



# NETL Life Cycle Inventory Data

## Process Documentation File

**Process Name:** Train Transport  
**Reference Flow:** 1 kg of Cargo  
**Brief Description:** Transport of an unspecified cargo via train to the energy conversion facility. Assumes backhaul and front haul have the same energy intensity and there are no fugitive/evaporative emissions. Includes diesel consumption.

### 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 *Round trip distance, in km*  
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*



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### Tracked Input Flows:

Diesel [Crude oil products]	<i>Diesel from crude oil, for consumption during cargo transport</i>
Cargo [Other]	<i>Unspecified type of cargo for transport</i>

### Tracked Output Flows:

Cargo [Other]	<i>Unspecified type of cargo received, reference flow</i>
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## Section II: Process Description

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### Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS\_Stage2\_O\_Train\_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 a unit train 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 train 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 (inside the U.S.) are irrelevant. This unit process assumes that the unspecified type of cargo is loaded into the train during a previous unit process. This unit process transports the unspecified type of cargo from one point 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 train, and the roundtrip transport distance. The default values for these parameters are, respectively, 36,641 Btu/liter, 225 Btu/kg-km, and 100 km. 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 train will be operating around or after the year 2015, 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<sub>x</sub>, PM, VOCs, and CO (US Federal Register 2008). Emission factors for CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O were taken from the documentation for the US Energy Information Administration's (EIA) form for the voluntary reporting of greenhouse gases (DOE 2006). Stoichiometric conversions determined the SO<sub>2</sub> emissions from diesel combustion. It was assumed that all sulfur contained in the diesel fuel would be converted to SO<sub>2</sub>.

Figure 1. Unit Process Flow Diagram

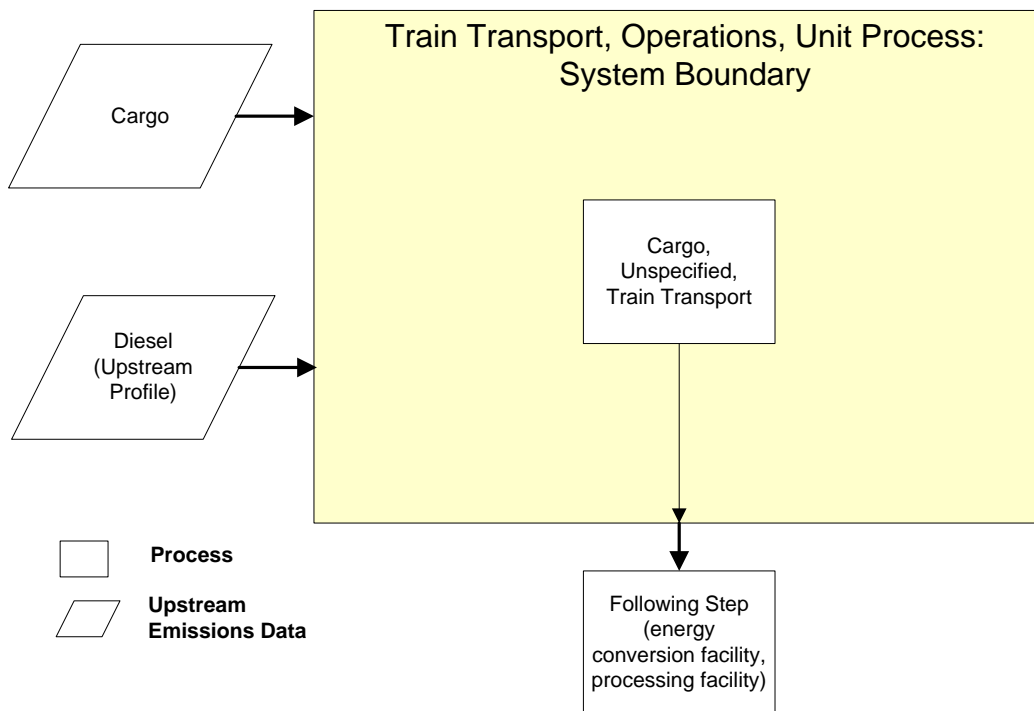


Table 1. Emission Factors for Train Transport

Emission	Value	Units (per kg cargo transported)	Reference
Carbon Dioxide	1.3716E-02 (3.0238E-02)	kg (lbs)	DOE 2006
Methane	4.9052E-04 (1.0814E-03)	kg (lbs)	DOE 2006
Nitrous Oxide	1.5942E-04 (3.5146E-04)	kg (lbs)	DOE 2006
Sulphur Oxide	2.8682E-07 (6.3233E-07)	kg (lbs)	NETL Engineering Calculation
Nitrogen Oxides	7.9709E-04 (1.7573E-03)	kg (lbs)	US Federal Register 2008
Particulate Matter, unspecified	1.8394E-05 (4.0552E-05)	kg (lbs)	US Federal Register 2008, Connell-Hatch 2008
VOCs, unspecified	8.5841E-05 (1.8925E-04)	kg (lbs)	US Federal Register 2008
Carbon Monoxide	9.1972E-04 (2.0276E-03)	kg (lbs)	US Federal Register 2008
Mercury (+II)	8.0844E-20 (1.7823E-19)	kg (lbs)	Conaway <i>et al.</i> 2005
Ammonia	6.7446E-08 (1.4869-07)	kg (lbs)	Battye <i>et al.</i> 1994

Table 2: Unit Process Input and Output Flows

Flow Name*	Value	Units (Per Reference Flow)
<b>Inputs</b>		
Cargo	1	kg/ kg cargo
Diesel [Crude oil products]	5.1337E-04	kg/ kg cargo
<b>Outputs</b>		
Cargo	1	kg
Carbon dioxide [Inorganic emissions to air]	1.6460E-03	kg/ kg cargo
Methane [Organic emissions to air (group VOC)]	1.2978E-07	kg/ kg cargo
Nitrous oxide (laughing gas) [Inorganic emissions to air]	4.2178E-08	kg/ kg cargo
Sulphur oxide [Inorganic emissions to air]	1.5385E-08	kg/ kg cargo
Nitrogen oxides [Inorganic emissions to air]	4.3865E-06	kg/ kg cargo
Particulate Matter, unspecified [Other emissions to air]	1.0123E-07	kg/ kg cargo
VOC (unspecified) [Organic emissions to air (group VOC)]	4.7239E-07	kg/ kg cargo
Carbon monoxide [Inorganic emissions to air]	5.0613E-06	kg/ kg cargo
Mercury (+II) [Heavy metals to air]	8.0281E-20	kg/ kg cargo
Ammonia [Inorganic emissions to air]	6.7549E-08	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=MIimg&imagekey=B6VH3-4DPC3KY-2-1&\\_cdi=6055&\\_user=2638189&\\_orig=search&\\_coverDate=01%2F01%2F2005&\\_sk=999609998&view=c&wchp=dGLbVzb-](http://www.sciencedirect.com/science?_ob=MIimg&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).

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**Section III: Document Control Information**

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