NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Combustion of Diesel

Reference Flow: 1 kg of Diesel

Brief Description: This unit process includes the emissions associated with the combustion of diesel

Section I: Meta Data

Geographical Coverage: United States **Region:** N/A

Year Data Best Represents: 2012

Process Type: Energy Conversion (EC)

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

Allocation Applied: No

Completeness: All Relevant Flows Captured

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	☑ Other
Releases to Water:	☐ Inorganic	☐ Organic Emissions	☐ Other
Water Usage:	☐ Water Consumption	☐ Water Demand (throughput)	
Releases to Soil:	☐ Inorganic Releases	☐ Organic Releases	☐ Other

Adjustable Process Parameters:

1_3_But	*[kg/kg diesel] 1,3-Butadiene emissions per kg of combusted diesel*
Ace_ene	*[kg/kg diesel] Acenaphthene emissions per kg of combusted diesel*
Ace_ylene	*[kg/kg diesel] Acenaphthylene emissions per kg of combusted diesel*
Ace_yde	*[kg/kg diesel] Acetaldehyde emissions per kg of combusted diesel*

Acrolein	*[kg/kg diesel] Acrolein emissions per kg of combusted diesel*
Aldehydes	*[kg/kg diesel] Aldehydes emissions per kg of combusted diesel*
Anthracene	*[kg/kg diesel] Anthracene emissions per kg of combusted diesel*
Arsenic	*[kg/kg diesel] Arsenic emissions per kg of combusted diesel*
Benzene	*[kg/kg diesel] Benzene emissions per kg of combusted diesel*
Benz_cene	*[kg/kg diesel] Benzo (a) anthracene emissions per kg of combusted diesel*
Benz_pyr	*[kg/kg diesel] Benzo (a) pyrene emissions per kg of combusted diesel*
Benz_b_fluor	*[kg/kg diesel] Benzo (b) fluoranthene emissions per kg of combusted diesel*
Benz_per	*[kg/kg diesel] Benzo (g,h,i) perylene emissions per kg of combusted diesel*
Benz_k_fluor	*[kg/kg diesel] Benzo (k) fluroanthene emissions per kg of combusted diesel*
Beryllium	*[kg/kg diesel] Beryllium emissions per kg of combusted diesel*
Cadmium	*[kg/kg diesel] Cadmium emissions per kg of combusted diesel*
CH4	*[kg/kg diesel] Methane emissions per kg of combusted diesel*
Chromium	*[kg/kg diesel] Chromium emissions per kg of combusted diesel*
Chrysene	*[kg/kg diesel] Chrysene emissions per kg of combusted diesel*
CO	*[kg/kg diesel] Carbon monoxide emissions per kg of combusted diesel*
CO2	*[kg/kg diesel] Carbon dioxide emissions per kg of combusted diesel*
Dib_anth	*[kg/kg diesel] Dibenzo(a,h) anthracene emissions per kg of combusted diesel*

Ethyl_b	*[kg/kg diesel] Ethyl Benzene emissions per kg of combusted diesel*
Fluoran	*[kg/kg diesel] Fluroanthene emissions per kg of combusted diesel*
Fluor	*[kg/kg diesel] Fluorene emissions per kg of combusted diesel*
Form	*[kg/kg diesel] Formaldehyde emissions per kg of combusted diesel*
HC	*[kg/kg diesel] Hydrocarbon emissions per kg of combusted diesel*
Ind_pyr	*[kg/kg diesel] Indeno(1,2,3,c,d)pyrene particle emissions per kg of combusted diesel*
Iso_xylene	*[kg/kg diesel] Isomers of xylene emissions per kg of combusted diesel*
Lead	*[kg/kg diesel] Lead emissions per kg of combusted diesel*
Manganese	*[kg/kg diesel] Manganese emissions per kg of combusted diesel*
Mercury	*[kg/kg diesel] Mercury emissions per kg of combusted diesel*
N2O	*[kg/kg diesel] Nitrous oxide emissions per kg of combusted diesel*
Naph	*[kg/kg diesel] Naphthalene emissions per kg of combusted diesel*
NH3	*[kg/kg diesel] Ammonia emissions per kg of combusted diesel*
Nickel	*[kg/kg diesel] Nickel emissions per kg of combusted diesel*
NO	*[kg/kg diesel] Nitric Oxide emissions per kg of combusted diesel*
NO2	*[kg/kg diesel] Nitrogen dioxide emissions per kg of combusted diesel*
Phen	*[kg/kg diesel] Phenanthrene emissions per kg of combusted diesel*

PM10_Great	*[kg/kg diesel] Particulate matter greater than 10 microns emissions per kg of combusted diesel*
PM2.5_PM10	*[kg/kg diesel] Particulate matter between 2.5 and 10 microns emissions per kg of combusted diesel*
PM2.5	*[kg/kg diesel] Particulate matter less than 2.5 microns emissions per kg of combusted diesel*
BC	*[kg/kg diesel] Black carbon particulates less than 2.5 microns emissions per kg of combusted diesel*
OC	*[kg/kg diesel] Organic carbon particulates less than 2.5 microns emissions per kg of combusted diesel*
PAH	*[kg/kg diesel] Polycyclic aromatic hydrocarbon emissions per kg of combusted diesel*
Prop	*[kg/kg diesel] Propylene emissions per kg of combusted diesel*
Pyrene	*[kg/kg diesel] Pyrene emissions per kg of combusted diesel*
Selenium	*[kg/kg diesel] Selenium emissions per kg of combusted diesel*
SO2	*[kg/kg diesel] Sulfur dioxide emissions per kg of combusted diesel*
SOX	*[kg/kg diesel] Sulfur oxides emissions per kg of combusted diesel*
TOC	*[kg/kg diesel] Total organic carbon emissions per kg of combusted diesel*
Toluene	*[kg/kg diesel] Toluene emissions per kg of combusted diesel*
VOC	*[kg/kg diesel] Volatile organic compound emissions per kg of combusted diesel*

Tracked Input Flows:

Diesel	*[Technosphere] Diesel for combustion*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *Stage3_Diesel_Combustion.02.xlsx*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

This unit process provides a summary of relevant input and output flows associated with the combustion of diesel utilized for several downstream processes. The reference flow of this unit process is: 1 kg of Diesel

Boundary and Description

Overview

This unit process provides a summary of relevant input and output flows associated with the combustion of diesel. There are several grouping scenarios that represent the type of engine, sector, and control. The electric generation or electric power sector includes the combustion of diesel in a reciprocating or turbine engine or an external combustion boiler for electricity only or combined heat and power (CHP) (EPA, 2014). The industrial sector includes the combustion of diesel in a reciprocating or turbine engine or an external combustion boiler for producing, processing, or assembling goods; i.e. manufacturing and mining (EPA, 2014). The commercial sector includes the combustion of diesel in a reciprocating or turbine engine or an external combustion boiler for nonmanufacturing business, such as private and public organizations, government activities, social groups, or institutional living quarters (EPA, 2014). The mobile source scenario in this process consists of diesel motor vehicles; specifically a car and truck type (EPA, 2014). Non-greenhouse gas (GHG) emissions for electric generation, industrial, and commercial scenarios were taken from the U.S.EPA's (United States Environmental Protection Agency) WebFIRE database (EPA, 2012), while GHG emissions for these scenarios were derived from EPA's 2011 GHG Emission Factors Hub (EPA 2011). These mobile source scenario emissions were derived from NREL's (National Renewable Energy Lab) US LCI (U.S. Life Cycle Inventory) Database (NREL, 2011a; 2011b). Additional mobile source scenarios are those for marine vessels using category 2, category 3, and auxiliary engines powered by marine distillate or residual

oil. These emissions scenarios were derived from Argonne National Laboratory's Life Cycle Analysis of Conventional and Alternative Marine Fuels in GREET (AGL, 2013). Table 1 through Table 5 shows which individual scenarios are available in the model. An "X" indicates that the scenario is available. A grey cell indicates that the scenario is not available.

Table 1: Scenarios Included for Reciprocating Engines

Sector	Nitrogen Oxide (NO_x) Reduction Technology		
	Uncontrolled	Selective non-catalytic reduction (SNCR)	Selective Catalytic Reduction (SCR)
Electric Generation	X	X	X
Industrial without Cogeneration	X	X	X
Industrial with Cogeneration	X	X	X
Commercial with Cogeneration	X	X	X

Table 2: Scenarios Included for Turbines

Sector	Nitrogen Oxide (NO_x) Reduction Technology				
	Uncontrolled	Selective non-catalytic reduction (SNCR)	Selective Catalytic Reduction (SCR)	Diesel engine with direct flame after burner (Flame)	Diesel engine with steam or water injection (Steam)
Electric Generation	X	X	X	X	X
Industrial without Cogeneration	X	X	X		X
Industrial with Cogeneration	X	X	X		X
Commercial with Cogeneration	X	X	X		X

Table 3: Scenarios Included for Mobile Sources

Vehicle Type	
Car	X
Truck	X

Table 4: Scenarios Included for Boilers

Sector		Nitrogen Oxide (NO_x) Reduction Technology				
		Uncontrolled	Selective non-catalytic reduction (SNCR)	Selective Catalytic Reduction (SCR)	Flue Gas Recirculation	Low NOX burners
Industrial	10-100 Million Btu/hr	X	X	X		
	<10 Million Btu/hr	X	X	X		
	>100 Million Btu/hr	X			X	X
Commercial and Institutional	10-100 Million Btu/hr	X	X	X		
	<10 Million Btu/hr	X	X	X		
	>100 Million Btu/hr	X			X	X
Electric Generation	10-100 Million Btu/hr					
	<10 Million Btu/hr					
	>100 Million Btu/hr	X			X	X

Table 5: Scenarios Included for Marine Vessels

Engine Type	Fuel Type	
	Residual Oil	Marine Distillate
Category 2 Engine	X	X
Category 3 Engine	X	X
Auxiliary Engine	X	X

Table 6: Scenarios Included for Nonroad Engines in Compliance with EPA Tier IV Requirements

Engine Size or Locomotive Type	
175 ≤ hp ≤ 750	X
> 750 hp	X
Line-Haul Locomotive	X

Figure 1: Unit Process Scope and Boundary

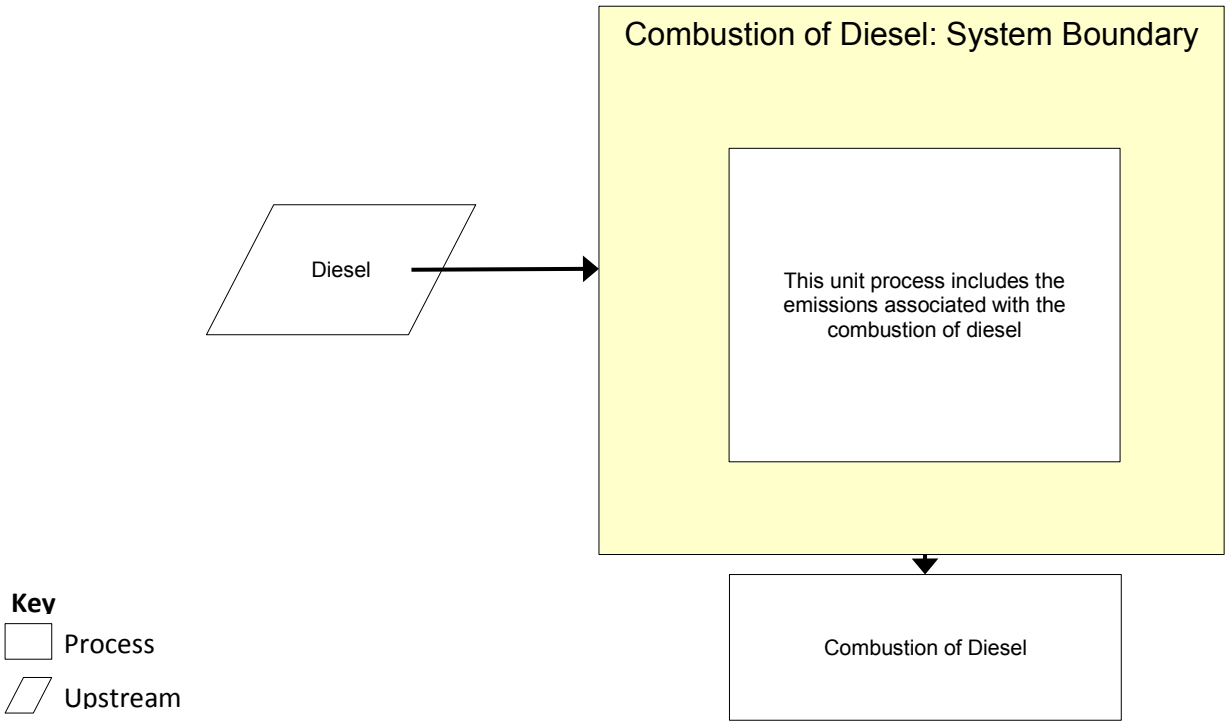

Table 6: Unit Process Input and Output Flows – Passenger Car

Flow Name	Value	Units (Per Reference Flow)
Inputs		
Diesel [Refinery products]	1.00	kg
Outputs		
Mobile Sources, Car [Crude oil products]	1.00E+00	kg
1,3-Butadiene [Hydrocarbons to air]	0.00E+00	kg
Acenaphthene [unspecified]	0.00E+00	kg
Acenaphthylene [Organic emissions to air (group VOC)]	0.00E+00	kg
Acetaldehyde (Ethanal) [Group NMVOC to air]	0.00E+00	kg
Acrolein [Group NMVOC to air]	0.00E+00	kg
Aldehyde (unspecified) [Group NMVOC to air]	0.00E+00	kg
Anthracene [Group PAH to air]	0.00E+00	kg
Arsenic [Heavy metals to air]	0.00E+00	kg
Benzene [Group NMVOC to air]	0.00E+00	kg
Benzo{a}anthracene [Group PAH to air]	0.00E+00	kg
Benzo{a}pyrene [Group PAH to air]	0.00E+00	kg
Benzo{b}fluoranthene [Group PAH to air]	0.00E+00	kg
Benzo{ghi}perylene [Group PAH to air]	0.00E+00	kg
Benzo{k}fluoranthene [Group PAH to air]	0.00E+00	kg
Beryllium [Inorganic emissions to air]	0.00E+00	kg
Cadmium [Heavy metals to air]	0.00E+00	kg
Methane [Organic emissions to air]	1.13E-04	kg
Chromium [Heavy metals to air]	0.00E+00	kg
Chrysene [Group PAH to air]	0.00E+00	kg
Carbon monoxide [Inorganic emissions to air]	3.73E-03	kg
Carbon dioxide [Inorganic emissions to air]	3.07E+00	kg
Dibenz(a,h)anthracene [Group PAH to air]	0.00E+00	kg
Ethyl benzene [Group NMVOC to air]	0.00E+00	kg
Fluoranthene [Group NMVOC to air]	0.00E+00	kg
Fluorene [Group NMVOC to air]	0.00E+00	kg
Formaldehyde (methanal) [Group NMVOC to air]	0.00E+00	kg
Hydrocarbons (unspecified) [Organic emissions to air (group VOC)]	8.08E-04	kg
Indeno[1,2,3-cd]pyrene [Group PAH to air]	0.00E+00	kg
Xylene (dimethyl benzene) [Group NMVOC to air]	0.00E+00	kg
Lead [Heavy metals to air]	0.00E+00	kg
Manganese [Heavy metals to air]	0.00E+00	kg
Mercury [Heavy metals to air]	0.00E+00	kg
Nitrous oxide (laughing gas) [Inorganic emissions to air]	4.89E-06	kg
Naphthalene [Group PAH to air]	0.00E+00	kg

Ammonia [Inorganic emissions to air]	5.48E-05	**kg**
Nickel [Heavy metals to air]	0.00E+00	**kg**
Nitrogen monoxide [Inorganic emissions to air]	8.28E-03	**kg**
Nitrogen dioxide [Inorganic emissions to air]	7.96E-04	**kg**
Phenanthrene [Group PAH to air]	0.00E+00	**kg**
Dust (> PM10) [Particles to air]	0.00E+00	**kg**
Dust (PM2,5 - PM10) [Particles to air]	1.51E-05	**kg**
Dust (PM2.5) [Particles to air]	4.56E-04	**kg**
Black carbon [Particles to air]	3.37E-04	**kg**
Organic carbon [Other emissions to air]	1.01E-04	**kg**
Polycyclic aromatic hydrocarbons (carcinogenic) [Group PAH to air]	0.00E+00	**kg**
Propene (propylene) [Group NMVOC to air]	0.00E+00	**kg**
Pyrene [Group PAH to air]	0.00E+00	**kg**
Selenium [Heavy metals to air]	0.00E+00	**kg**
Sulphur dioxide [Inorganic emissions to air]	4.82E-05	**kg**
Sulphur oxide [Inorganic emissions to air]	0.00E+00	**kg**
TOC, Total Organic Carbon [unspecified]	0.00E+00	**kg**
Toluene (methyl benzene) [Group NMVOC to air]	0.00E+00	**kg**
NMVOC (unspecified) [Group NMVOC to air]	8.26E-04	**kg**

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

Embedded Unit Processes

None.

References

AGL (2013) Argonne National Laboratory (2013). Life Cycle Analysis of Conventional and Alternative Marine Fuels in GREET™ <https://greet.es.anl.gov/publication-marine-fuels-13>. Last Accessed January 23, 2015.

EPA (2014) U.S. Energy Information Administration (2014). Definitions of EIA Distillate Categories and Fuels Contained in the Distillate Grouping. EIA. Washington, DC. http://www.eia.gov/dnav/pet/tbldefs/pet_cons_821dsta_tbldef2.asp. Last Accessed: March 25, 2014

EPA (2012) U.S. Environmental Protection Agency (2012). WebFIRE. EPA. Washington, DC.

	http://cfpub.epa.gov/webfire/ Last Accessed: March 23, 2014
EPA (2011)	U.S. Environmental Protection Agency (2011). Emission factors for greenhouse gas inventories. EPA. Washington, DC. http://www.epa.gov/climateleadership/inventory/ghg-emissions.html. Last Accessed: March 24, 2014
NREL (2011a)	National Renewable Energy Laboratory (2011). Transport, passenger car, diesel powered. NREL. https://www.lcacommons.gov/nrel/process/show/a2f7a82a-cd47-436d-97af-6cdc0ed4c19d?qlookup=diesel+passenger+car&max=35&hfacet=&hfacetCat=&loc=&year=&dtype=&crop=&index=1&numfound=40&offset=. Last Accessed: March 26, 2014
NREL (2011b)	National Renewable Energy Laboratory (2011). Transport, passenger car, diesel powered. NREL. https://www.lcacommons.gov/nrel/process/show/8a1a1102-a870-44fa-acd6-52c844ac181f?qlookup=diesel+passenger+truck&max=35&hfacet=&hfacetCat=&loc=&year=&dtype=&crop=&index=1&numfound=114&offset=. Last Accessed: March 26, 2014

Section III: Document Control Information

Date Created: March 27, 2014

Point of Contact: Timothy Skone (NETL), Timothy.Skone@NETL.DOE.GOV

Revision History:

Original/no revisions

How to Cite This Document: This document should be cited as:

NETL (2014). NETL Life Cycle Inventory Data – Unit Process: Combustion of Diesel. U.S. Department of Energy, National Energy Technology Laboratory. Last Updated: January 2015 (version 02). www.netl.doe.gov/LCA (http://www.netl.doe.gov/LCA)

Section IV: Disclaimer

Neither the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) nor any person acting on behalf of these organizations:

A. Makes any warranty or representation, express or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this document, or that the use of any information, apparatus, method, or process disclosed in this document may not infringe on privately owned rights; or

B. Assumes any liability with this report as to its use, or damages resulting from the use of any information, apparatus, method, or process disclosed in this document.

Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by NETL. The views and opinions of the authors expressed herein do not necessarily state or reflect those of NETL.