NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Geothermal Power Plant Assembly, Construction

Reference Flow: 1 MWh of electricity

Brief Description: This assembly process apportions the construction and installation requirements of equipment and materials used in the assembly of a geothermal 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 geothermal electricity generation*

Tracked Input Flows:

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

Geothermal Well Construction	*Pieces of geothermal well construction needed over the lifetime of the energy conversion facility (geothermal), normalized to 1 MWh of electricity*
Plant Construction	*Pieces of plant construction needed over the lifetime of the energy conversion facility (geothermal), normalized to 1 MWh of electricity*
Access Road Construction	*Pieces of access road construction needed over the lifetime of the energy conversion facility (geothermal), normalized to 1 MWh of electricity*
Pipeline Construction	*Pieces of pipeline construction needed over the lifetime of the energy conversion facility (geothermal), normalized to 1 MWh of electricity*

Tracked Output Flows:

Electricity [Valuable Substance]	*Electricity produced by the geothermal power plant*

Section II: Process Description

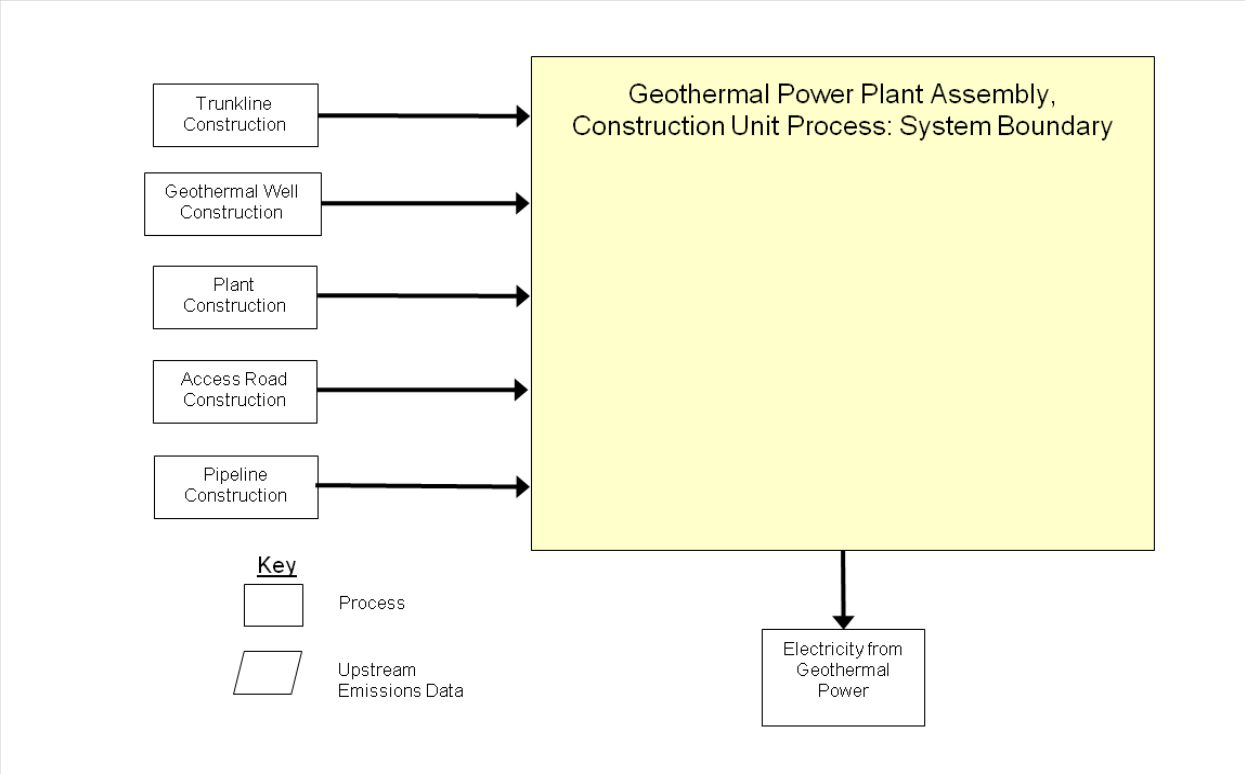
Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage3_Assembly_Geothermal_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 geothermal 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 geothermal power because geothermal 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 geothermal power because it uses a natural energy source that does not require anthropogenic inputs prior to power generation.

The steady state operation of the flash steam geothermal power plant does not use any purchased fuels or result in direct environmental emissions; thus, this analysis does not have a unit process for the operation of a geothermal power plant.

The LCA model of this analysis uses a screening approach, which means that proxy data were used instead of developing new data specific to geothermal systems. Five key existing unit processes were identified for the construction and operation of a flash steam geothermal power plant:

- Well construction and installation
- Power plant construction and installation
- Pipeline construction and installation
- Trunkline construction and operation
- Access road construction

The data used for these five processes are described below.

The natural gas conventional onshore well construction unit process was used as a proxy for geothermal well construction and installation. The unit process was modified slightly to account for the difference in functional unit. The natural gas extraction model is based on one kg of natural gas output, whereas the geothermal power plant is based on one MWh of electricity. The inputs to this unit process are steel pipe and concrete (which are used as casing materials for the well) and diesel (which is combusted in drilling equipment during well installation). The energy and material flows for the upstream production and delivery of steel, concrete, and diesel are not included in this unit process but are accounted for by other unit process. The output of this unit process is the fraction of the well materials and installation energy that is attributable to one MWh of geothermal produced electricity. This unit process also accounts for environmental emissions that are directly released by the combustion of diesel during well installation.

The balance of the geothermal 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 process is based on the reference flow of one piece of geothermal power plant construction and installation per MWh of electricity produced. 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 pipeline used to transport fluid from the well to the balance of the geothermal plant was modeled using the natural gas pipeline construction/installation unit process. This process estimates the emissions consistent with welded steel pipeline manufacturing, installation and deinstallation. The process includes heavy construction equipment exhaust emissions, emissions from transport of pipes and associated materials (200 miles round-trip), and fugitive dust. The reference flow of this process is one mile of onshore pipeline (installed)

The trunkline unit process originally developed for modeling a 200 MW onshore wind farm was used as a proxy for the trunkline for the geothermal 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 geothermal 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 geothermal 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.

The access road unit process covers the materials required for the construction of a (linear) meter of gravel road, used on site at a geothermal power plant, to facilitate the use of large/heavy transport trucks and other heavy duty vehicles for well installation and maintenance. The road is assumed to be constructed entirely of gravel. Installation of the road on site is presumed to require conventional diesel fuel for the use of grading and other construction equipment. The process is based on the reference flow of one meter of gravel road per MWh of electricity output from the geothermal power plant.

Table 1: Geothermal Power Modeling Parameters

Parameter	Nominal Value	Units
Net capacity	50	MW
Capacity factor	90	%
Depth per well	10,600 (3,230)	ft (m)
Number of production wells	25	count
Number of injection wells	10	count
Plant life	25	years
Trunkline distance	25.0 (40.2)	miles (km)

Table 2: Unit Process Input and Output Flows

Flow Name	Value	Units (Per Reference Flow)
Inputs		
Trunkline Construction [Installation]	1.015E-07	pcs
Geothermal Well Construction [Installation]	1.015E-07	pcs
Plant Construction and Installation [Installation]	1.015E-07	pcs
Access Road Construction [Installation]	1.015E-07	pcs
Pipeline Construction [Installation]	1.015E-07	pcs
Outputs		
Electricity [Valuable Substance]	1	MWh

Embedded Unit Processes

NETL (2010). *NETL Life Cycle Inventory Data – Unit Process: Natural Gas Well Construction and Installation (conventional onshore).* 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: Gravel Road, 12 Inch Deep Roadbed, Construction .* U.S. Department of Energy, National Energy Technology Laboratory. Last Updated: February 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: 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 (2010). *NETL Life Cycle Inventory Data – Unit Process: Onshore Pipeline Installation and Deinstallation.* U.S. Department of Energy, National Energy Technology Laboratory. Last Updated: January 2010 (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