Update on Johnson Matthey LCH™ Technology

PEP Review 2025-07

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Glossary

atm	Atmospheres
ATR	Autothermal reforming; also used for autothermal reformer in BFDs
ASU	Air separation unit
Bcm	Billion cubic meters
BET	Brunauer-Emmett-Teller
BFD	Block flow diagram
BFW	Boiler feedwater
bhp	Brake horsepower
BLI	Battery limits investment
Btu/h-ft^2	British thermal units per hour-square feet
Btu/kg	British thermal units per kilogram
°C	Degree Celsius
capex	Capital expenditure
CCUS	Carbon capture, utilization, and storage
¢/lb	Cents per pound
¢/kWh	Cents per kilowatt-hour
cm^3/g	Cubic centimeters per gram
cm^3/g-min	Cubic centimeters per gram-minute
¢/Mgal	Cents per thousand gallons
CPOX	Partial oxidation with a catalyst
CW	Cooling water
$/h	Dollars per hour
DME	Dimethyl ether
°F	Degree Fahrenheit
FOB	Free/freight on board
ft	Feet
ft dia	Feet diameter
G&A	General and administrative
gal	Gallons
GHG	Greenhouse gas
GHR	Gas-heated reformer
GHSV	Gas hourly space velocity
gpm	Gallons per minute
h	Hours
HTS	High-temperature shift
HVAC	Heating, ventilation, and air conditioning
ID	Inside diameter
IEA	International Energy Agency
IRENA	International Renewable Energy Agency
ISBL	Inside battery limits
ITS	Isothermal shift
K	Degree Kelvin
kcal/m^2/h	Kilocalories per square meter per hour
kg	Kilograms
kgf	Kilogram-force
kg/h	Kilograms per hour
kg/m^3	Kilograms per cubic meter
kg/m^2/h	Kilograms per square meter per hour
kg/mm	Kilograms per millimeter
kJ/mol	Kilojoules per mole
KO	Knockout
kW	Kilowatts
kWh	Kilowatt-hour
lb/h	Pounds per hour
lb/MMscf	Pounds per million standard cubic feet
lb/y	Pounds per year
LCA	Leading concept ammonia
LCM	Leading concept methanol
LNG	Liquefied natural gas
LPM	Low-pressure methanol

LTS	Low-temperature shift
MDEA	Methyldiethanolamine
m^2g	Square meters per gram
MJ/kg	Megajoules per kilogram
Mlb/h	Thousand pounds per hour
ml/g	Milliliters per gram
mm	Milliliters
MMBtu/h	Million British thermal units per hour
MMBtu/m^3	Million British thermal units per cubic meter
MMlb/y	Million pounds per year
MMscf/d	Million standard cubic feet per day
MMt	Million metric tons
mol%	Molar percent
MP	Medium-pressure
NA	Not available
nm	Nanometers
Nm^3/h	Normal cubic meters per hour
OD	Outside diameter
opex	Operating expenditure
OSBL	Outside battery limits
OSHA	Occupation Safety and Health Administration
PEP	Process Economics Program
PFD	Process flow diagram
POX	Partial oxidation
ppb	Parts per billion
ppm	Parts per million
PSA	Pressure swing adsorption
psia	Pounds per square inch absolute
psig	Pounds per square inch gauge
PZ	Piperazine
ROI	Return on investment
S/C	Steam-to-carbon
SMR	Steam methane reforming; also used for steam methane reactor/reformer in BFDs
sq ft	Square feet
SS	Stainless steel
Syngas	Synthesis gas
T	Temperature
TFC	Total fixed capital
t/y	Metric tons per year
vol%	Volume percent
WGS	Water-gas shift
WHB	Waste heat boiler
WHR	Waste heat recovery
wppm	Weight parts per million
wt%	Weight percent

Abstract

Hydrogen is one of the most important chemical products manufactured and used globally. It is produced in large quantities as an on-purpose product, mostly from natural resources, such as biomass, coal, natural gas, and refinery products (for example, naphtha). Small amounts of hydrogen are also produced by electrolysis of water. It is also generated as a byproduct of several chemical processes. Most of this on-purpose hydrogen is used as a captive product in different applications.

The primary demand for hydrogen today is in petroleum refining and ammonia and methanol production. Nevertheless, hydrogen is used across multiple sectors, in other chemical and industrial processes, and as a reducing or hydrogenating reagent. Another unique point is that hydrogen can be used as a clean fuel — for example, when consumed in a fuel cell, hydrogen produces only electric energy and water — hence, it can be used in integrated clean energy systems and auto transportation.

Clean hydrogen — produced from renewables, nuclear, or fossil fuels with carbon capture, utilization, and storage — can help decarbonize a range of sectors, including long-haul transport, chemicals, and iron and steel, where reducing emissions is otherwise difficult. It can also help to improve air quality in cities and improve energy security.

Hydrogen is mostly produced from steam reforming of fossil fuels and emits 8-10 metric tons of CO_2 per metric ton of hydrogen produced.

In this review, we have updated our analysis of blue hydrogen production using the LCH™ technology developed by Johnson Matthey PLC, which was earlier covered in PEP Report 32F *Commercially Available Blue Hydrogen Production* (December 2023; revised December 2024). The review is updated after discussions with the licensor. The hydrogen technology is coupled with an amine-based carbon capture that reduces the process CO_2 emissions by more than 90%. The capacity selected in this review is 100,000 metric tons per year (t/y), or 220.5 million pounds per year (MMlb/y).

The process flow diagrams, material balance, major equipment list with specifications, cost information for battery limits, variable costs, capital expenditure (capex) and operating expenditure (opex), and total production costs are evaluated in this analysis. The technological and economic assessment of the process is the Process Economics Program (PEP)'s independent interpretation of a commercial process. Each of these is based on the information presented in the open literature, such as patents or technical articles, along with discussions with the licensor, and may not reflect in whole or in part the actual plant configuration. We do believe that these sources are sufficient to represent the process and process economics within the range of accuracy necessary for the economic evaluations of the conceptual process designs. This review will be a valuable resource for planners, producers, and designers who are looking for an authentic evaluation of the capital and production costs for blue hydrogen production using the LCH™ technology.

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