tkm]	Fuel consumption [g/ tkm]	Energy [MJ]
Container ship, 1 000 TEU	41.41	41.81	13.29	0.537
Container ship, 2 000 TEU	27.81	28.09	8.92	0.360
Bulk carrier, medium	12.37	12.50	3.97	0.160
Bulk carrier, large	9.26	9.35	2.97	0.119
General cargo, small	27.51	27.78	8.83	0.356
Tanker, crude carrier, short voyage	5.16	5.21	1.64	0.066
Tanker, crude carrier, long voyage	3.06	3.09	0.97	0.039
Tanker, product carrier, short voyage	11.84	11.96	3.76	0.151
Tanker, product carrier, long voyage	8.00	8.07	2.54	0.103

Following table shows sources considered from JEC:

JEC v.5. 2020	Energy [MJ/tkm]	Comment
Sea-going tanker (50t) (HFO)	0.124	Oeko Inventar 1996
Sea-going tanker 23 kt (HFO)	0.1031	JRC interna
LPG carrier (84 km ³) (HFO)	0.132	[Mann B&W 2003], [Kawasaki 2000]
Inland/Coastal tanker 1.2 kt	0.5040	[Oeko Inventar 1996]
Inland/Coastal bulk carrier (8.8 kt	0.3240	[Oeko Inventar 1996]

VTT LIPASTO offers average waterborne transport emission values for the year 2016. LIPASTO values include the common fuel types and are in accordance with EEA Guidebook 2019. The selected ship types are the types that were considered relevant for calculating the emissions of waterborne freight transport used in the construction process. Container ship usage percentage of containers in LIPASTO is 65% for 1000 TEU ships. For small Bulk carrier, the usage percentage is

60% of bulk freight weight of DWT. Return trip doesn't need to be calculated separately as it's included in the emission factors in LIPASTO.

JEC v.5.a. report describes the well-to-tank emissions of fuels used in the transport process. JEC well-to-tank values were added to LIPASTO emission values to represent the actual values of the whole transportation process. JEC v.5.a well-to-tank emission value for heavy fuel oil is 5,7 CO₂e g/MJ.

JEC-values are added to emission factor by multiplying the share of well-to-tank process of heavy fuel oil to the emission factor of heavy fuel oil combustion. Heavy fuel oil (HFO) well-to-tank emissions are 7,9 % of HFO emissions from combustion.

Example of adding JEC well-to-tank emission values to LIPASTO's emission values (averages in 2016):

Container ship, 1 000 TEU: 41,81 CO₂e/tkm (LIPASTO) * 1,074 (JEC WTT v5.a, HFO) = 44,91 CO₂e/tkm

Bulk carrier, medium: 12,50 CO₂e/tkm (LIPASTO) * 1,074 (JEC WTT v5.a, HFO) = 13,42 CO₂e/tkm

Values declared for database:

- Transport, container ship, 1 000 TEU: 0.045 kg CO₂e/tkm
- Transport, bulk carrier, medium, 14 000 DWT: 0.012 kg CO₂e/tkm

Sources

Edwards, R., Larivé, J.-F., Rickeard, D., Weindorf, W. 2014. Well-to-Tank report version 4.a. JEC Well-to-Wheels Analysis. JRC Technical Reports. EN, Publications Office of the European Union, Luxemb DOI: 10.2790/95533. ISBN 978-92-79-33888-5.

https://publications.jrc.ec.europa.eu/repository/bitstream/JRC85326/wtt_report_v4a_april2014_publication.pdf

Liikennefakta 2021. (English: Reducing greenhouse gas emissions from maritime transport.

<https://www.liikennefakta.fi/fi/ymparisto/meriliikenteen-kasvihuonekaasupaastojen-vahentaminen>

Prussi, M., Yugo, M., De Prada, L., Padella, M., Edwards, R. and Lonza, L., 2020. JEC Well-to-Tank report v5, EUR 30269 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-76-19926-7 (online), doi:10.2760/959137 (online), JRC119036.

<https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/jec-well-tank-report-v5>

VTT LIPASTO Unit Emissions: Methodology: Waterborne transport. LIPASTO unit emissions database (deprecated)

http://lipasto.vtt.fi/yksikkopaastot/infoe_vesi.htm

Annex 1: Calculation example for container ship, 1 000 TEU in LIPASTO

Translated from Finnish Lipasto example.

http://lipasto.vtt.fi/yksikkopaastot/guide_vesi.htm

Calculation of CO₂ emissions and SO₂ emissions from shipping for the round trip between ports A and B. The cargo is 5,000 tons, which is equivalent to about 550 containers (TEU). The distance between ports A and B is 2,000 km. The transport is carried out on a 1,000 TEU container ship. The cargo is transported only from A to B and average container ship is considered for the return trip.

- LIPASTO unit emissions page for waterborne freight transport is used to find out the correct emission value for the container ship in question: (41 CO₂ g / tkm and 0.025 SO₂ g / tkm).
- Next, the transport performance (tkm) is calculated by multiplying the freight weight by the length of the journey (5,000 t * 2,000 km = 10,000,000 tkm).
- To determine the outbound trip emissions, the transport performance (3,000,000 tkm) is multiplied by the unit emission factors reported in LIPASTO (410 t CO₂ and 0.25 t SO₂)
- As the emission factors already include the return journey, the total emissions from transport have already been considered.

The result: Transport generates about 410 tonnes of CO₂ emissions and 0.25 tonnes of SO₂ emissions.