NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Truck transport of spent uranium fuel

Reference Flow: 1 kg of cargo

Brief Description: Transport of spent uranium fuel from a nuclear power plant to long-term waste disposition. Assumes backhaul and front haul have different energy intensities. Includes diesel consumption.

Section I: Meta Data

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

Year Data Best Represents: 2005

Process Type: Transport Process

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 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:

Miles_OneWay	*Adjustable parameter, distance from origin to destination*
Capacity	*Total cargo capacity of the transport vehicle*

Tracked Input Flows:

Cargo [Other]	*Quantity of cargo that is transported*
Diesel [Crude oil products]	*Diesel used for transportation of cargo*

Tracked Output Flows:

Cargo [Other]	*Quantity of cargo that is transported*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage3_O_TruckTransport_Spent_UO2_2011.01.xls*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

This unit process accounts for the transport of spent uranium fuel from a nuclear power plant to long-term waste disposition. All spent nuclear fuel is assumed to be transported by a combination truck. The key input is diesel fuel, and key outputs include diesel combustion emissions. The elevated security and safety requirements related to the transport of nuclear waste are not accounted for by this unit process. The reference flow of this unit process is the transport of one kilogram of nuclear waste (either LLW or HLW), as described below and shown in **Figure 1**. This unit process is used within Life Cycle (LC) Stage #3 of NETL's model of nuclear power.

Boundary and Description

This unit process accounts for the transport of spent uranium fuel from a nuclear power plant to long-term waste disposition. All spent nuclear fuel is assumed to be transported by a combination truck. The key input is diesel fuel, and key outputs include diesel combustion emissions. The elevated security and safety requirements related to the transport of nuclear waste are not accounted for by this unit process. The reference flow of this unit process is the transport of one kilogram of nuclear waste (either LLW or HLW).

The default transport distance for the transport of spent uranium is 1,000 miles (one way). The truck has a fuel efficiency of 5.1 miles/gallon when fully loaded (Wang, 2006). The truck makes an empty return trip with a fuel efficiency of 9.4 miles/gallon (Franklin Associates, 2004). The total round-trip distance is 2,000 miles. The payload (which is the maximum mass of cargo that can be transported by a single trip) of the combination truck is 20,000 kilogram.

The air emissions from diesel combustion in combination trucks are based on emission factors from GREET, a life cycle model for transportation (Wang, 2006). These emission factors include GHGs and criteria air pollutants. The combustion of one MMBtu of diesel in a combination truck produces 77.8 kilogram of CO_2 emissions. The lower heating

value of diesel is 0.128 MMBtu per gallon (Wang, 2006), and the density of diesel is 3.21 kilogram per gallon (Oak Ridge National Laboratory, 2007). Applying the lower heating value and density of diesel to the above CO_2 emission factor gives an emission factor of 3.11 kilogram CO_2 per kilogram of diesel. This same conversion was also applied to the emission factors for other greenhouse gas emissions and criteria air pollutants.

The following table shows the energy and emission for the truck transport of spent uranium fuel. All flows are scaled to the basis of the reference flow (the transport of one kilogram of waste).

Figure 1 provides an overview of the boundary of this unit process. There are two inputs to this unit process. Diesel is an upstream input; the energy and material flows for the production and delivery of diesel are not included in this unit process, but the emissions from the combustion of diesel are included in this unit process. Cargo (specifically, spent UO_2 fuel from a nuclear power plant) is the other input to this unit process. There is one tracked output for this unit process: the transport of 1 kg of spent uranium fuel.

Figure 1: Unit Process Scope and Boundary

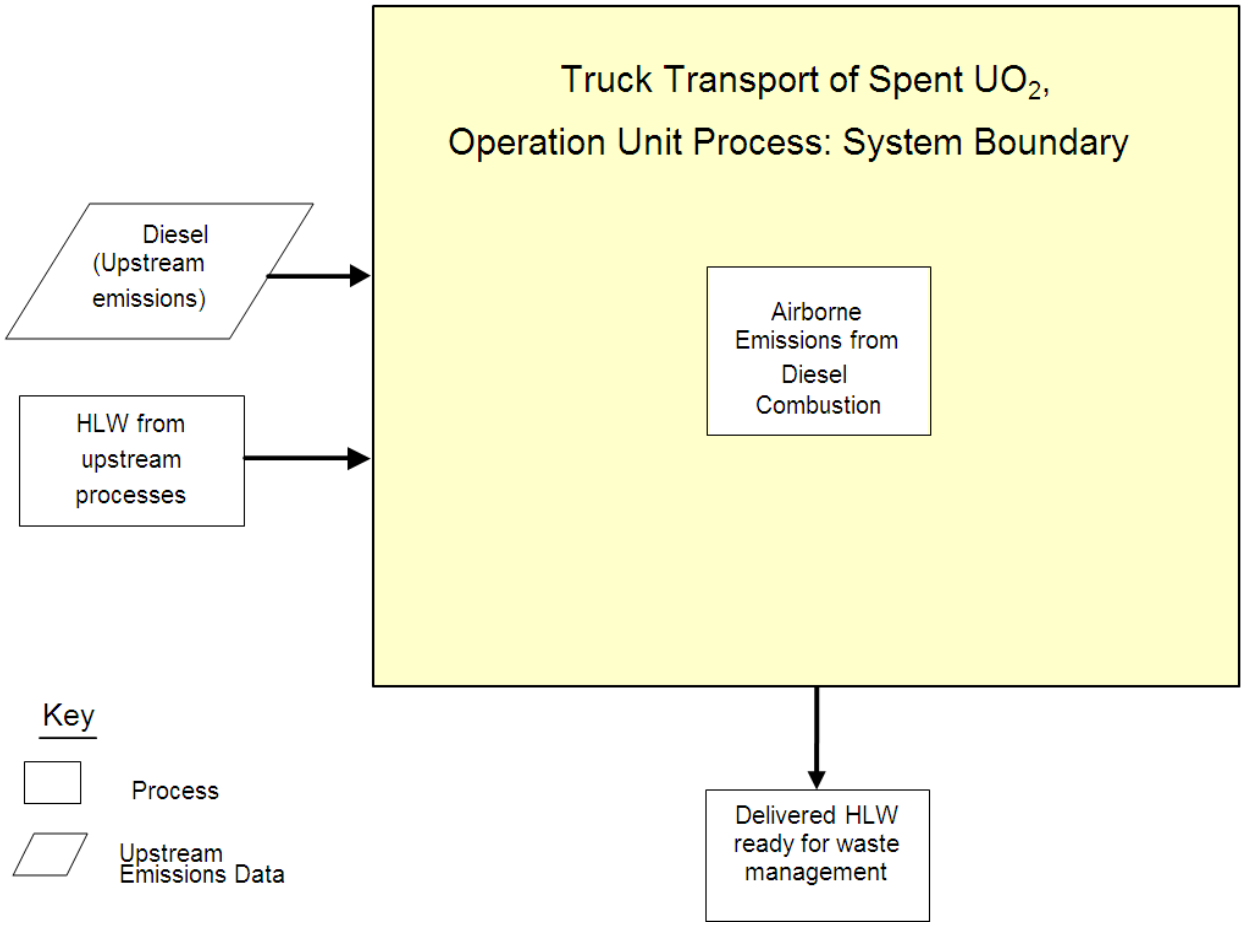

Table 1 summarizes airborne emission factors and other parameters that are relevant to this unit process. **Table 2** provides a summary of modeled input and output flows. Additional detail regarding input and output flows, including calculation methods, is contained in the associated DS.

Table 1: Emission Factors and Other Relevant Parameters

Flow Name	Value	Units
Emission Factors for Diesel Combustion		
Volatile organic compounds (VOC)	1.347E-03	kg/kg diesel
Carbon monoxide (CO)	7.150E-03	kg/kg diesel
Nitrogen oxides (NOx)	1.469E-02	kg/kg diesel
Particulate Matter (PM10)	3.017E-04	kg/kg diesel
Sulfur oxides (SOx)	2.197E-05	kg/kg diesel
Methane (CH_4)	6.230E-05	kg/kg diesel
Nitrous oxide (N_2O)	8.005E-05	kg/kg diesel
Carbon dioxide (CO_2)	3.113	kg/kg diesel
Other Parameters		
Fuel efficiency, empty	9.4	miles/gal
Fuel efficiency, loaded	5.1	miles/gal
Mileage, one way	1,000	miles
Diesel density	3.210	kg/gal
Single-trip payload capacity of truck	20,000	kg/trip

Table 2: Unit Process Input and Output Flows

Flow Name	Value	Units (Per Reference Flow)
Inputs		
Cargo (spent UO_2 fuel)	1.0	kg
Diesel	4.86E-02	kg
Outputs		
Cargo [Other]	1	kg
VOC (unspecified) [Organic emissions to air (group VOC)]	6.541E-05	kg
Carbon dioxide [Inorganic emissions to air]	1.511E-01	kg
Methane [Organic emissions to air (group VOC)]	3.025E-06	kg
Nitrous oxide (laughing gas) [Inorganic emissions to air]	3.887E-06	kg
Sulphur oxide [Inorganic emissions to air]	1.067E-06	kg
Particulate matter, unspecified [Other emissions to air]	1.465E-05	kg
Nitrogen oxides [Inorganic emissions to air]	7.133E-04	kg
Carbon monoxide [Inorganic emissions to air]	3.472E-04	kg

* **Bold face** clarifies that the value shown *does not* include upstream environmental flows. Upstream environmental flows were added during the modeling process using GaBi modeling software, as shown in Figure 1.

Embedded Unit Processes

None.

References

Franklin Associates 2004 — Franklin Associates, Ltd. (1992). Energy Requirements and Environmental Emissions for Fuel Consumption: Appendix A. Franklin Associates. Energy requirements and Environmental Emissions for fuel consumption, Appendix A. http://www.deq.state.or.us/lq/pubs/docs/sw/packaging/LifeCycleAppendixA.pdf (accessed December 16, 2009).

Oak Ridge National Laboratory 2007 — Oak Ridge National Laboratory (2007). *Transportation Energy Data Book: Edition 28.* Oak Ridge, Tennessee : Department of Energy, 2007.

Wang 2006 — Wang, M (2006). *Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model, Version 1.7.* [software] Ann Arbor, MI : s.n., 2006.

Section III: Document Control Information

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