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Electrified Reforming technologies for Low-Carbon Hydrogen and Methanol

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Vijayanand Rajagopalan, **Director, Process Economics Program**

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Glossary

¢/lb	Cents per pound
¢/kWh	Cents per kilowatt-hour
¢/Mgal	Cents per thousand gallons
$/kg	Dollar per kilogram
$/Mgal	Dollars per thousand gallons
$/t	Dollars per metric ton
AC	Alternating current
atm	Atmospheres
Bcm	Billion cubic meters
Bhp	Brake horsepower
BFD	Block flow diagram
BFW	Boiler feedwater
BLI	Battery limits investment
Btu	British thermal units
Btu/h-ft^2	British thermal units per hour-square foot
CCUS	Carbon capture, utilization, and storage
°C	Degrees Celsius
cf/ft^3	Cubic feet
cP	Centipoise
CRU	Carbon dioxide recovery unit
CW	Cooling water
DME	Dimethyl ether
DRM	Dry reforming of methane
eSMR	Electrified steam methane reforming
FOB	Freight on board
g	Grams
G&A	General and administrative
GHG	Greenhouse gas
GJ/t	Gigajoule per metric ton
g/mol	Grams per mole
gpm	Gallons per minute
h	Hours
HHV	Higher heating value
HTS	High-temperature shift
IEA	International Energy Agency
ISBL	Inside battery limits
kcal/m^2/h	Kilocalories per square meter per hour
kg	Kilograms
kg/h	Kilograms per hour
kg/m^3	Kilograms per cubic meter
kg/m^2/h	Kilograms per square meter per hour
kJ	Kilojoules
kJg^{-1}	Kilojoules per gram
KO	Knockout
kPa	Kilopascals
kt/y	Kilotons per year
kW	Kilowatts
kW/m^2	Kilowatts per square meter
kWh/Nm^3	Kilowatt-hours per normal cubic meter
lb/h	Pounds per hour
lb/y	Pounds per year
LHV	Lower heating value
LNG	Liquefied natural gas
LTCS	Low-temperature carbon steel
LTS	Low-temperature shift

m^2/m^3	Meter square per cubic meter
Mgal	Thousand gallons
Mlb	Thousand pounds
MCM	Mobil composition of matter
mJ	Millijoules
mm	Millimeters
MMlb/y	Million pounds per year
MMt	Million metric tons
MMtoe	Million metric tons of oil equivalent
MMt/y	Million metric tons per year
mol%	Molar percent
mPa	Megapascals
MTBE	Methyl tert-butyl ether
MTO	Methanol-to-olefins
MW	Megawatts
NG	Natural gas
Nm^3/h	Normal cubic meters per hour
Ω.m	Ohm-meter
OSBL	Outside battery limits
PEP	Process Economics Program
PFD	Process flow diagram
PPA	Power purchase agreements
ppb	Parts per billion
ppm	Parts per million
PSA	Pressure-swing adsorption
psi	Pounds per square inch
psia	Pounds per square inch absolute
psig	Pounds per square inch gauge
ROI	Return on investment
RWGS	Reverse water gas shift
s	Second(s)
SBA	Santa Barbara Amorphous
S/C	Steam-to-carbon
scf	Standard cubic feet
scm	Standard cubic meters
SHS	Super-heated steam
SMR	Steam methane reforming
SN	Stoichiometric number
sq ft	Square feet
SS	Stainless steel
STP	Standard temperature and pressure
syngas	Synthesis gas
t	Metric tons
TC	Temperature Controller
t/d	Metric tons per day
t/t	Metric tons per metric ton
t/y	Metric tons per year
TFC	Total fixed capital
TRL	Technology readiness level
USGC	United States Gulf Coast
V	Volts
vol%	Volume percent
w/w	Weight for weight
WT	Waste treatment
wt%	Weight percent
y	Year

Abstract

As the world strives to meet the increasing demand for clean energy in a shift toward decarbonization, and with long-term net-zero goals in mind, the significance of emerging technologies that enable the transition toward a hydrogen economy continues to grow. Currently, fossil fuels — especially natural gas and coal — are the predominant sources of hydrogen production. Traditional steam methane reforming processes, which rely heavily on fossil fuels for heat generation, contribute to about 3% of global CO_2 emissions. Electrified reforming is an emerging technology that decarbonizes syngas production by replacing conventional fossil-fueled reforming with electrically driven processes, enabling highly efficient and flexible operations with significantly reduced emissions. This approach lowers the carbon footprint of syngas generation and facilitates decarbonization of the production of derived fuels and chemicals such as hydrogen, methanol, ammonia, and aviation fuel.

In this report, we review the current industrial status of hydrogen and methanol production. A brief technology overview of various processes to produce hydrogen and methanol, via electrified reforming, is presented, covering aspects such as process design, reactor performance, energy efficiency, and overall technology readiness. A further in-depth analysis, including technoeconomic evaluations, is presented for the following three processes:

– Hydrogen from natural gas via electrified reforming (based on Nu:ionic's technology)

– Hydrogen from biogas via electrified reforming (based on SYPOX's technology)

– Methanol from biogas via electrified reforming (based on SYPOX's technology)

This report serves as a valuable resource for industry professionals, researchers, and policymakers seeking to understand the current landscape and prospects of electrified reforming technologies to produce industrial gases and chemicals.

The production economics assessment in this report is based on a US Gulf Coast (USGC) location. An iPEP Navigator tool is also attached with the electronic version of this report. The interactive iPEP Navigator module provides an economic snapshot for each of the processes, with options to choose from different units as well as regions of interest. Apart from the technical and economic analyses, we have included the material balance tables, a sized equipment list, and process flow diagrams for each of these technologies.

The technological and economic assessment of the process is the Process Economics Program (PEP)'s independent interpretation of a potential commercial process. Each is based on the information presented in the open literature, such as patents or technical articles, 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 design.

Contacts

Vijayanand Rajagopalan

Director, Process Economics Program
vijayanand.rajagopalan@spglobal.com

Rajiv Narang

Executive Director, Process Economics Program
rajiv.narang@spglobal.com

CONTACTS

Europe, Middle East, Africa: +44 (0) 203 367 0681
Americas: +1 800 332 6077
Asia-Pacific: +60 4 296 1125

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