NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Horizontal Turbine Hub, 1.5-6 MW Capacity, Manufacturing

Reference Flow: 1 piece (pcs) of Horizontal Turbine Hub, 1.5-6 MW Capacity

Brief Description: Models manufacturing of the hub, blade pitch mechanisms, and bearings of a variable megawatt (range 1.5-6 MW) capacity wind turbine. Assumes all components manufactured of cast iron and steel with negligible amounts of other materials.

Section I: Meta Data

Geographical Coverage: US **Region:** Average

Year Data Best Represents: 2010

Process Type: Manufacturing Process (MP)

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:

HT_CPTY	*Power production capacity of the wind turbine*
DIAMETER	*Diameter of the rotor*
NO_BLADES	*Number of blades per turbine*
MNU_WSTE	*Percentage of manufacturing waste in this process*
RECY_MAT	*Percentage of destruction and manufacturing waste to be recycled*
MJ_KG	*Amount of energy in the form of electricity used to manufacture per kg of blade-hub*

Tracked Input Flows:

Cast iron part [Metal parts]	*Cast iron used for hub manufacture*
Cold rolled steel [Metals]	*Steel used for hub manufacture*
Stainless steel cold roll, 431 [Metals]	Stainless steel used for hub manufacture
Power [Electric Power]	*Electricity used for hub manufacture*

Tracked Output Flows:

Horizontal Turbine Hub [Manufacturing]	*Manufacturing of a single piece of hub supporting multi-megawatt capacity horizontal wind turbines*
Unspecified scrap waste [Consumer waste]	*Mass of manufacturing waste that is landfilled*
Scrap waste [Waste for recovery]	*Mass of manufacturing waste that is recovered for recycling*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage3_M_HTurbine_Hub_1.5-6MW_2010.01.xls*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

The scope of this unit process encompasses the material and energy inputs for the manufacture a single hub for horizontal wind turbines with capacities ranging from 1.5 to 6.0 MW. The unit process is based on the reference flow of 1 pcs of hub. The relevant flows of this unit process are described below and shown in **Figure 1.**

This unit process is combined with other wind turbine component unit processes in an assembly unit process for a single horizontal wind turbine: DF_Stage3_M_Assembly_Turbine_2010.01.doc. The assembly unit process quantifies the number of each wind turbine component required to assemble a single horizontal wind turbine.

Boundary and Description

The mass relationships between turbine capacity and turbine components are based on equations developed using a wind turbine scaling model (NREL 2006). The conventional components are representative of 2002 technologies, while the advanced components

represent pending designs. The equations for estimating conventional and advanced hub mass are shown in **Table 1**.

The types of materials used for hub manufacture are based on estimated material profiles for wind turbine components (NREL 2006). Cast iron makes up about 63 percent of the hub mass for both conventional and advanced turbines (NREL 2006), while cold rolled steel makes up about 23 percent and stainless steel makes up the remainder. The percentages for estimating the material compositions of conventional and advanced hub pieces are shown in **Table 1**.

This unit process assumes that scrap material is generated by the manufacturing process at a rate of one percent of the weight of the finished hub piece. Of this manufacturing scrap, 90 percent is recovered for recycling and 10 percent is landfilled (Nalukowe *et al* 2006).

Figure 1 provides an overview of the boundary of this unit process. The cradle-to-gate emissions for the production of materials used for hub manufacture (e.g., cast iron, cold rolled steel, stainless steel) are calculated outside the boundary of this unit process and are based on profiles available within the life cycle inventory (LCI) databases.

Figure 1: Unit Process Scope and Boundary

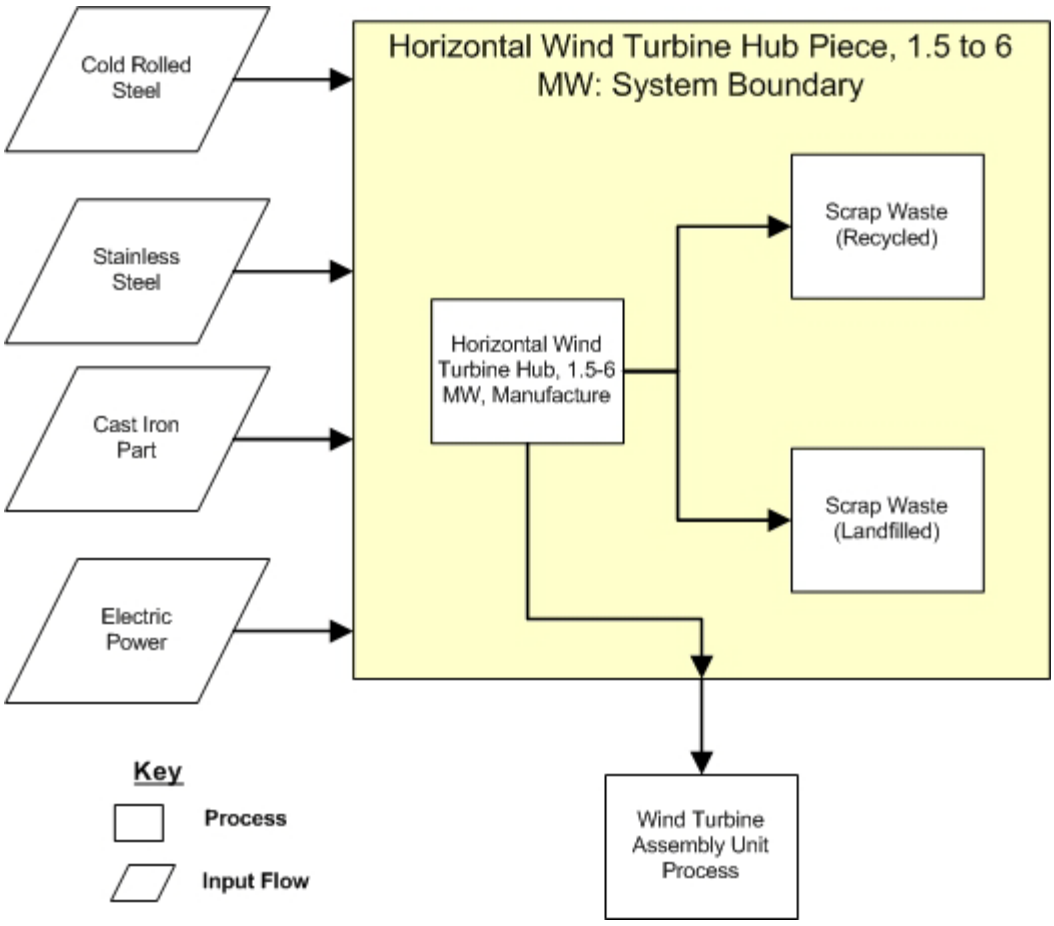

Table 1: Mass Scaling Equations for a Hub Piece

Component	Conventional Turbine	Advanced Turbine	Notes	Source
Mass scaling equation	(0.954 x B) + 5680.30	(0.954 x B) + 5680.30	B = single rotor blade mass in *kg*	NREL 2006
Cold rolled steel	100%	100%	none	NREL 2006

Table 2: Unit Process Input and Output Flows

Flow Name*	Conventional Turbine	Advanced Turbine	Units (Per Reference Flow)
Inputs			
Cast iron part [Metal parts]	10082	10082	kg
Cold rolled steel [Metals]	3588	3588	kg
Stainless steel cold roll, 431 [Metals]	2284	2284	kg
Power [Electric power]	44675	44675	MJ
Outputs			
Horizontal turbine hub [Manufacturing]	1.00	1.00	pcs
Unspecified scrap waste [Consumer waste]	1611	1611	kg
Scrap waste [Waste for recovery]	14503	14503	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 2.

Embedded Unit Processes

None.

References

NREL 2006	Fingersh, L. Hand, M. Laxson, A. 2006. *Wind Turbine Design Cost and Scaling Model.* National Renewable Energy Laboratory. NREL/TP-500-40566. Golden, Colorado. December 2006. (Accessed June 15, 2010).
Nalukowe *et al*. 2006	Nalukowe, B.B. Liu, J. Damien, W. Lukawski, T. 2006. *Life Cycle Assessment of a Wind Turbine*. May 22, 2006.

Section III: Document Control Information

Date Created: October 25, 2010

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

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