NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Ocean Freighter Transport

Reference Flow: 1 kg of Cargo

Brief Description: Transport of an unspecified cargo via an ocean freighter of 10000 TEUs. Assumes backhaul and front haul have the same energy intensity. Includes diesel consumption.

Section I: Meta Data

Geographical Coverage: US **Region:** N/A

Year Data Best Represents: 2014

Process Type: Transport Process (TP)

Process Scope: Gate-to-Gate Process (GG)

Allocation Applied: No

Completeness: All Relevant Flows Recorded

Flows Aggregated in Data Set:

☒ Process ☒ Energy Use ☐ Energy P&D ☐ Material P&D

Relevant Output Flows Included in Data Set:

Releases to Air:	☒ Greenhouse Gases	☒ Criteria Air Pollutants	☒ Other
Releases to Water:	☐ Inorganic Emissions	☐ Organic Emissions	☐ Other
Water Usage:	☐ Water Consumption	☐ Water Demand (throughput)	
Releases to Soil:	☐ Inorganic Releases	☐ Organic Releases	☐ Other

Adjustable Process Parameters:

Distance	*Round trip distance, in nautical miles*
Btu per liter of diesel	*Energy content of diesel, in Btu/liter of diesel*
Energy per kg-km	*Power demand per kilogram carried per kilometer of transport, in Btu/kg-nautical mile*

Tracked Input Flows:

Diesel [Crude oil products]	*Diesel from crude oil, for consumption during cargo transport*
Cargo [Other]	*Unspecified type of cargo for transport*

Tracked Output Flows:

Cargo [Other]	*Unspecified type of cargo received, reference flow*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage2_O_Ocean_Freighter_Transport_2010.01.xls*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

The scope of this unit process covers the transportation of an ocean freighter loaded with an unspecified type of cargo from the end of a processing unit process to the entry of another process (either another processing unit process or the energy conversion facility) as well as the empty return trip back to the starting place. This unit process has the ability to encompass all of LC Stage #2 or any portion of it or may be used in a different LC Stage as needed. This unit process is based on the reference flow of 1 kg of an unspecified type of cargo being delivered, as shown in **Figure 1**. Considered are the consumption of diesel and the resulting emissions from diesel combustion, and assumes that the cargo being transported will not have any emissions (i.e. fugitive dust particles) that may be lost during transport.

Boundary and Description

Operational data for the ocean freighter is compiled from many sources, to create an emissions profile for criteria air pollutants and other pollutants of interest. The unit process is designed such that the type of cargo being transported and location of transport are irrelevant. This unit process assumes that the unspecified type of cargo is loaded into the ocean freighter during a previous unit process. This unit process transports the unspecified cargo from one location to another.

Figure 1 provides an overview of the boundary of this unit process. As shown, upstream emissions associated with the production diesel fuel and processed cargo are accounted for outside of the boundary of this unit process.

The user has the ability to vary certain parameters to tailor the dataset to fit the diesel production profile used. The parameters listed in the Adjustable Process Parameter section are the primary differentiators between diesel analyses. Three of the four adjustable parameters help to determine the amount of diesel needed for transportation. These include the energy content of the diesel, the power demand of the ocean freighter, and the roundtrip transport distance. The default values for these parameters are, respectively, 36,641 Btu/liter, 10,099,939 Btu/kg-km, and 1 nautical mile. The fourth adjustable parameter is the sulfur content of the diesel fuel, with a default value of 0.000015 kg S/kg diesel. The sulfur content of the fuel is important due to the effect on the resulting air emissions. These parameters may be varied based on updated information, or the specific values needed for a given investigation.

All emission factors for diesel combustion are provided in **Table 1**. It is assumed that the ocean freighter will be operating around or after the year 2014, and will therefore be in compliance with the US Environmental Protection Agency's (EPA) Tier 4 emissions standards, which will become effective in 2015. The Tier 4 standards include regulations for NO_X, PM, VOCs, and CO (US Federal Register 2008). Emission factors for CO_2, CH_4, and N_2O were taken from the documentation for the US Energy Information Administration's (EIA) form for the voluntary reporting of greenhouse gases (DOE 2006). Stiochiometric conversions determined the SO_2 emissions from diesel combustion. It was assumed that all sulfur contained in the diesel fuel would be converted to SO_2.

Figure 1. Unit Process Flow Diagram

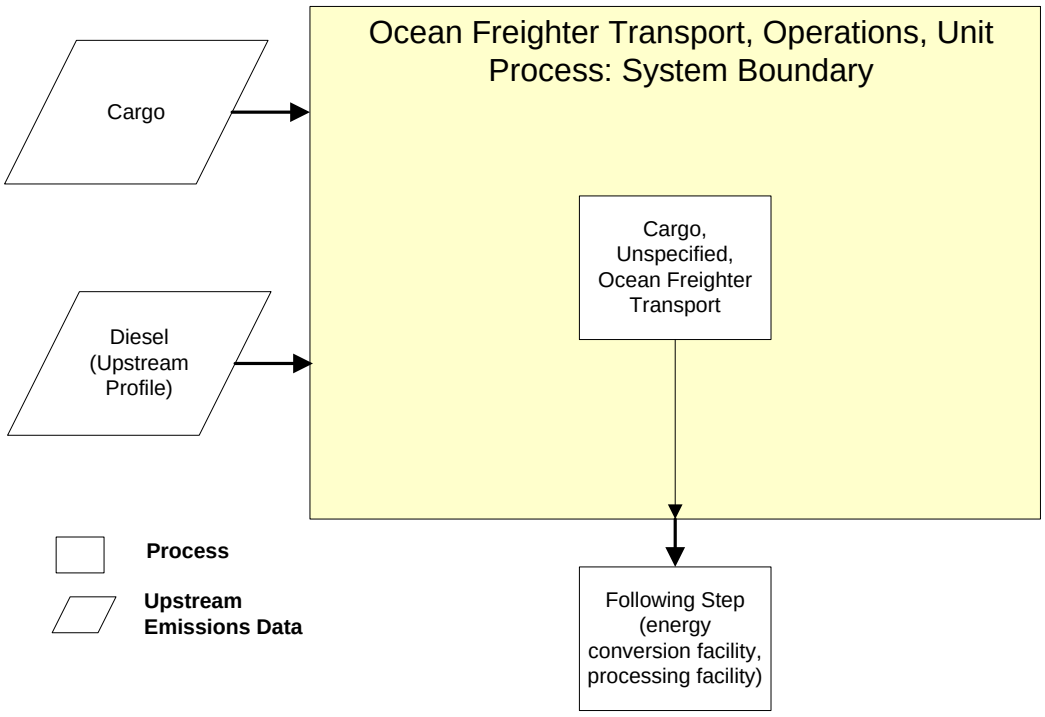

Table 1. Emission Factors for Ocean Freighter Transport

Emission	Value	Units (per kg cargo transported)	Reference
Carbon Dioxide	5.3666E-05 (1.1831E-04)	kg (lbs)	DOE 2006
Methane	1.9192E-06 (4.2312E-06)	kg (lbs)	DOE 2006
Nitrous Oxide	6.2375E-07 (1.3751E-06)	kg (lbs)	DOE 2006
Sulphur Oxide	1.1222E-09 (2.4741E-09)	kg (lbs)	NETL Engineering Calculation
Nitrogen Oxides	3.1187E-06 (6.8756E-06)	kg (lbs)	US Federal Register 2008
Particulate Matter, unspecified	2.1591E-07 (4.7601E-07)	kg (lbs)	US Federal Register 2008, Connell-Hatch 2008
VOCs, unspecified	3.3586E-07 (7.4045E-07)	kg (lbs)	US Federal Register 2008
Carbon Monoxide	8.8764E-06 (1.9569E-05)	kg (lbs)	US Federal Register 2008
Mercury (+II)	3.1632E-22 (6.9736E-22)	kg (lbs)	Conaway *et al*. 2005
Ammonia	2.6389E-10 (5.8178E-10)	kg (lbs)	Battye *et al*. 1994

Table 2: Unit Process Input and Output Flows

Flow Name*	Value	Units (Per Reference Flow)
Inputs		
Cargo	**1**	**kg**
Diesel [Crude oil products]	**2.16915E-06**	**kg/kg cargo**
Outputs		
Cargo	1	kg/ kg cargo
Carbon dioxide [Inorganic emissions to air]	6.96E-06	kg/ kg cargo
Methane [Organic emissions to air (group VOC)]	5.48E-10	kg/ kg cargo
Nitrous oxide (laughing gas) [Inorganic emissions to air]	1.78E-10	kg/ kg cargo
Sulphur oxide [Inorganic emissions to air]	6.50E-11	kg/ kg cargo
Nitrogen oxides [Inorganic emissions to air]	1.85E-08	kg/ kg cargo
Particulate Matter, unspecified [Other emissions to air]	4.28E-10	kg/ kg cargo
VOC (unspecified) [Organic emissions to air (group VOC)]	2.00E-09	kg/ kg cargo
Carbon monoxide [Inorganic emissions to air]	2.14E-08	kg/ kg cargo
Mercury (+II) [Heavy metals to air]	3.39E-22	kg/ kg cargo
Ammonia [Inorganic emissions to air]	2.85E-10	kg/ kg cargo

* **Bold face** clarifies that the value shown *does not* include upstream environmental flows.

Embedded Unit Processes

None.

References

Battye *et al*. 1994 — Battye, R., Battye, W., Overcash, C., Fudge, S. 1994. *Development and Selection of Ammonia Emissions Factors, Final Report*. U.S. Environmental Protection Agency, Washington, D.C. http://www.epa.gov/ttn/chief/old/efdocs/ammonia.pdf (Accessed December 16, 2009).

Conaway *et al*. 2005 — Conaway, C.H., Mason, R.P., Steding, D.J., Flegal, A.R. 2005. "Estimate of mercury emission from gasoline and diesel consumption, San Francisco Bay area, California." *Atmospheric Environment* 39:101-105. http://www.sciencedirect.com/science?_ob=MImg&_imagekey=B6VH3-4DPC3KY-2-1&_cdi=6055&_user=2638189&_orig=search&_coverDate=01%2F01%2F2005&_sk=999609998&view=c&wchp=dGLbVzb-

zSkWA&md5=08247b48f4834470afb239b4a93b0efd&ie=/sdarticle.pdf (Accessed December 16, 2009).

DOE 2006 — US DOE. 2006. *Form EIA-1605 Long Form for Voluntary Reporting of Greenhouse Gases: Instructions. Appendix H: Fuel Emissions Factors.* OMB No. 1905-0194. U.S. Department of Energy. March, 2006. http://www.eia.doe.gov/oiaf/1605/excel/Fuel%20Emission%20Factors.xls (Accessed December 16, 2009).

US Federal Register 2008 — National Archives and Records Administration. 2008. "Part IV: Environmental Protection Agency: 40 CFR Parts 9, 85, et al. Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression-Ignition Engines Less Than 30 Liters per Cylinder, Republication, Final Rule." National Records and Archives Administration, Washington, D.C. *Federal Register* 73(126). June 30, 2008. http://www.epa.gov/fedrgstr/EPA-AIR/2008/June/Day-30/a7999a.pdf (Accessed December 16, 2009).

Section III: Document Control Information

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