NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Fuel, Train Transport

Reference Flow: 1 kg of Cargo

Brief Description: Transport of an unspecified form of petroleum via train to the energy conversion facility. Assumes back haul and front haul have the same energy intensities. Includes diesel consumption and evaporative emissions.

Section I: Meta Data

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

Year Data Best Represents: 2015

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	*Roundtrip distance, in km*
Cargo Out	*Amount of fuel at the unloading, in kg*
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-km*
Evaporation of Fuel	*The amount of cargo (fuel) which evaporates during transport, based on the type of fuel (gasoline, diesel, or jet fuel) being transported*

Tracked Input Flows:

Diesel [Crude oil products]	*Diesel from crude oil for transport*
Cargo [Other]	*Unspecified type of fuel for transport*

Tracked Output Flows:

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

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage4_O_Petro_Train_Transport_2010.01.xls*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

The scope of this process covers the transportation of a train loaded with an unspecified type of petroleum-based fuel at the end of Life Cycle (LC) Stage #3, the energy conversion facility (ECF), to the bulk storage facility within LC Stage #4 and the empty return trip back to the ECF. This process encompasses part of LC Stage #4, which includes all transportation and storage between the ECF and when the fuel enters a vehicle's fuel tank. This process is based on the reference flow of 1 kg of an unspecified type of petroleum-based fuel (gasoline, diesel, or jet fuel) being transported from the ECF, and is shown in **Figure 1**. Considered are the consumption of diesel and the resulting emissions from diesel combustion, as well as the evaporative emissions that may be lost during transport.

Boundary and Description

The train operation process is designed to be independent of the type of petroleum-based fuel being transported and the U.S. location in which the train is operating. This unit process assumes that the unspecified petroleum-based fuel is loaded into the train during a previous unit process. This unit process transports the unspecified petroleum-based fuel from an unspecified type of ECF to a bulk storage facility.

Figure 1 provides an overview of the boundary of this unit process. Rectangular boxes represent relevant sub-processes, while trapezoidal boxes indicate upstream data that are outside of the boundary of this unit process. As shown, upstream emissions associated with the production of diesel for combustion by the train are accounted for outside of the boundary of this unit process.

Several adjustable parameters are used within this process to adjust transport emissions for different types of petroleum-based fuel cargo. Four of the adjustable

parameters combine to help determine the amount of diesel needed to fuel the train. These include diesel density, energy content, train power demand, and roundtrip transport distance. Additional adjustable parameters are provided for the calculation of evaporative emissions. Evaporative emissions should be adjusted appropriately to the type of petroleum-based fuel being transported; suggested values are provided in **Table 1**.

All emission factors for diesel combustion are provided in **Table 2**. It is assumed that the train will be operating around or after the year 2015 and will therefore be in compliance with EPA's Tier 4 emissions standards, which become effective in 2015. The Tier 4 standards include regulations for nitrogen oxides (NO_X), particulate matter (PM), volatile organic compounds (VOCs), and carbon monoxide (CO) (US Federal Register 2008). Emission factors for carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) were taken from the documentation for EIA's form for the voluntary reporting of greenhouse gases (DOE 2006). Stiochiometric conversions determined the sulfur dioxide (SO_2) emissions from diesel combustion. It was assumed that all sulfur contained in the diesel fuel would be converted to SO_2.

Table 3 provides a summary of modeled input and output flows. Additional detail regarding input and output flows, including calculation methods, is contained in the associated DS.

Figure 1. Unit Process Scope and Boundary

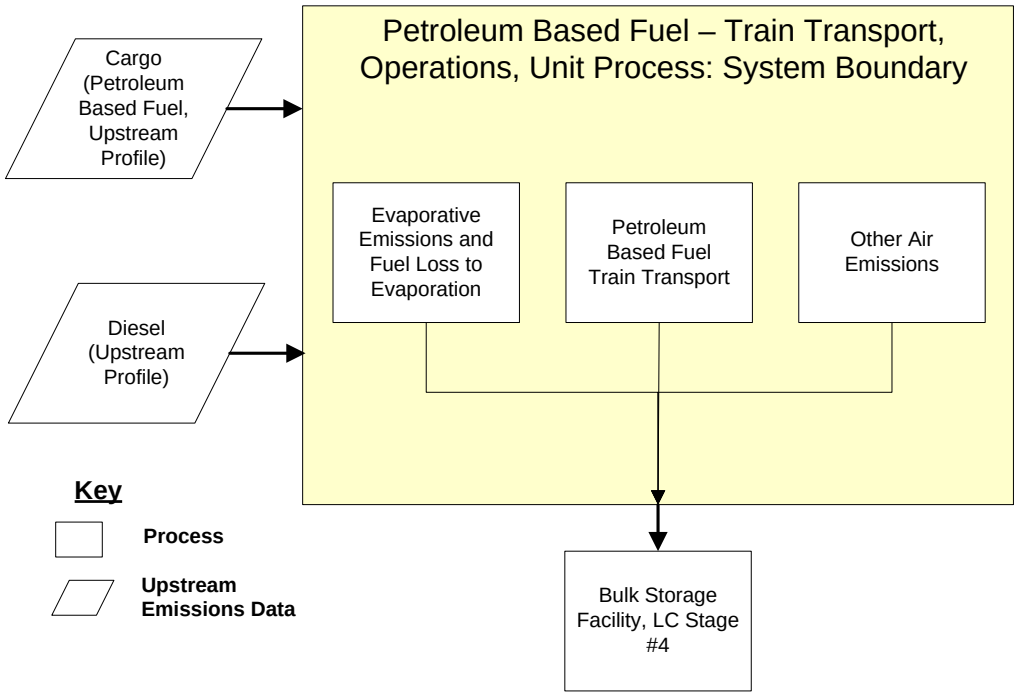

Table 1. Evaporative Emission Factors for Various Fuels

Emission	Value	Units (per kg cargo transported)	Reference
Gasoline	0.0008510	kg	NETL 2008
Diesel	0.0000019	kg	NETL 2008
Jet Fuel	0.0000094	kg	NETL 2008

Table 2. Combustion Emission Factors for Train Transport

Emission	Value	Units (per kg cargo transported)	Reference
Carbon Dioxide	0.0106	kg	DOE 2006
Methane	8.3420E-07	kg	DOE 2006
Nitrous Oxide	2.7111E-07	kg	DOE 2006
Sulphur Oxide	9.9737E-08	kg	Calculated
Nitrogen Oxides	2.8196E-05	kg	US Federal Register 2008
Particulate Matter, unspecified	1.6484E-04	kg	US Federal Register 2008,
VOCs, unspecified	3.0365E-06	kg	US Federal Register 2008
Carbon Monoxide	3.2534E-05	kg	US Federal Register 2008
Mercury (+II)	8.0913E-14	kg	Conaway *et al*. 2005
Ammonia	4.3419E-07	kg	Battye *et al*. 1994

Table 3: Unit Process Input and Output Flows

Flow Name*	Value	Units (Per Reference Flow)
Inputs		
Cargo [Other]	**1.000851**	**kg**
Diesel [Crude oil products]	**6.1367E-04**	**L**
Outputs		
Unspecified Coal	1.00E+00	kg
Carbon dioxide [Inorganic emissions to air]	1.6450E-03	kg
Methane [Organic emissions to air (group VOC)]	1.2969E-07	kg
Nitrous oxide (laughing gas) [Inorganic emissions to air]	4.2150E-08	kg
Sulphur oxide [Inorganic emissions to air]	1.5506E-08	kg
Nitrogen oxides [Inorganic emissions to air]	4.3836E-06	kg
Particulate Matter, unspecified [Other emissions to air]	1.0116E-07	kg
VOC (unspecified) [Organic emissions to air (group VOC)]	8.5476E-04	kg
Carbon monoxide [Inorganic emissions to air]	5.0580E-06	kg
Mercury (+II) [Heavy metals to air]	8.0913E-14	kg
Ammonia [Inorganic emissions to air]	6.7504E-08	kg

* **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).
NETL 2008	NETL. 2008. Development of Baseline Data and Analysis of Life Cycle Greenhouse Gas Emissions of Petroleum Based Fuels. DOE/NETL-2009/1346. U.S. Department of Energy, National Energy Technology Laboratory. Pittsburgh, PA. November 26, 2008.
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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