NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Solid Oxide Electrolysis

Reference Flow: 1 kg of Hydrogen, 100 vol-%, 290 psia (1.99 MPa)

Brief Description: Energy use, feedstocks (including feedstock and water use), and emissions associated with solid oxide electrolysis to produce 100 vol-% hydrogen for generic industrial use.

Section I: Meta Data

Geographical Coverage: United States **Region:** N/A

Year Data Best Represents: 2018

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:

None.

Tracked Input Flows:

Water, purified

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

Electricity, AC, 120 V

[Technosphere] Auxiliary electricity required, scaled to reference flow.

Natural gas, combusted

[Technosphere] Natural gas combusted for heat, scaled to reference flow.

Tracked Output Flows:

Hydrogen (H_2), 100 vol-%, 290 psia (1.99 MPa)

[Reference flow]

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_O_Solid_Oxide_Electrolysis_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 associated with solid oxide electrolyzer cells (SOECs) to produce hydrogen. This process occurs at high temperatures in a series of SOECs that take in water and electricity to produce hydrogen. Natural gas is combusted and used as a heat source. The reference flow of this unit process is: 1 kg of Hydrogen (H_2), 100 vol-%, 290 psia.

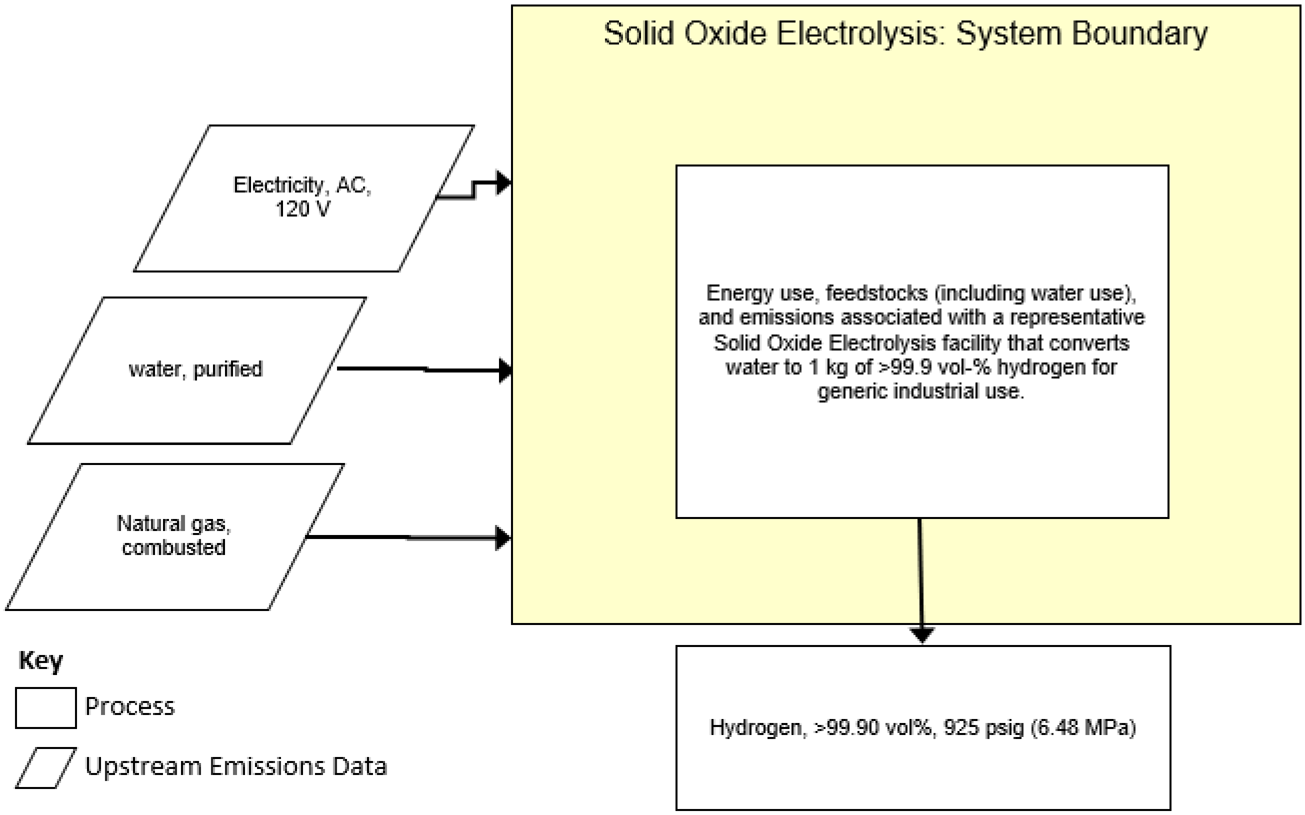
Boundary and Description

This unit process provides a summary of the input and output flows associated with solid oxide electrolysis (SOEC). SOEC is an advanced technology that uses electricity to split highly pure water into H_2 and O_2 at high temperatures (600-1,000 °C). Due to their high electricity consumption, the source of electricity will have a large impact on both the cost and the environmental impact of the process. SOECs are expected to increase in efficiency as they become mature. SOEC is expected to require demineralized water as the water source (Wang et al. 2019). Demineralization is not included in the system boundaries of this model, though purified water is an input to this process.

The material and energy details are based on the paper by Daneshpour and Mehrpooya (2018) and the technical presentation by James et al. (2015). The paper includes flow diagrams of a theoretical plant, and the presentation includes technical surveys from industry experts about current and future specifications of solid oxide electrolysis. The configuration used for this unit process uses natural gas to provide heat to the system, which appears to be representative of most SOEC systems in the United States during the year 2018. Oxygen is produced in the process but is not resold and therefore is not treated as a co-product.

Inputs and outputs have been scaled to a reference flow of 1 kg of gaseous hydrogen of 100% purity (idealized) at 290 psia.

Figure 1: Unit Process Scope and Boundary



Embedded Unit Processes

None.

References

Daneshpour, R., & Mehrpooya, M. (2018). Design and optimization of a combined solar thermophotovoltaic power generation and solid oxide electrolyser for hydrogen production. Energy Conversion and Management, 176, 274-286.

James, B. D., Moton, J. M., DeSantis, D.A. & Saur, G. Analysis of Advanced H2 Production Pathways. 2015 DOE Hydrogen and Fuel Cells Program and Vehicle Technologies Office Annual Merit Review and and Peer Evaluation Meeting. http://www.hydrogen.energy.gov/pdfs/review15/pd102_james_2015_o.pdf

Wang, L., Chen, M., Kungas, R., Lin, T-E., Diethelm, S., Marechal, F. & Ven herle, J. Power-to-Fuels via Solid-Oxide Electrolyzer: Operating Window and Techno-Economics. Renewable and Sustainable Energy Reviews. http://doi.org/10.1016/j.rser.2019.04.071

Section III: Document Control Information

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None

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