NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Carbon Dioxide Well Construction and Installation

Reference Flow: 1 pcs of Salt Dome CO2 Well

Brief Description: Materials of construction and installation fuels and emissions for a carbon dioxide well.

Section I: Meta Data

Geographical Coverage: United States **Region:** Colorado and New Mexico

Year Data Best Represents: 2012

Process Type: Installation Process (IP)

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

Allocation Applied: No

Completeness: All 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	☐ Other
Releases to Water:	☐ Inorganic	☐ Organic Emissions	☐ Other
Water Usage:	☑ Water Consumption	☐ Water Demand (throughput)	
Releases to Soil:	☐ Inorganic Releases	☐ Organic Releases	☐ Other

Adjustable Process Parameters:

Drill_speed	*[m/h] Drilling rate, estimated from anecdotal account of the number of days to drill a well of 7000 feet. Uncertainty of +/-20% is based on professional judgement.*

Drill_depth	*[m] Well depth is highly variable, depending on reservoir; weighted average is calculated using McElmo, Bravo, and Doe Canyon domes*
Product_rate	*[kg/d] Daily production rate of carbon dioxide. See "Field Profiles" sheet for production rate calculations. Uncertainty range of +/-30% is based on professional judgment.*
Life_well	*[yr] Life of primary production phase of well. Uncertainty is +/- 20% range based on professional judgement.*
Drill_power	*[MW] Power of drilling equipment; brake specific power. See "Fuel and emissions" worksheet for power ratings for different wells.*
Diesel_rate	*[kg/MWh] Use rate of diesel; kg of diesel combusted per MWh of brake specific drilling energy.*
EF_NOx	*[kg/MWh] NOx emission factor; kg of emission per MWh of brake specific drilling energy.*
EF_CO	*[kg/MWh] CO emission factor; kg of emission per MWh of brake specific drilling energy.*
EF_SOx	*[kg/MWh] SOx emission factor; kg of emission per MWh of brake specific drilling energy.*
EF_CO2	*[kg/MWh] CO2 emission factor; kg of emission per MWh of brake specific drilling energy.*
EF_PM	*[kg/MWh]PM emission factor; kg of emission per MWh of brake specific drilling energy.*
EF_CH4	*[kg/MWh] CH4 emission factor; kg of emission per MWh of brake specific drilling energy.*
EF_VOC	*[kg/MWh] VOC emission factor; kg of emission per MWh of brake specific drilling energy.*

Total_Case_wt	*[kg] Total weight of carbon steel well casing - includes conductor, surface, and production casing*
Total_Conc_wt	*[kg] Total weight of concrete well casing - includes conductor, surface, and production casing*
Prop_Gwater	*Fraction of groundwater where source is not known.*
Prop_Swater	*Fraction of surface water where source is not known.*
Fresh_water	*[kg] Fresh water demand for drilling.*
Brine_water	*[kg] Brine water demand for drilling.*
Temp_land	*[m2] Temporary land use. This area is reseeded after well construction is completed.*
Perm_land	*[m2] Permanent land use.*
CO2_loss_kg	*[kg] Fugitive loss of CO2 from valves, on the basis of 1 kg.*

Tracked Input Flows:

Steel, pipe welded, BF (85% Recovery Rate) [Metals]	*[Technosphere] Welded steel pipe used for well casing.*
Concrete, ready mix, R-5-0 [Concrete_Cement]	*[Technosphere] Concrete used for well casing.*
Diesel [Crude oil products]	*[Technosphere] Diesel used for powering drilling equipment.*
Water (surface water) [Water]	*[Resource] Fresh water used in drilling.*
Water (ground water) [Water]	*[Resource] Fresh and salt water used in drilling.*
Water Delivery	*[Technosphere] Not for hydraulic fracturing.*
Land use	*[Resource] Colorado and New Mexico.*
Carbon Dioxide	*[Resource] Carbon dioxide from salt dome.*

Tracked Output Flows:

Salt Dome CO_2 Well [Valuable substance]	*Reference flow*
Carbon dioxide [Inorganic emissions to air]	*Emission to air*

Methane [Organic emissions to air (group VOC)]	*Emission to air*
Nitrogen oxides [Inorganic emissions to air]	*Emission to air*
Sulphur oxides [Inorganic emissions to air]	*Emission to air*
Carbon monoxide [Inorganic emissions to air]	*Emission to air*
NMVOC (unspecified) [Group NMVOC to air]	*Emission to air*
Dust (PM10) [Particles to air]	*Emission to air*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage1_C_CO2_Well_Salt_Dome_2012_01.xlsx*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

This unit process provides a summary of relevant input and output flows associated with the construction and installation of a well for extracting carbon dioxide from a natural salt dome. Steel and concrete are used for the construction of the well casing; these materials enter the boundaries of this unit process in the form of prefabricated steel pipe and ready-mix concrete. Diesel is used for firing the internal combustion engines used for powering the rotary equipment used for drilling. The air emissions from diesel combustion include greenhouse gases and criteria air pollutants. Water quality is not included in this unit process, nor is the construction of injection wells for the disposal of water. The reference flow of this unit process is: 1 pcs of Salt Dome CO_2 Well Construction.

Boundary and Description

Carbon dioxide reservoirs trapped by salt domes are a common source of CO_2 for EOR in the Permian Basin region. Three domes in Colorado and New Mexico – McElmo, Bravo, and Doe Canyon – provide nearly all of the compressed CO_2, with McElmo dome accounting for around 70 percent of the total (DiPietro, Balash, & Wallace, 2012). Well construction begins with clearing roads and a well pad, neither of which are included in this unit process. A well is drilled down to the producing zone where the CO_2 is naturally pressurized. Wellhead pressure and depth of producing zones can vary widely between domes. The production zone of McElmo is at 8,000 feet, while at Bravo dome it is at 2,300 feet. A weighted average of well depth based on expected production volumes is used in this unit process (DiPietro, et al., 2012; Kinder Morgan, 2002, 2008; Rabinowitz & Janowiak, 2005).

The process describes a single production hole that is drilled down to the producing zone. Carbon steel casing is used for approximately a third of the total well depth, with chrome steel production tubing inside it for the entire length of the well. Cement surrounds both the carbon steel casing and the chrome steel production tubing. A diagram of the well hole is shown in **Figure** 2. Both fresh and brackish water are trucked in from nearby locations for the drilling mud, and recycled whenever possible for drilling additional wells (Kinder Morgan, 2002, 2008). While it is becoming common to use directional drilling for both the initial well hole and for additional lateral holes, that practice is not represented here (Pecor, 2012).

Figure 1: Unit Process Scope and Boundary

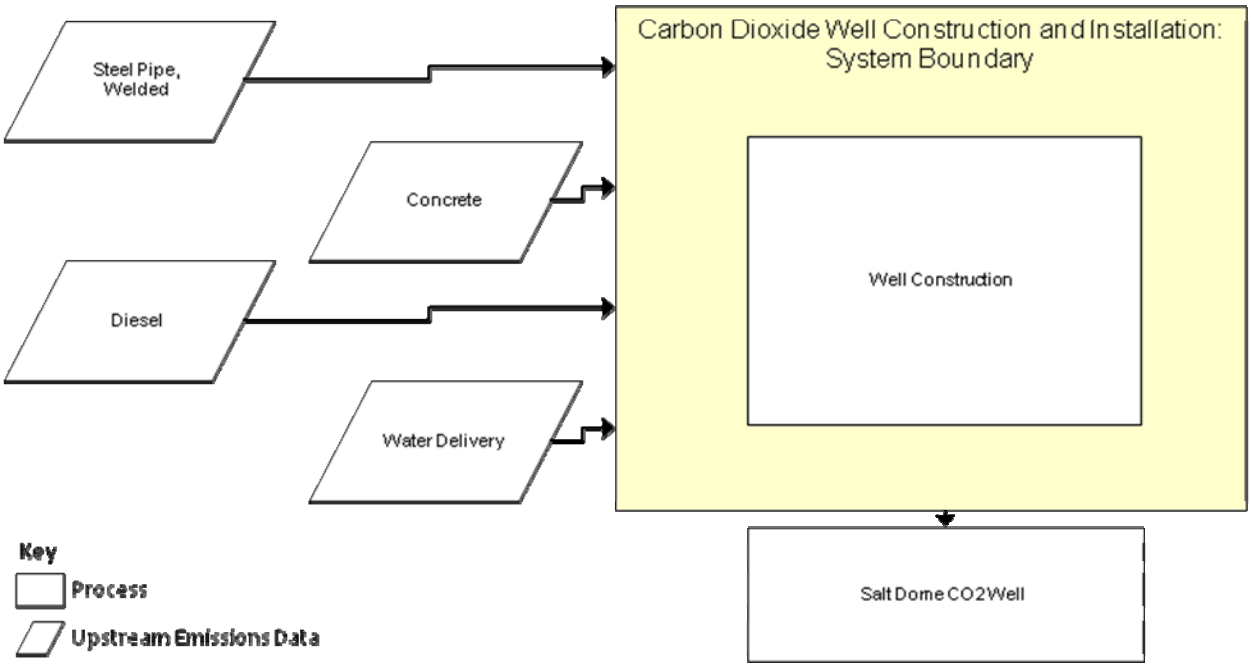
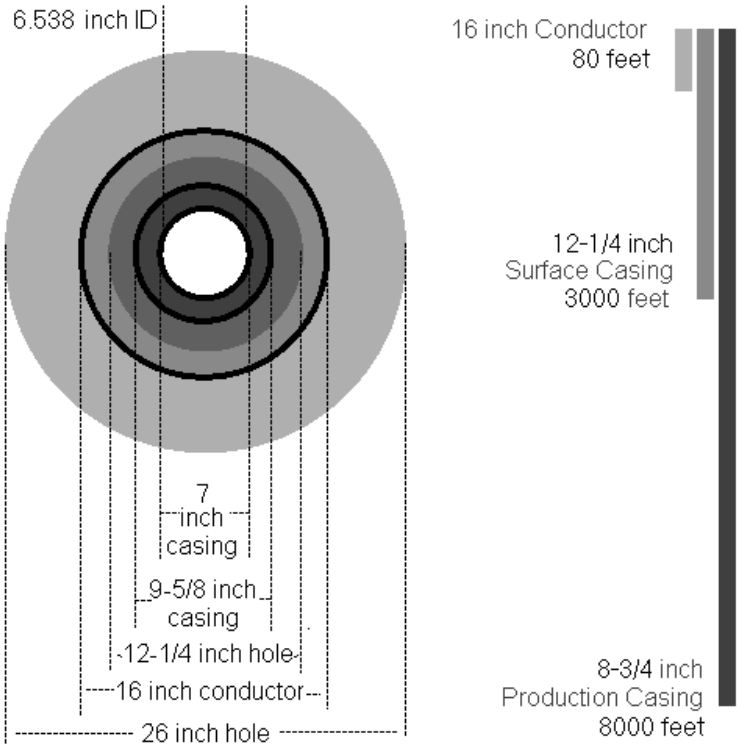


Figure 2: Well Casing Diagram



Key properties of the well construction are summarized in **Table 1.** The inputs and outputs of this unit process are summarized in **Table 2.**

Table 1: Default Parameters for Salt Dome Well Assembly

Property	Value	Units
Drill speed	17.8	m/h
Well depth	2,076	m
Well lifetime	25	yr
Drilling power	0.45	MW
Diesel rate	221	kg/MWh
Steel casing weight	1.03E+05	kg
Concrete weight	1.11E+05	kg
Fresh water demand	6.65E+05	kg
Brine water demand	3.11E+05	kg
Temporary land use	7.50E+03	m2/well
Permanent land use	9.75E+03	m2/well

Table 2: Unit Process Input and Output Flows

Flow Name	Value	Units (Per Reference Flow)
Inputs		
Steel, pipe welded, BF (85% Recovery Rate) [Metals]	1.03E+05	kg
Concrete, ready mix, R-5-0 [Concrete_Cement]	1.11E+05	kg
Diesel [Crude oil products]	1.15E+04	kg
Water (surface water) [Water]	3.32E+05	kg
Water (ground water) [Water]	6.43E+05	kg
Water Delivery [Intermediate product]	9.75E+05	kg
Land use	1.72E+04	m^2
Outputs		
Salt Dome CO2 Well [Valuable substance]	1.00	pcs
Carbon dioxide [Inorganic emissions to air]	3.69E+04	kg
Methane [Organic emissions to air (group VOC)]	2.02E+00	kg
Nitrogen oxides [Inorganic emissions to air]	7.63E+02	kg
Sulphur oxides [Inorganic emissions to air]	3.86E-01	kg
Carbon monoxide [Inorganic emissions to air]	1.75E+02	kg
NMVOC (unspecified) [Group NMVOC to air]	2.04E+01	kg
Dust (PM10) [Particles to air]	2.22E+01	kg

* **Bold face** clarifies that the value shown *does not* include upstream environmental flows.

Embedded Unit Processes

None.

References

DiPietro, P., Balash, P., & Wallace, M. (2012). A Note on Sources of CO2 Supply for Enhanced-Oil-Recovery Operations. *SPE Economics & Management, 4*(2), 69-74.

Kinder Morgan. (2002). Final Draft Environmental Assessment: Kinder Morgan Well Sites YE-5, HB-4, HE-5, and SC-10.

Kinder Morgan. (2008). Environmental Assessment #CO-800-2007-043: Kinder Morgan Proposed Goodman Point Development Project.

Pecor, J. (2012, November 28). [Personal phone conversation].

Rabinowitz, D., & Janowiak, M. (2005). *Reasonable, Foreseeable Development: Oil, Natural Gas, and Carbon Dioxide in Canyons of the Ancients National Monument*. Bureau of Land Management Retrieved November 19, 2012, from http://www.blm.gov/pgdata/etc/medialib/blm/wo/Planning_and_Renewable_Resources/NEPS.Par.99344.File.dat/(6.8.1.2)%20Example%20of%20Reasonably%20Foreseeable%20Development%20Scenario%202.pdf

Section III: Document Control Information

Date Created: November 29, 2012

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Revision History:

Original/no revisions

How to Cite This Document: This document should be cited as:

NETL (2010). NETL Life Cycle Inventory Data – Natural Gas Well Construction and Installation (Conventional Onshore). U.S. Department of Energy, National Energy Technology Laboratory. Last Updated: July 2010 (version 01). www.netl.doe.gov/energy-analyses (http://www.netl.doe.gov/energy-analyses)

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