NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Horizontal Wind Turbine Tower, 1.5-6 MW, Manufacturing

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

Brief Description: Assumes horizontal turbine tower manufactured entirely of cold rolled 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	*Select TECH_ID = 0 if Current Technology (> 2MW) OR TECH_ID = 1 if Advance Technology (< 2MW)*
DIAMETER	*Diameter of the rotor*
HUB_HGT	*Height of the Hub*
MNU_WSTE	*Percentage of manufacturing waste in this process*
MJ_KG	*Required energy (electricity) to manufacture one piece of horizontal tower of the turbine*
RECY_PER	*Recycling percentage of recyclable materials (steel, caste iron etc)*

Tracked Input Flows:

Steel cold rolled (St) [Metals]	*Steel used for tower manufacture*
Power [Electric Power]	*Electricity used for tower manufacture*

Tracked Output Flows:

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

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage3_M_HTurbine_Tower_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 tower 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 tower. 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 tower mass are shown in **Table 1**.

The types of materials used for tower manufacture are based on estimated material profiles for wind turbine components (NREL 2006). Cold rolled steel is assumed to be 100 percent of the tower 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 tower 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 tower 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 tower 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

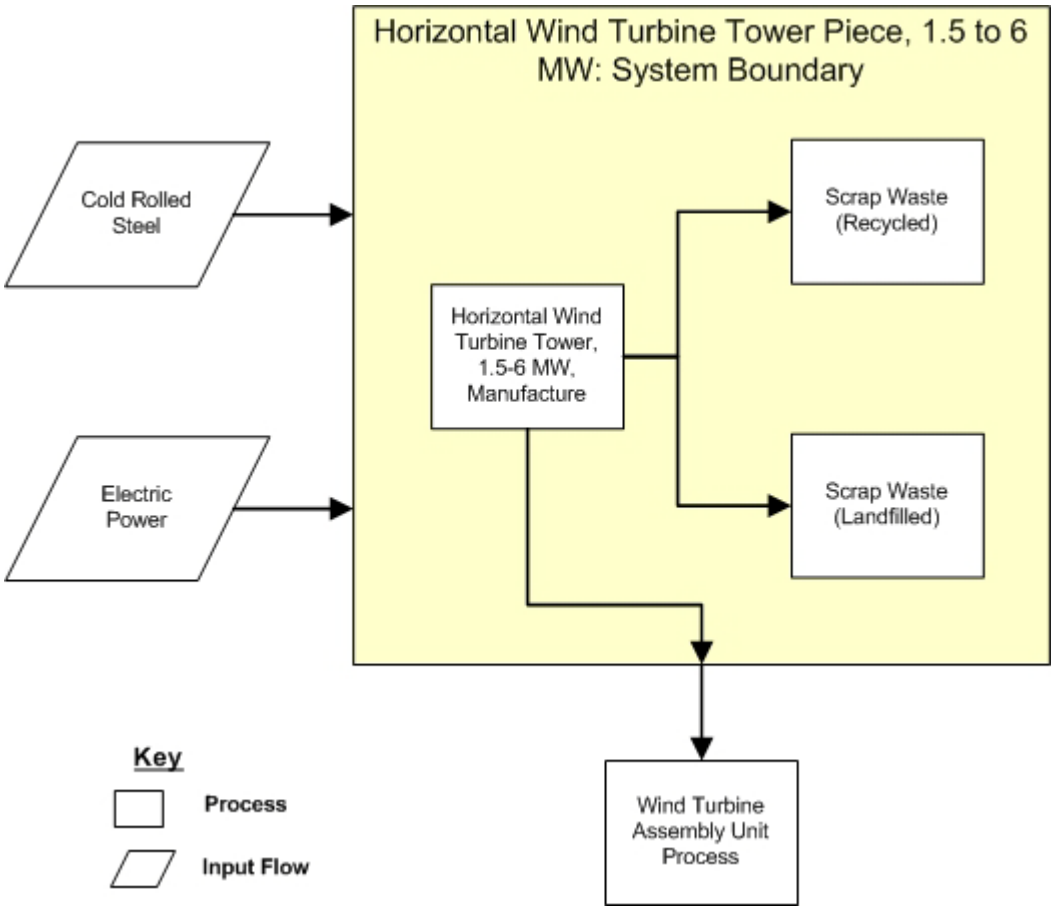

Table 1: Mass Scaling Equations for a Tower Piece

Component	Conventional Turbine	Advanced Turbine	Notes	Source
Mass scaling equation	0.3973 × swept area × hub height – 1414	0.2694 × swept area × hub height + 1779	swept area is in m^2 hub height is 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]	117787	117787	kg
Power [Electric power]	103652	103652	MJ
Outputs			
Tower [Manufacturing]	1.00	1.00	pcs
Scrap waste [Waste for recovery]	107068	107068	kg
Unspecified scrap waste [Consumer waste]	11896	11896	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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