NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Solar Thermal Power Plant, Assembly

Reference Flow: 1 MWh of electricity

Brief Description: This assembly process apportions the construction, installation, and operations requirements of equipment and materials used in the assembly of a solar thermal power plant.

Section I: Meta Data

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

Year Data Best Represents: 2008

Process Type: Installation Process (IP)

Process Scope: Cradle-to-Gate Process (CG)

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:

CONS_PCS	*The number of construction pieces per MWh of solar thermal electricity generation*

Tracked Input Flows:

Trunkline Construction	*Pieces of trunkline construction needed over the lifetime of the energy conversion facility (solar thermal), normalized to 1 MWh of electricity*

Plant Construction	*Pieces of plant construction needed over the lifetime of the energy conversion facility (solar thermal), normalized to 1 MWh of electricity*
Solar Collector Construction	*Pieces of solar collector construction needed over the lifetime of the energy conversion facility (solar thermal), normalized to 1 MWh of electricity*
Solar Thermal Operation	*Pieces of solar thermal operation needed over the lifetime of the energy conversion facility (solar thermal), normalized to 1 MWh of electricity*

Tracked Output Flows:

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

Section II: Process Description

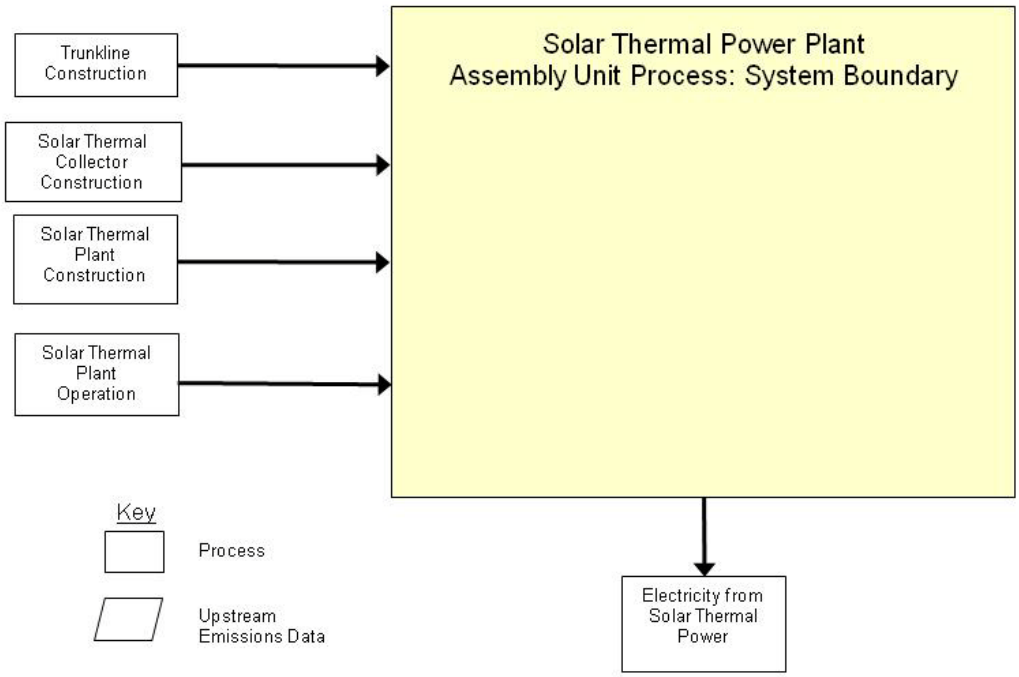
Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage3_Assembly_Solar_Thermal_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 and installation of the energy conversion facility (ECF), in this case the solar thermal power plant, along with the supporting infrastructure required to operate the plant and connect it to the electrical grid as seen in **Figure 1**. At the end, 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

LC Stage #1 or RMA (raw material acquisition) is not relevant to solar thermal power because solar thermal energy is a natural resource that does not require anthropogenic inputs prior to power generation. LC Stage #2 or RMT (raw material transport) is not relevant to solar thermal power because it uses a natural energy source that does not require anthropogenic inputs prior to power generation.

Four key unit processes were identified for the construction and operation of a solar thermal power plant:

- Solar thermal collector construction and installation
- Power plant construction and installation
- Solar thermal power plant operation
- Trunkline construction and operation

The data used for these four processes are described below.

The inputs to the solar thermal collector construction unit process are steel plate and glass, which comprise the solar collector. The total mass of the solar collectors is determined by the size of the plant, the conversion efficiency from solar energy to electricity (STE), the intensity of solar radiation (insolation), and the total area of solar collectors at the site. The unit process also includes inputs for the initial charge of heat transfer fluid (HTF) into the plant and water use during the construction of the solar

thermal plant. The energy and material flows for the upstream production and delivery of steel, glass, and heat transfer fluid are not included in this unit process but are accounted for by other unit process. The process is based on the reference flow of one piece of solar collector construction and installation per one MWh of electricity produced.

The balance of the solar thermal power plant was modeled by using the natural gas combined cycle (NGCC) plant construction and installation unit process. Inputs to the unit process for the construction of the plant include steel plate, steel pipe, aluminum sheet, cast iron, and concrete. These inputs were scaled in the assembly based on the design capacity of the plant. The energy and material flows for the upstream production and delivery of steel, concrete, aluminum, and cast iron are not included in this unit process but are accounted for by other unit process. Diesel, water, and emissions associated with plant installation are also included and were also scaled based on the size of the plant. The NGCC construction unit process had a 50-mile trunkline already built into the model; however, in order to view the trunkline impacts separately and parameterize the distance, that trunkline was removed and replaced with the standalone unit process.

The solar thermal power plant operations unit process accounts for diesel, gasoline, and natural gas combustion for auxiliary processes at the solar thermal power plant. Diesel fuel is used to supply both a fire pump and an emergency generator. Natural gas is used to supply an auxiliary boiler. Gasoline is used to fuel maintenance vehicles at the facility. This unit process accounts for direct combustion emissions of all three fuels, but does not include upstream acquisition and transport. Those impacts are accounted for by other unit processes. The final input to this unit process is additional HTF that is added to account for system losses. An upstream unit process accounts for the emissions associated with the production of the heat transfer fluid

The trunkline unit process originally developed for modeling a 200 MW onshore wind farm was used as a proxy for the trunkline for the solar thermal power plant. The unit process was modified to all for the parameterization of capacity factor, plant design net electricity output, and plant lifetime to reflect the difference between the solar thermal plant and the wind farm. The trunkline distance was already parameterized in the unit process. This unit process provides a summary of relevant input and output flows associated with the construction of a trunkline that connects the solar thermal power plant to the main electricity transmission grid. Key components include steel towers, concrete foundations, and steel-clad aluminum conductors. The lifetime electricity throughput of the trunkline is estimated in order to express the inputs and outputs on the basis of mass of materials per one MWh of electricity transport.

Table 1: Solar Thermal Power Modeling Parameters

Parameter	Nominal Value	Units
Net Capacity	250	MW
Capacity Factor	0.2730	proportion
Plant Life	30	years
Trunkline Distance	25.00 (40.23)	miles (km)
Solar to Electric Conversion Efficiency	0.1430	proportion
Intensity of Solar Radiation (Insolation)	3.558E-04	MW/m^2
Solar Collector Density	28.50	kg/m^2
Steel Portion of Collector Material	0.7500	proportion

Table 2: Unit Process Input and Output Flows

Flow Name	Value	Units (Per Reference Flow)
Inputs		
Trunkline Construction [Installation]	5.575E-08	pcs
Solar Thermal Collector Construction [Installation]	5.575E-08	pcs
Plant Construction and Installation [Installation]	5.575E-08	pcs
Solar Thermal Power Plant Operation [Operation]	5.575E-08	pcs
Outputs		
Electricity [Valuable Substance]	1	MWh

Embedded Unit Processes

NETL (2010). *NETL Life Cycle Inventory Data – Unit Process: Trunkline Construction.* U.S. Department of Energy, National Energy Technology Laboratory. Last Updated: October 2010 (version 01). www.netl.doe.gov/energy-analyses (http://www.netl.doe.gov/energy-analyses)

NETL (2010). *NETL Life Cycle Inventory Data – Unit Process: Natural Gas Combined Cycle Power Plant Construction-Installation.* U.S. Department of Energy, National Energy Technology Laboratory. Last Updated: May 2010 (version 01). www.netl.doe.gov/energy-analyses (http://www.netl.doe.gov/energy-analyses)

NETL (2011). *NETL Life Cycle Inventory Data – Unit Process: Solar Thermal Collector Field, Construction.* U.S. Department of Energy, National Energy Technology Laboratory. Last Updated: October 2011 (version 01). www.netl.doe.gov/energy-analyses (http://www.netl.doe.gov/energy-analyses)

NETL (2011). *NETL Life Cycle Inventory Data – Unit Process: Solar Thermal Power Plant, Operation.* U.S. Department of Energy, National Energy Technology Laboratory. Last Updated: October 2011 (version 01). www.netl.doe.gov/energy-analyses (http://www.netl.doe.gov/energy-analyses)

References

None.

Section III: Document Control Information

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Section IV: Disclaimer