NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Steam Methane Reforming with CSS

Reference Flow: 1 kg of Hydrogen, >99.90 vol-%, 925 psig (6.48 MPa)

Brief Description: Energy use, feedstocks (including feedstock and water use), and emissions associated with a representative steam methane reforming with carbon capture (SMR + CCS) facility that converts natural gas to >99.9 vol-% hydrogen for generic industrial use.

Section I: Meta Data

Geographical Coverage: United States **Region:** Midwest

Year Data Best Represents: 2021

Process Type: Basic Process (BP)

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:

groundwater_pct

[%] Percent of water supply sourced from groundwater

potw_pct

[%] Percent of water supply sourced from publicly-owned treatment works.

Tracked Input Flows:

natural gas, delivered

[Technosphere] Amount of natural gas used as both feedstock and supplemental fuel for heating.

Electricity, AC, 2300-7650 V

[Technosphere] Auxiliary grid electricity required to operate the full SMR + CCS facility.

Water, purified

[Technosphere] Water filtered to acceptable purity by water treatment train.

Tracked Output Flows:

Hydrogen, >99.90 vol%, 925 psig (6.48 MPa)

[Reference flow]

Carbon dioxide, captured product

[Technosphere] Mass flow rate of the captured carbon dioxide, scaled to the reference flow.

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_O_Steam_Methane_Reforming_with_CCS_2022.01.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 that are associated with steam methane reforming with pre- and post-combustion carbon capture. The overall carbon capture rate for this configuration is 96.2%, which is defined as one minus the percentage of carbon in the stack relative to the total carbon. The reaction occurs in a single-train, vertical tube steam methane reformer that is externally heated by recycled syngas and supplemental natural gas. This configuration does not generate excess steam. The reference flow of this unit process is: 1 kg of >99.9 vol-% hydrogen at 925 psia.

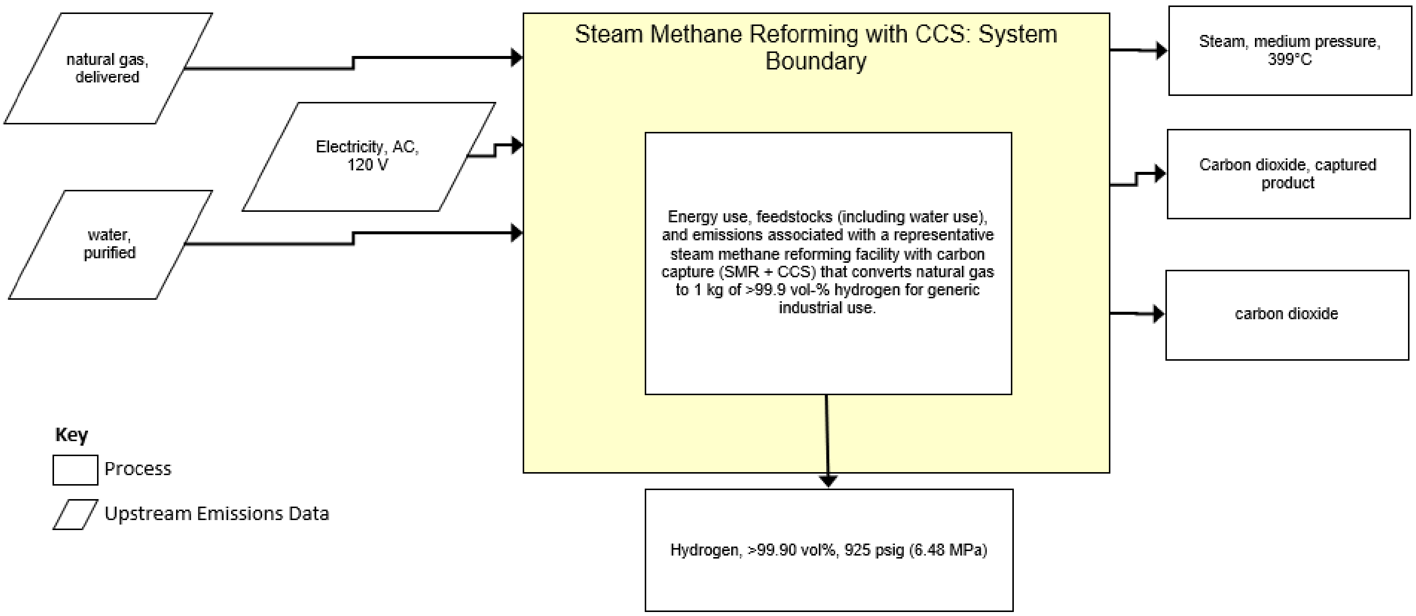
Boundary and Description

This unit process provides a summary of relevant input and output flows associated with steam methane reforming with CCS (SMR w/ CCS). The plant configuration for SMR w/ CCS is nearly identical to that of SMR w/o CCS -- a two-step process that converts methane or natural gas with steam to concentrated hydrogen. The first step is reformation, where excess steam reacts with the methane at high temperatures (700°C - 1000°C) to form synthesis gas (syngas, H_2 + CO). This is followed by the water-gas shift reaction, where remaining steam reacts with carbon monoxide to form additional hydrogen and carbon dioxide. SMR w/ CCS includes two additional unit processes for pre- and post-combustion capture of 96.2% of the carbon dioxide produced by the system, as well as a system for CO2 compression and drying. Unlike conventional SMR, this configuration of SMR w/ CCS utilizes all of the steam generated within the plant due to the process steam demands of the carbon capture systems. SMR w/ CCS is often referred to as "blue hydrogen." This technology is not widespread and there are few, if any, world-scale production facilities operating with this configuration at the time of writing (October 2021).

The material, energy, and emissions reported in this unit process are based on the NETL publication, Comparison of Commercial, State-of-the-Art, Fossil-Based Hydrogen Production Technologies (2022). The plant modeled is a single-train, vertical tube steam methane reformer that is externally heated by recycled syngas plus supplemental natural gas, configured to produce 20,125 kg/hr, or 200 MMSCFD, of >99.90 vol-% hydrogen suitable for generic industrial use. A refrigerated methyl diethanolamine (MDEA) system was used to model pre-combustion CO_2 capture from the shifted synthesis gas stream (62%). Secondary post-combustion capture of CO_2 from the reformer heater stack is based on the Cansolv system. Data on CO_2 compression is based on model characteristics of an eight-stage front-loaded integrally geared centrifugal compressor.

Inputs and outputs have been scaled to a reference flow of 1 kg of gaseous hydrogen at 925 psia. The facility is assumed to be located at a generic, greenfield plant site in the Midwestern U.S.

Figure 1: Unit Process Scope and Boundary



Embedded Unit Processes

None.

References

Lewis et al. 2022

Lewis, E., McNaul, S., Jamieson, M., Henriksen, M. S., Matthews, H. S., Walsh, L., Grove, J., Shultz, T., Skone, T. J., and Stevens, R. 2022. Comparison Of Commercial, State-of-the-Art, Fossil-Based Hydrogen Production Technologies. DOE/NETL-2022/3241. U.S. Department of Energy, National Energy Technology Laboratory. April 12, 2022. Pittsburgh, PA.

Section III: Document Control Information

Date Created: October 26, 2021

Point of Contact: Timothy Skone (NETL), Timothy.Skone@netl.doe.gov

Revision History:

Rev 2, 5/9/2022, Updated Flow Chart to include relevant flows

Rev 3, 8/18/2022, Updated Various parts given overall DS Review, including Origin/References, UUID flow names, tracked flows, etc.

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Section IV: Disclaimer

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