NETL Life Cycle Inventory Data
Process Documentation File

Process Name: DF_Stage3_M_HTurbine_Main_Shaft_1.5-6MW_2010.01

Reference Flow: 1 piece (pcs) of HTurbine Shafts & Bearings

Brief Description: Manufacture of shafts and bearings for a horizontal multi-capacity (1.5-6MW) wind turbine. Assumes shafts (main & low-speed) and bearings are manufactured entirely of cold rolled stainless 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:

DIAMETER	*Diameter of the rotor*
MNU_WSTE	*Percentage of manufacturing waste (scraps) in this process*
MJ_KG	*Required energy (electricity) to manufacture one kg of main shaft and bearings of the turbine*
ST_PER	*Percentage of steel scraps recovery*

Tracked Input Flows:

Stainless steel [Metals]	*Steel used for main shaft and bearings manufacture*
Power [Electric power]	*Electricity used for main shaft and bearings manufacture*

Tracked Output Flows:

Horizontal Turbine shafts and bearings [Manufacturing]	*Manufacturing of a single piece of main shaft and bearings 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_Main_Shaft_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 main shaft and bearings 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 main shaft and bearings. 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 main shaft and bearings mass are shown in **Table 1**.

The types of materials used for main shaft and bearings manufacture are based on estimated material profiles for wind turbine components (NREL 2006). Cold rolled steel is assumed to be 100 percent of the main shaft and bearings mass for both conventional and advanced turbines (NREL 2006), with negligible amounts of other materials. The percentages for estimating the material compositions of conventional and advanced main shaft and bearings 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 main shaft and bearings 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 main shaft and bearings manufacture (e.g., cold rolled 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

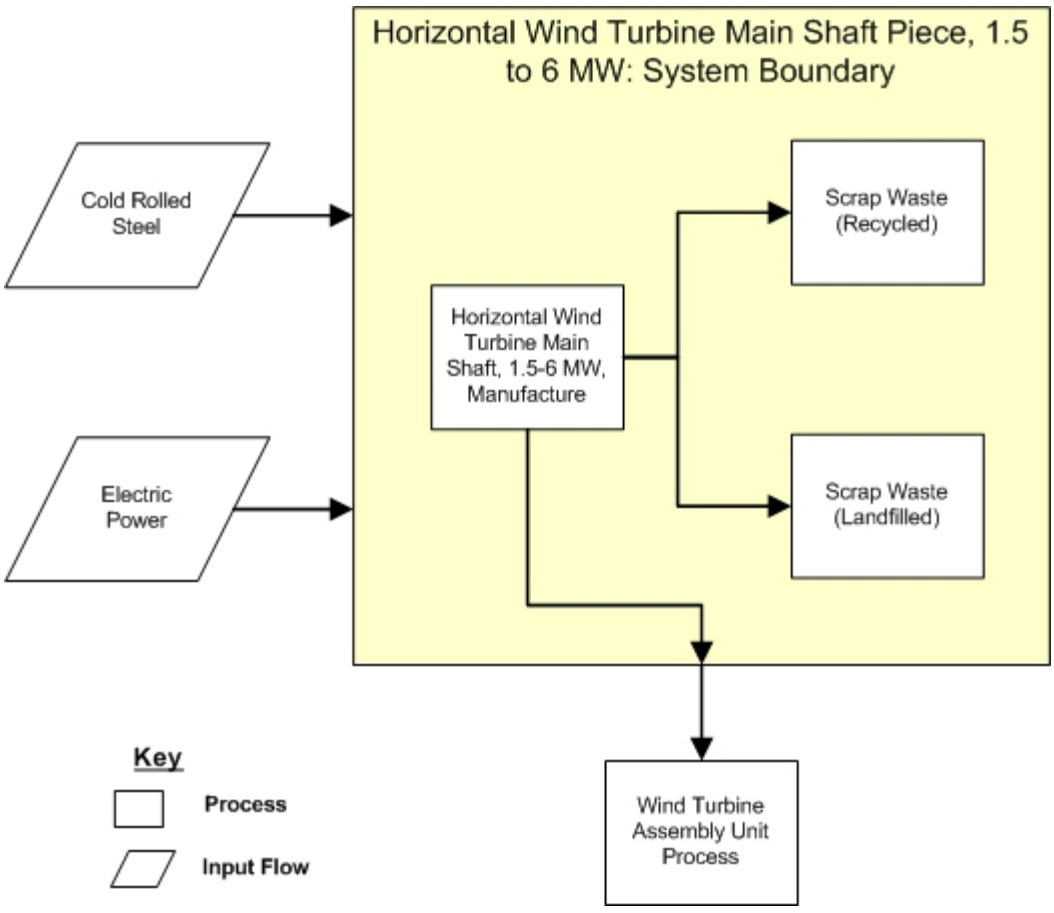

Table 1: Mass Scaling Equations for a Main Shaft and Bearings Piece

Component	Conventional Turbine	Advanced Turbine	Notes	Source
Mass scaling equation	1.6 x (0.0009 x $d^{3.314}$)	1.6 x (0.0009 x $d^{3.314}$)	d = rotor diameter in *m*	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			
Steel cold rolled (St) [Metals]	5241	5241	kg
Power [Electric power]	445491	445491	MJ
Outputs			
Horizontal Turbine Shafts & Bearings [Manufacturing]	1.00	1.00	pcs
Unspecified scrap waste [Consumer waste]	529.4	529.4	kg
Scrap waste [Waste for recovery]	4764	4764	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

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