NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Hydrokinetic Power, Construction

Reference Flow: 1 MWh of Electricity

Brief Description: This unit process calculates the construction materials that would be required for the installation of hydrokinetic turbines within a river. Hydrokinetic turbines do not require the installation of impoundments or dams.

Section I: Meta Data

Geographical Coverage: US **Region:** N/A

Year Data Best Represents: 2010

Process Type: Manufacturing Process (MP)

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:

CAPACITY_FAC	*Capacity factor expressed as a proportion*

Tracked Input Flows:

Steel Plate, BF (85% Recovery Rate) [Metals]	*Steel plate from blast furnace (BF) used to construct turbines, assumes 85% recycled/recovery rate*

Tracked Output Flows:

Electricity [Electric power]	*Electricity generated by the hydrokinetic turbines*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage3_C_Hydrokinetic_2011.01.xls*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

The scope of this unit process encompasses the weight of materials necessary to construct hydrokinetic turbines and associated equipment, with a capacity of 1 MW. The hydrokinetic equipment considered in this unit process consists of a vertical axis hydrokinetic turbine that is anchored to a small floating platform. Construction materials required for the turbine, platform, and other components required for the implementation of hydrokinetic power generation within a river are accounted for. The process is based on the reference flow of 1 megawatthour (MWh) of hydrokinetic electric power, as described below, and as shown in **Figure 1.** The hydrokinetic turbine, platform, and all other associated materials and facilities are assumed to be constructed entirely of steel, and other materials are assumed to be negligible. By default, all steel within this study was assumed to be steel plate, based on available GaBi profiles, unless other steel types were specified per available data, or a higher grade of steel would be required, per NETL engineering judgment. Therefore, all steel considered in this unit process was assumed to be steel plate.

This process is as the sole unit process under Life Cycle (LC) Stage #3, for the implementation of hydrokinetic power. At the time of publication of this document, no associated LC Stage #3 operations unit process had been completed, due to lack of additional operation period input or output flows, or emissions, that would be required for the operation of hydrokinetic power. Therefore, this unit process functions as the sole LC Stage #3 process within a hydrokinetic power LCA. Electricity produced within this unit process is transmitted via grid infrastructure (LC Stage #4) to its eventual end use under LC Stage #5.

Boundary and Description

Construction of the hydrokinetic turbine and associated facilities is based on manufacturer specifications for a 10 kW EnCurrent hydrokinetic turbine. The 10 kW turbine is vertical axis, and is rated to generate 10 kW of power at river flow rates of approximately 3 meters per second (m/s). The turbine can generate power at lower flow rates, however, according to available documentation, the amount of power that can be generated drops off quickly in slower moving waters. For instance, available manufacturer documentation indicates that the turbine can generate approximately 3 kW of power at water flow rates of 2 m/s, And slightly more than 1 kW of power at 1.5 m/s. The total mass of the turbine and associated facilities was found to be 639 kg for a single 10 kW turbine, which scales up to 63,865 kg for a facility designed for 1 MW.

Because power generation rate for the turbine is dependent upon the rate of water movement, this unit process assumes that the turbine would not function consistently at 100% capacity factor. To the contrary, the turbine would be subject to variation in capacity factor. Therefore, based on power output rating curves provided by the manufacturer, and based on professional judgment regarding flow rates, an average water velocity of 2.5 m/s was presumed, resulting in sufficient generation capacity to maintain 5.7 kW of power, on average, for each 10 kW turbine that would be employed. Capacity factor was included as a variable parameter so as to enable easy comparison and sensitivity analysis. NETL's suggested range for the capacity factor parameter is +/- 20%, or 0.46 to 0.68.

Figure 1 provides an overview of the boundary of this unit process. Emissions related to the physical assembly of the turbine and associated components (e.g., emitted while assembling the components of the turbine and associated facilities, including transport of those components) are not considered in this study. Upstream emissions from the production of raw materials used for the construction of the turbine and associated components (e.g., steel plate) are calculated outside the boundary of this unit process, based on proprietary profiles available within the GaBi model.

The total weight of a hydrokinetic turbine and associated components was readily available, but reliable data for the material breakdown of turbine subcomponents were not. Therefore, the facility is assumed to be composed entirely of steel plate (Steel plate, BF (85% Recovery Rate) [Metals]).

Table 1 shows relevant properties and assumptions used to estimate the amount of steel plate contained in a hydrokinetic turbine and associated equipment. The manufacturer show a total combined weight of 1,408 lbs (639 kg) for a 10 kW installation (Tideworks LLC 2010). Based on the assumption that the unit is constructed entirely out of steel plate, the total weight is assigned to this material. **Table 2** 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.

Figure 1: Unit Process Scope and Boundary

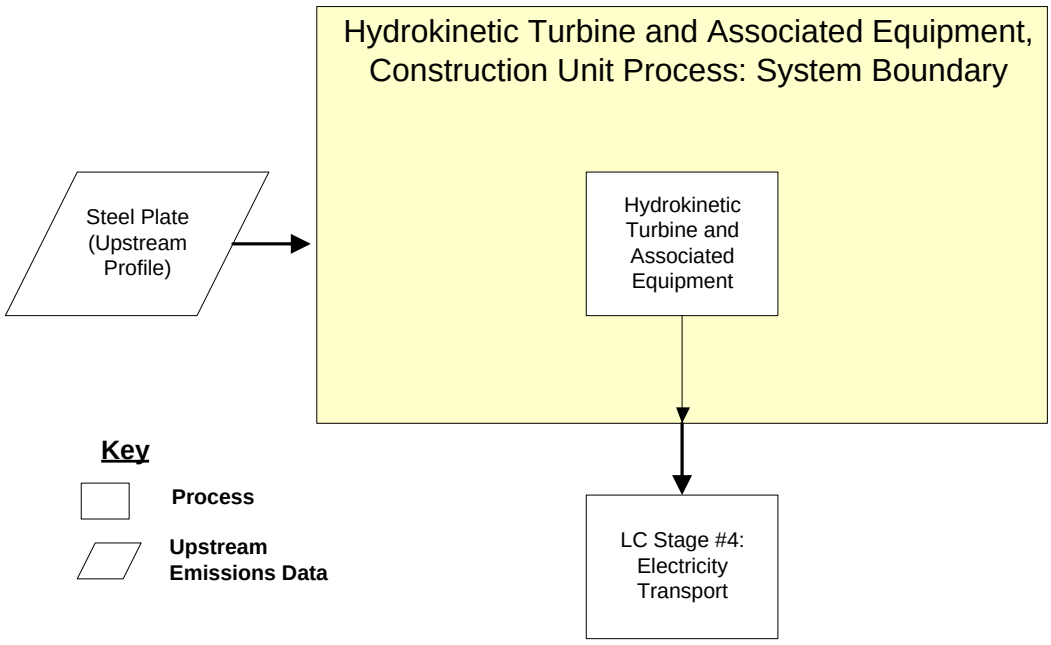

Table 1: Properties of the Hydrokinetic Turbine and Associated Equipment

Total Weight of Single Harvester	Weight	Reference
Unit Weight, kg (lbs)	639 (1,408)	TideWorks LLC 2010
Power Output at 3 m/s water speed	10 kW	TideWorks LLC 2010
Power Output at 1.5 m/s water speed	1 kW	TideWorks LLC 2010
Average Power Output	5.7 kW	NETL Engineering Judgment
Average Capacity Factor	0.57	NETL Engineering Judgment
Lifetime	20 years	NETL Engineering Judgment

Table 2: Unit Process Input and Output Flows

Flow Name*	Value	Units (Per Reference Flow)
Inputs		
Steel Plate, BF (85% Recovery Rate) [Metals]	0.6395	kg/MWh
Outputs		
Electricity [Electric Power]	1	MWh

* **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.

References

TideWorks LLC 2010. TideWorks, LLC. 2010. Final Application to FERC. P-13656-000. January 11, 2010.

Section III: Document Control Information

Date Created: September 7, 2011

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