NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Construction of a 250 MW solar thermal collector field

Reference Flow: 1 MWh of solar thermal electricity generation

Brief Description: Construction of a collector field for a 250 MW solar thermal power plant

Section I: Meta Data

Geographical Coverage: US **Region:** U.S. Southwest

Year Data Best Represents: 2010

Process Type: Energy Conversion (EC)

Process Scope: Gate-to-Gate Process (GG)

Allocation Applied: No

Completeness: Individual 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:

Steel_share	*[dimensionless] Fraction of solar collector that is steel*
Capacity	*[MW] Capacity of solar thermal facility*
CF	*[dimensionless] Capacity factor of solar thermal facility*
Life	*[yr] Life of solar thermal facility*
Dens_collectors	*[kg/m2] Mass per unit area of solar collectors*
Insolation	*[MW/m2] Intensity of solar radiation*
STEefficiency	*[dimensionless] Solar to electric efficiency*

Tracked Input Flows:

Heat transfer fluid	*[kg/MWh] Heat transfer fluid that is circulated through the solar thermal system.*
Steel	*[kg/MWh] Steel used for construction of solar collectors*
Glass	*[kg/MWh] Glass used for construction of solar collectors*

Tracked Output Flows:

Electricity [Valuable Substance]	*Electricity produced by the solar thermal power plant*

Section II: Process Description

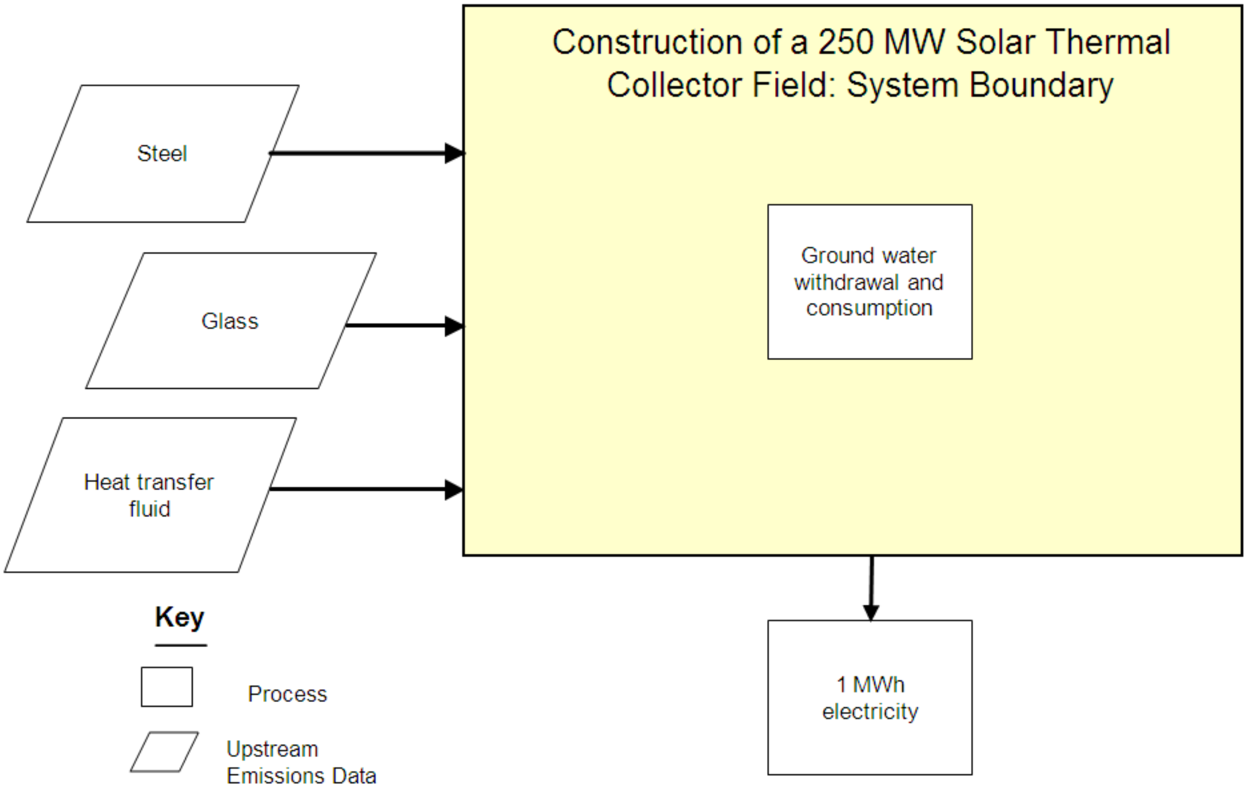
Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage3_Solar_Thermal_Construction_2011.01.xls*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

The scope of this unit process covers the construction of the energy conversion facility (ECF), in this case the solar thermal power plant, as shown in **Figure 1**. The inputs include construction materials (specifically, glass and steel) as well as an initial charge of heat transfer fluid. The output of this unit process is one MWh of electricity is delivered to the life cycle (LC) Stage #4 (Transmission and Distribution) boundary.

Figure 1: Unit Process Scope and Boundary



Boundary and Description

This unit process accounts for the construction of a collector field for a 250 MW solar thermal facility, which is part of an energy conversion facility categorized by LC Stage #3 of NETL's LCA framework. The collector field consists of parabolic trough collectors (made of steel and glass) that focus solar energy on a pipe that circulates heat transfer fluid between the collector field and a power generation system. This unit process accounts for the construction of the collector field only, not the associated power generation system.

The average capacity factor of a solar thermal power plant is 27.3 percent. For a 250 MW installation, this translates to 600,000 MWh of electricity produced per year. The plant has an operating life of 30 years (BLM 2010). All construction materials and installation requirements are divided by the lifetime electricity production (30 years times 600,000 MWh/yr) to arrive at the share of construction and installation burdens per unit of solar thermal electricity production.

Water is used during the construction of the solar thermal facility for dust suppression. According to the environmental impact statement for the Genesis Solar Energy Project (BLM 2010), 2,600 acre-feet of groundwater are used during the construction of a 250 MW facility. An acre-foot of water is equal to 1,234,000 kg of water. Applying this conversion factor to the report volume of groundwater translates to 3.207 billion kg of water for the construction of the facility.

The environmental impact statement (EIS) for the Genesis Solar Energy Project (BLM 2010) provides information on the heat transfer fluid used by the solar thermal facility (BLM 2010).

The total volume of heat transfer fluid for a 250 MW facility is 2 million gallons of Therminol, a proprietary heat transfer fluid comprised of a mix of organic compounds (BLM 2010; Solutia Inc. 2011). No life cycle data are available for the production of Therminol, and thus this analysis uses life cycle data for the production of benzene as a proxy for Therminol. The density of Therminol is 1,005 kg/m^3 (8.39 lb/gal) (Solutia Inc. 2011). Factoring the total volume (2 million gallons) and density (8.39 lb/gal) and converting to metric units gives a total mass of 7.610 million kg of heat transfer fluid contained by the solar thermal system.

The mass per unit area of a solar collector ranges from 24.0 to 33.0 kg/m^2 (Sagent & Lundy LLC Consulting Group 2003) with 28.5 kg/m^2 as the midpoint. The average solar radiation (insolation) of a solar thermal power plant in the Southwest U.S. is 8.054 (kWh/m^2)/day (Sagent & Lundy LLC Consulting Group 2003). In terms of power per unit area, this insolation is equivalent to 3.36E-04 MW/m^2. The solar-to-electric efficiency of a solar thermal system 14.3 percent, with low and high bounds of 10.6 and 17.0 percent respectively (Sagent & Lundy LLC Consulting Group 2003). All of these factors are parameterized in the unit process so the total collector area per MWh of electricity production can be calculated.

No data are available for a detailed material profile of a parabolic trough. This analysis assumes that 75 percent of the collector is comprised of carbon steel, and the remaining 25 percent is comprised of glass. These material shares are parameterized in the unit process to facilitate sensitivity analysis.

Table 1 shows key parameters for a solar thermal power facility, and **Table 2** shows the input and output flows of this unit process.

Table 1: Solar Thermal Collector (Parabolic Trough) Construction Modeling Parameters

Parameter	Nominal Value	Units
Net capacity	250	MW
Capacity factor	27.3	%
Annual electricity production	600,000	MWh
Plant life	30	yrs
Total mass of heat transfer fluid in system	7.610E+06	kg
Parabolic trough mass per unit area	28.5	kg/m^2
Average solar radiation (insolation)	8.054	(kWh/m^2)/day
Solar-to-electric efficiency	14.3	%
Share of carbon steel in parabolic trough	75	%
Share of glass in parabolic trough	25	%

Table 2: Unit Process Input and Output Flows

Flow Name	Value	Units (Per Reference Flow)
Inputs		
Heat transfer fluid	4.243E-01	kg
Steel	6.208E+00	kg
Glass	2.069E+00	kg
Water (ground water) [Water]	1.788E+02	kg
Outputs		
Solar Thermal Electricity Generation	1	MWh

Embedded Unit Processes

none

References

BLM 2010 U.S. Bureau of Land Management. (2010). Plan Amendment/Final EIS for the Genesis Solar Energy Project. http://www.blm.gov/ca/st/en/fo/palmsprings/Solar_Projects/Genesis_Ford_Dry_Lake.html (Accessed September 30, 2011)

Sagent & Lundy LLC Consulting Group. (2003). Assessment of Parabolic Trough and Power Tower Solar Technology Cost and Performance Forecasts.

Solutia Inc. (2011). Therminol 66 -- High temperature liquid phase heat transfer fluid. http://www.therminol.com/pages/products/66.asp (Accessed October 10, 2011)

Section III: Document Control Information

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Original/no revisions

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