NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Airplane Combustion of Blended F-T/Conventional Jet Fuel

Reference Flow: 1 kg of Blended Jet Fuel Combusted

Brief Description: This unit process provides a summary of relevant input and output flows associated with use of blended jet fuel (50% conventional petroleum, 50% Fischer-Tropsch) to power an aircraft.

Section I: Meta Data

Geographical Coverage: US **Region:** Not Applicable

Year Data Best Represents: 2010

Process Type: Basic Process (BP)

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

Allocation Applied: No

Completeness: Individual 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:

Mercury Emissions — *Rate of airborne mercury emissions per kg blended jet fuel*

Tracked Input Flows:

Blended Jet Fuel — *Blended jet fuel (50% Fischer-Tropsch, 50% conventional petroleum based) utilized as airplane fuel*

Tracked Output Flows:

None.

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage5_O_Aircraft_F-T_JetFuel _2012.01.xls*, which provides additional details regarding relevant, calculations, data quality, and references.

Goal and Scope

The scope of this unit process covers the combustion of 1 kg of blended jet fuel in an aircraft in Life Cycle (LC) Stage #5, end use. Fuel efficiency of the aircraft is not considered. This unit process is combined with an airplane construction process to calculate the total emissions that would result from combustion of blended jet fuel in an airplane.

Boundary and Description

Figure 1 provides an overview of the boundary of this unit process. Emissions related to the construction of the aircraft are considered in another unit process. Associated fuel transport and refueling processes are considered within LC Stage #4 in a separate unit process.

As represented in **Equation 1**, the principal products resulting from the combustion of jet fuel are CO_2 and H_2O, but the combustion also results in the creation of SO_X, NO_X, CO, unburned hydrocarbons (UHC), and fine particulate matter (PM).

Equation 1 $$\text{Fuel} + \text{Air}\ (O_2 + N_2) \rightarrow CO_2 + H_2O + SO_x + NO_x + PM + CO + UHC$$

The mass of emissions per mass of fuel consumed, a quantity known as an emissions index or emissions factor, have been compiled for all of the quantities listed in **Equation 1** for both commercial and military jet engines. It is important to note that the emissions indices of PM, CO, UHC, and NO_X vary with engine operation (e.g., idle, takeoff, and cruise operations), and that there are recommended practices for estimating the time and fuel use in each operating mode (Kim et al. 2007).

Alternative fuels may change the emissions produced by aircraft. For example, because the chemical composition of the F-T jet fuel considered differs from that of conventional jet fuel, there will be changes in the combustion products, as compared to petroleum-derived fuels. Knowledge of these changes varies with our fundamental understanding of how these pollutants are created. The emissions of CO_2, H_2O, and SO_X can be estimated for any fuel composition, including F-T jet fuel, based on complete combustion. These emissions indices (EI) are summarized along with the carbon mass fraction of the fuel in **Table 1** (Hileman and Stratton 2010). Because complete combustion of the fuel has been assumed, (i.e., all fuel carbon is assumed to be converted to CO_2 via combustion), the aircraft CO_2 emissions would be the same whether the fuel were used in a jet aircraft or another application.

Figure 1: Unit Process Inputs, Outputs, and Boundaries

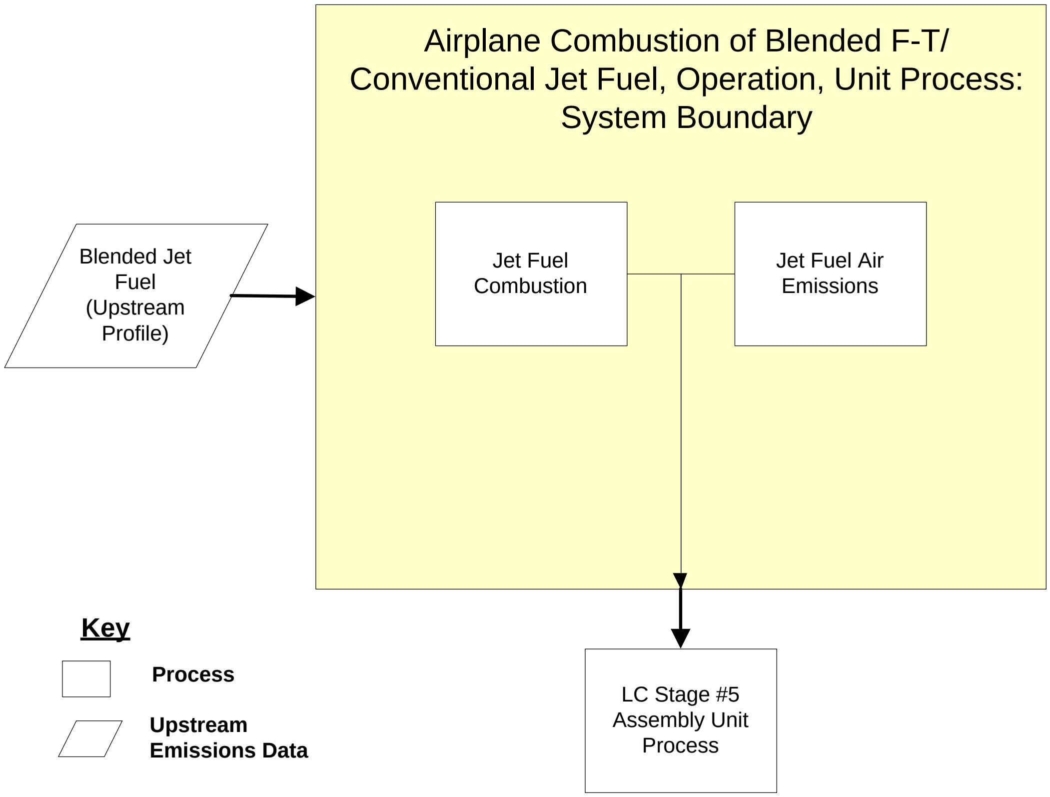

Table 1: Compositional Properties and Emission Indices for CO_2 (Hileman and Stratton 2010)

Fuel	Carbon Mass Fraction	Energy Content (MJ/kg)	CO_2e (g/kg)	CO_2e (g/MJ)
JP-8	0.862	43.2	3,159	73.1
F-T Jet Fuel	0.847	44.1	3,105	70.4

The F-T jet fuel compositional properties in **Table 1** are based on measured properties for typical F-T jet fuels. In evaluation presented in this case study, the properties of the F-T jet fuel were determined based on the results of ASPEN modeling that was completed in support of this study. The carbon mass fraction and density of the F-T jet fuel varied depending on the modeled scenario that was selected, due to variability in fuel composition.

With respect to emissions from the combustion of conventional jet fuel, measurements indicate that the use of F-T jet fuel could result in no change in NO_X emissions to a reduction of up to 10 percent, relative to JP-8 (Dewitt et al. (2008); Timko et al. (2008); Bester and Yates (2009); and Miake-Lye (2010)). NO_X is produced by the oxidation of atmospheric nitrogen during combustion; for gas turbine engines, NO_X formation is largely a function of combustion temperature. Estimation of other byproducts, such as PM, CO, and UHC (which are the result of incomplete fuel combustion) are less understood, even for conventional jet fuel. However, measurements consistently indicate that there is a substantial decrease in PM emissions with the use of F-T jet fuels in gas turbine engines (Corporan et al. (2007a and 2007b); Dewitt et al. (2008); Timko et al. (2008); Whitefield (2008); Bester and Yates (2009); and Whitefield et al. (2010)).

Table 2 shows relevant properties used to calculate the emissions from combustion of 1 kg of blended jet fuel. **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.

Table 1: Properties of F-T Diesel and Passenger Vehicle

Property	Value	Reference
F-T Jet Fuel Energy Content (LHV) MJ/kg	43.8	Noblis 2012
Conventional Jet Fuel Energy Content (LHV) MJ/kg	43.2	NETL 2009

Table 2: Unit Process Input and Output Flows

Flow Name*	Value	Units (Per Reference Flow)
Inputs		
Blended Jet Fuel	**1.00**	**kg**
Outputs		
Blended Jet Fuel Combustion	1	MJ
Carbon dioxide [Inorganic emissions to air]	7.214E-02	kg
Carbon monoxide [Inorganic emissions to air]	1.774E-04	kg
Methane [Organic emissions to air (group VOC)]	4.739E-07	kg
Nitrous oxide (laughing gas) [Inorganic emissions to air]	1.896E-06	kg
VOC [emissions to air]	1.774E-05	kg
Nitrogen Oxides [Inorganic emissions to air]	2.788E-04	kg
Sulphur dioxide [Inorganic emissions to air]	1.267E-05	kg
Particulate matter	8.505E-06	kg
Ammonia	5.575E-06	kg
Mercury [Heavy metals to air]	6.885E-10	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

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Section III: Document Control Information

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