NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Electricity Transmission

Reference Flow: 1 MWh of Electricity delivered to distribution

Brief Description: SF_6 emissions and transmission losses for electricity

Section I: Meta Data

Geographical Coverage: United States **Region:** National

Year Data Best Represents: 2011

Process Type: Transport Process (TP)

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:

SF6	*[kg/MWh] SF_6 emissions from the transmission and distribution of 1 MWh of electricity*
Loss	*[dimensionless] Electricity loss during transmission*

Tracked Input Flows:

Electricity	*[Technosphere] Electricity from power plant*

Tracked Output Flows:

Electricity delivered to distribution	*Reference flow (this flow goes to electricity distribution, either industrial or residential)*
Sulfur Hexafluoride [Inorganic emissions to air]	*Emission to air*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage4_O_Electricity_Transmission_2013.01.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 transmission losses and sulfur hexafluoride (SF_6) emissions and for electricity transmission. The reference flow of this unit process is 1 MWh of transmitted electricity ready for distribution.

Boundary and Description

The input to this unit process is electricity from a power plant, and the output from this process is electricity that has been through the transmission network. There is a loss of electricity during transmission as well as sulfur hexafluoride (SF_6) emissions from electrical equipment. The output of this unit process (transmitted electricity) is an input to one of two unit processes for electricity distribution (industrial distribution and residential distribution).

In 2011, the emission of SF_6 from the manufacture and operation of electric power systems accounted for 7.0 teragrams (7.0 billion kilograms) of carbon dioxide equivalents (CO_2e) (EPA, 2013). The manufacture of electrical equipment accounted for 11 percent of these SF_6 emissions, and the operation of electric power systems

accounted for the remaining 89 percent (EPA, 2013). EPA estimated the uncertainty around this emission rate in their 2011 inventory of greenhouse gas emissions; 7.0 teragrams is the expected value, and the low and high values are 5.8 and 8.5 teragrams, respectively (within a 95 percent confidence interval) (EPA, 2013). To be consistent with past GHG inventories, EPA expresses GHG emissions in terms of 1996 IPCC 100-year global warming potentials (GWP) (EPA, 2013). This unit process uses a factor of 23,900 (the IPCC 1996 100-year GWP for SF_6) to convert GHG emissions from CO_2e to the actual mass of SF_6. When converted to kilograms of SF_6, 7.0 teragrams of CO_2e is 0.000293 teragrams (293,000 kg) of SF_6.

The total annual transmission of electricity is used to apportion annual SF_6 emissions per MWh of electricity delivered. In 2011, 3.9 billion MWh of electricity was delivered in the U.S. This value was calculated by subtracting electricity losses (0.255 billion MWh) from the electricity supply (4.153 billion MWh) (EIA, 2013). Dividing annual SF_6 emissions (293,000 kg SF_6) by annual electricity transmission (3.9 billion MWh) gives an SF_6 emission factor of 7.51E-05 kg SF_6/MWh delivered.

The data in this unit process are representative of 2011 conditions. Annual emissions of SF_6 from power systems have been reduced since the implementation of EPA's SF_6 Partnership program in 1999 (EPA, 2011). Since 1999, members of EPA's SF_6 Partnership program have reduced their annual SF_6 inventory losses from 14 percent to 4 percent (EPA, 2011).

This unit process accounts for the operation of an electricity transmission system, but the data used to develop the SF_6 emission factor are representative of transmission and distribution. This is a data limitation. To avoid double counting of SF_6 emissions, the unit processes for electricity distribution do not include SF_6 emissions.

The main characteristics that distinguish transmission lines from distribution lines are that they are operated at high (115 kV, 138 kV, 161 kV and 230 kV) and extra-high (345 kV, 500 kV and 765 kV) voltages (AEP, 2012a), they have a network configuration with more than one electrical path between any two points in the system and they transmit large quantities of power (the capacity of transmission line can be between 50 MVA and 2,000 MVA) over longer distances. Distribution lines are operated at medium (1.1 kV up to 69 kV) and low voltages (120 V up to 480 V), they mostly have a radial configuration with a single electrical path between any two points in the system and they transmit smaller quantities of power (from 5 kVA to 30 MVA) over shorter distances. For a given amount of power, a higher voltage reduces the load current and thus the energy lost since the energy lost is proportional to the square of the load current.

T&D losses can be sub-grouped as transmission, sub-transmission and distribution losses. For example, a sample of American Electric Power's transmission losses ranges from 2.5 percent to 5 percent, sub-transmission losses from 1 percent to 2.5 percent, and distribution losses from 6 percent to 8 percent (Nourai et al, 2008). The distribution losses can be further sub-grouped based on the customer's delivery service voltage level as primary and secondary distribution losses (primary voltage level is delivery at 2

– 20 kV and secondary voltage level is delivery at 0.120 – 2 kV) (Dominion, 2011). The losses are used to determine how much produced energy can be delivered to the customer. For example, if losses are 7 percent then 1.075 MWh of electricity needs to be produced by the generator to deliver 1 MWh to the customer (1.075 MWh multiplied by 1-0.07 equals 1 MWh).

This unit process accounts for the electricity loss from transmission. Publicly available loss factors were converted to losses and used to develop a 25-75 confidence range for energy losses at transmission, primary and secondary distribution levels. Data sources for the transmission losses are transmission-owning utilities (utilities) and regional transmission organizations (RTOs) filings (PPL Corporation, 2012; FERC, 2012; AEP, 2012b) with the Federal Energy Regulatory Commission (FERC) and Open Access Transmission Tariff documents (Xcel Energy, 2012; PacifiCorp, 2013; Duke Energy Ohio, 2012). Utilities and RTOs file a request with FERC every time when they need to modify the loss compensation service of their Open Access Transmission Tariff (OATT). They submit as a single transmission loss factor value to FERC. A set of 24 different utilities was used to calculate transmission losses and the confidence range.

Figure 1: Unit Process Scope and Boundary

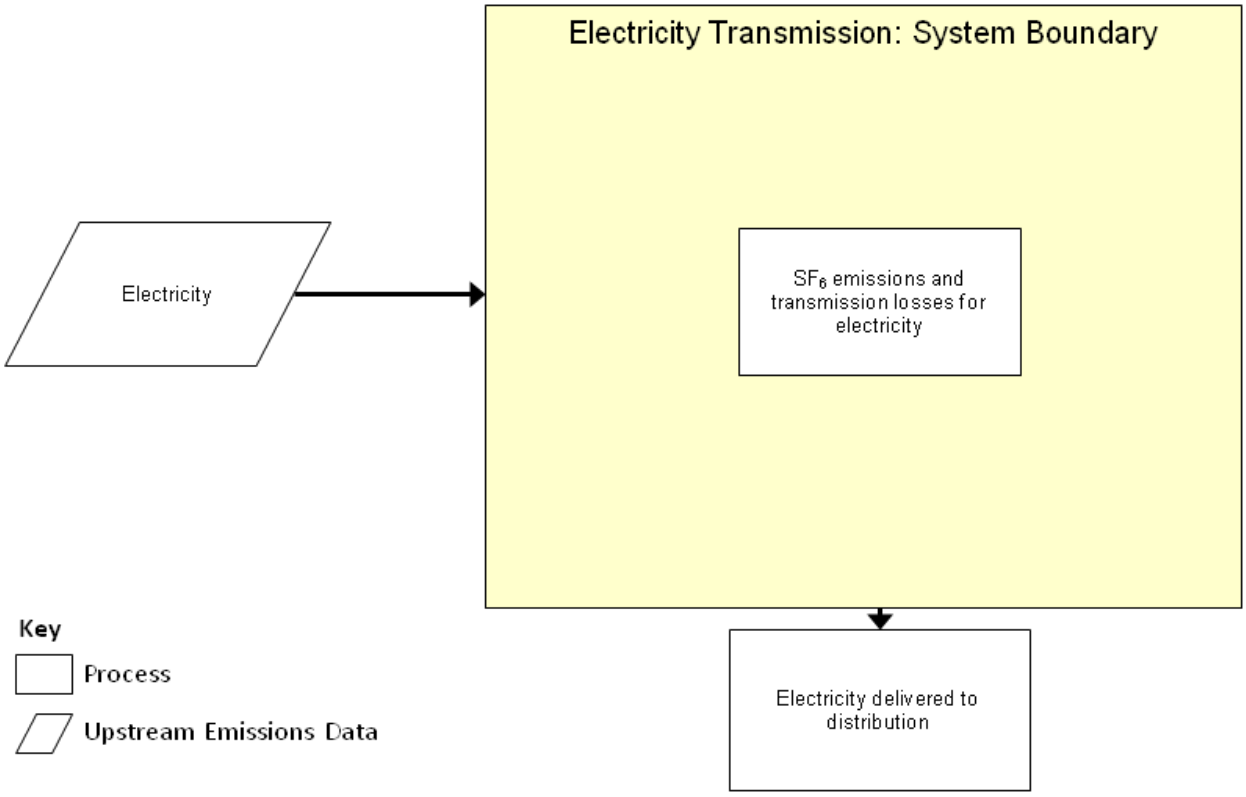

Table 1: Analysis of Electricity Transmission Losses

Property	Value
Average	3.05%
Maximum	6.32%
Third Quartile (Q3)	3.54%
First Quartile (Q1)	2.31%
Minimum	1.07%

Table 2: Unit Process Input and Output Flows

Flow Name	Value	Units (Per Reference Flow)
Inputs		
Electricity	1.0315	MWh
Outputs		
Electricity delivered to distribution	1.00	MWh
Sulfur Hexafluoride [Inorganic emissions to air]	7.51E-05	kg

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

Embedded Unit Processes

None.

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Section III: Document Control Information

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