NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Conventional Hydropower, Construction

Reference Flow: 1 MWh of Electricity

Brief Description: This unit process quantifies the construction requirements for either a concrete or an earthen dam, used for large scale conventional hydropower.

Section I: Meta Data

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

Year Data Best Represents: 1930-2011

Process Type: Installation Process (IP)

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:

DamType_switch	*Toggle between cement dam ("0") and earthen dam ("1")*
CapacityFac	*Capacity factor expressed as a proportion; varies regionally within the U.S.*
Lifetime	*Dam lifetime*

Tracked Input Flows:

Steel cold rolled (St) [Metals]	*Cold rolled steel used to construct dam, turbines, and associated equipment*

Steel Plate, BF (85% Recovery Rate) [Metals]	*Steel plate from blast furnace (BF) used to construct dam, pipes, and associated equipment, assumes 85 percent recycled/recovery rate*
Concrete, ready mix, R-5-0 [Concrete_Cement]	*Concrete used to construct dam*

Tracked Output Flows:

Electricity [Electric power]	*Electricity generated by the conventional hydropower dam*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage3_C_Conventional_Hydropower_Dam_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 a fraction of a conventional hydropower dam and associated infrastructure for a concrete dam, or the airborne emissions associated with the construction of an earthen dam, used for the generation of 1 MWh of conventional hydropower. The equipment considered in this unit process consists of either a concrete dam and associated turbines and other facilities required for power generation, or an earthen dam. The process is based on the reference flow of 1 megawatthour (MWh) of conventional hydroelectric power, as described below, and as shown in **Figure 1.** The concrete dam and power plant is assumed to be constructed entirely of concrete, steel plate, and cold rolled steel. The earthen dam is assumed to be constructed entirely of dirt/clay aggregate, extracted near the dam site. All other materials are assumed to be negligible.

This process functions in tandem with a conventional hydropower operations unit process for LC Stage #3. Because no fuel production or transport occurs for hydropower, there are no LC Stage #1 or #2 unit processes that are applied in support of the conventional hydropower LCA. Flows from this unit process are combined with inputs and emissions associated with conventional hydropower operations (evaluated in a separate unit process), in order to evaluate the total environmental burdens associated with conventional hydropower production.

Boundary and Description

This unit process includes an adjustable parameter that allows the user to toggle between construction values for a concrete dam and an earthen dam. Data included for construction of the concrete dam was taken from available documentation on Hoover Dam, located along the Colorado River in Arizona. Hoover Dam was selected as a representative dam due to its intermediate to large size, combined with a high availability of construction materials data for the dam. The dam was constructed between 1931 and 1936. Construction materials are accounted for, but emissions associated with the operation of cranes and other facilities needed for dam construction are not evaluated. Construction materials, nameplate generation capacity, and other specifications for the dam are shown in **Table 1**, below (Bureau of Reclamation 2005).

Construction figures for an earthen dam were calculated in a slightly different manner. NETL's review of available data indicated that construction of earthen dams typically relies on earthen materials that are sourced locally to the dam construction site, such as within the reservoir basin for the new dam. To that end, application of a materials profile, for instance as is done within this unit process for concrete in support of the concrete dam, was determined to be not applicable to an earthen dam construction. Instead, earthen dam construction was evaluated based on construction emissions required for the movement of clay and other soils from the newly formed reservoir bottom to the dam, for dam construction. Emission values were based on data available for the construction of the Los Vaqueros Reservoir, an earthen dam that was constructed in the 1990s, that is currently undergoing expansion. Emission values shown in **Table 1** include mitigation applied for the reduction of NOx, carbon monoxide, and particulate matter (Contra Costa Water District 2009).

Generation capacity for the earthen dam was estimated based on a dam of similar size and capacity, also located in California. The dam for which construction data were available is used as an off-stream storage reservoir, and therefore power generation data does not match that for a conventional reservoir. Therefore, nameplate capacity from the Whiskeytown Lake Dam, located in Northern California, was applied to the earthen dam used in this unit process (California Department of Water Resources 2005).

Capacity factor is a key adjustable parameter in support of this unit process, because it strongly influences the amount of electricity that can be generated over a dam's lifetime. Capacity factor was calculated based on regional average capacity factors for the U.S. West, Southwest, South, Midwest, and Northeast. These were determined using data from the Velocity Suite Database (Ventyx 2011). Location and capacity factor were queried for approximately 150 U.S. reservoirs, having nameplate capacities of at least 100 MW. Data were acquired for 2002 through 2010, and average capacity factors were generated for each U.S. region. These are as follows: Northeast, 52.0 percent; West, 42.7 percent; Midwest, 41.9 percent; Alaska, 36.3 percent; South, 29.5 percent; and Southwest, 26.3 percent.

Dam lifetime is also included as an adjustable parameter. Based on NETL judgment, this parameter has a default value of 80 years, and can be varied from 60 to 100 years.

Figure 1 provides an overview of the boundary of this unit process. As shown, steel plate, cold rolled steel, and concrete are considered upstream emission profiles that are input into the unit process. Emissions associated with earthen dam construction are calculated within the boundary of the unit process. Emissions associated with the use of cranes and other construction activities, in support of the concrete dam, were not considered. Upstream emissions from the production of raw materials used for the construction of the turbine and associated components (e.g., steel plate, cold rolled steel, and concrete) are calculated outside the boundary of this unit process, based on proprietary profiles available within the GaBi model.

Table 1 shows relevant properties and assumptions used to estimate materials flows and emissions that would result from the construction of a conventional hydropower dam. **Table 2** provides a summary of modeled input and output flows for a conventional concrete dam. Additional detail regarding input and output flows, including calculation methods and values for alternative adjustable parameter values, is contained in the associated DS.

Figure 1: Unit Process Scope and Boundary

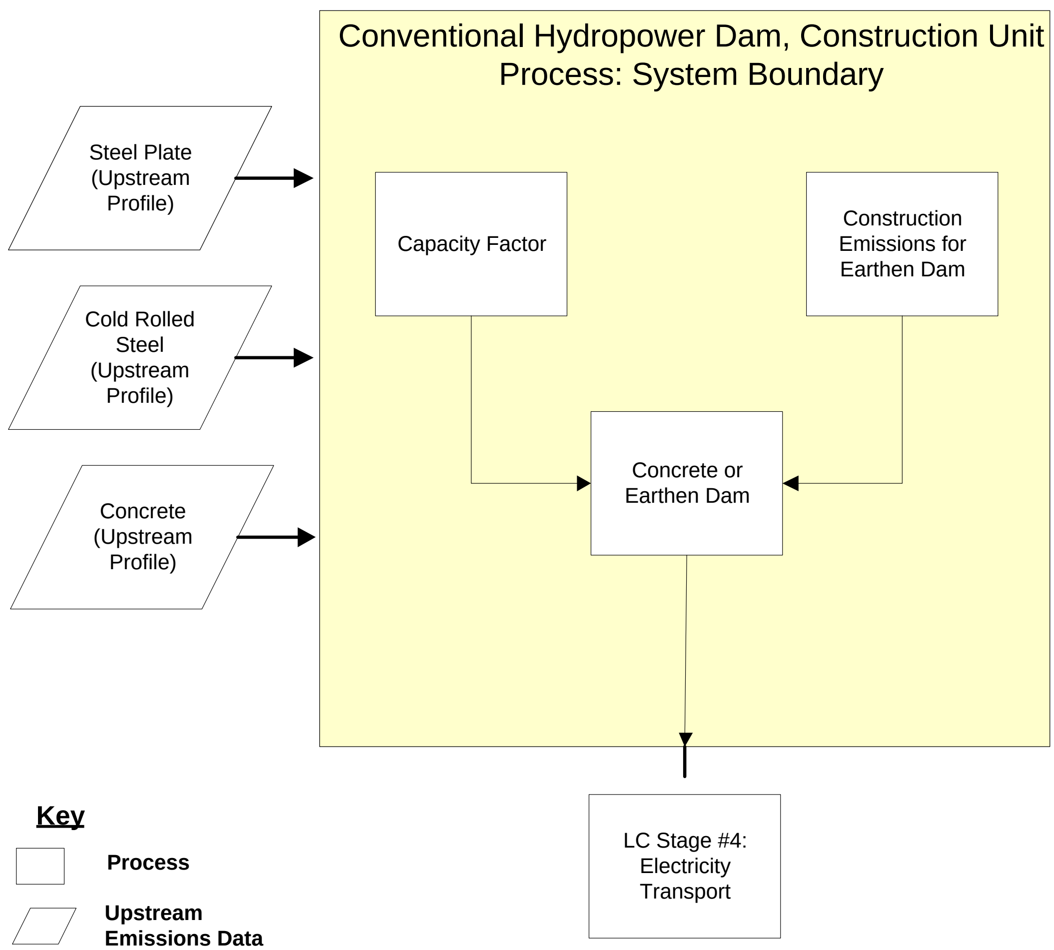

Table 1: Properties of Hydropower Dams Considered

Item	Weight	Reference
Concrete Dam		
Concrete, kg (lbs)	7.667E+09 (1.690E+10)	U.S. Bureau of Reclamation 2005
Cold Rolled Steel, kg (lbs)	3.841E+07 (8.467E+07)	U.S. Bureau of Reclamation 2005
Steel Plate, kg (lbs)	4.536E+07 (1.000E+08)	U.S. Bureau of Reclamation 2005
Nameplate Capacity (MW)	2080	U.S. Bureau of Reclamation 2005
Earthen Dam		
Carbon Monoxide Emissions for Dam Construction, kg (lbs)	3.627E+06 (7.996E+06)	Contra Costa Water District 2009
NOx Emissions for Dam Construction, kg (lbs)	4.215E+06 (9.292E+06)	Contra Costa Water District 2009
PM10 Emissions for Dam Construction, kg (lbs)	1.911E+06 (4.214E+06)	Contra Costa Water District 2009
CO_2 Emissions for Dam Construction, kg (lbs)	1.216E+09 (2.680E+09)	Contra Costa Water District 2009
Nameplate Capacity (MW)	2080	Contra Costa Water District 2009
Lifetime	80 years	Contra Costa Water District 2009

Table 2: Unit Process Input and Output Flows

Flow Name*	Value	Units (Per Reference Flow)
Inputs**		
Steel cold rolled (St) [Metals]	0.0711	kg/MWh
Steel plate, BF (85% Recovery Rate) [Metals]	0.0840	kg/MWh
Concrete, ready mix, R-5-0 [Concrete_Cement]	14.2	kg/MWh
Outputs**		
Electricity [Electric Power]	1.00	kg/MWh
Carbon dioxide [Inorganic emissions to air]	0.00	kg/MWh
Nitrogen oxides [Inorganic emissions to air]	0.00	kg/MWh
Carbon monoxide [Inorganic emissions to air]	0.00	kg/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.

**Values shown are default values for a concrete dam at 37% capacity factor and 80 year lifetime. Adjustable parameters in the associated DS may be varied to determine values for an earthen dam and/or other capacity factors and dam lifetimes.

Embedded Unit Processes

None.

References

California Department of Water Resources 2005.	California Department of Water Resources. 2005. California Reservoir Summary. Available at: http://www.waterplan.water.ca.gov/docs/cwpu2005/vol4/vol4-infrastructure-careservoirsummary.pdf (Accessed May 27, 2011).
Contra Costa Water District 2009	Contra Costa Water District. 2009. Los Vaqueros Reservoir Expansion Project EIS/EIR. February, 2009.
U.S. Bureau of Reclamation 2005	U.S. Bureau of Reclamation. 2005. The Colorado River and Hoover Dam Facts and Figures. Available at: http://www.usbr.gov/lc/region/pao/brochures/faq.html#concrete (Accessed May 27, 2011).
Ventyx 2011	Ventyx. 2011. Velocity Suite Databases. Available for purchase at http://www.ventyx.com/velocity/energy-market-data.asp (Accessed May 25, 2011).

Section III: Document Control Information

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