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Carbon Dioxide Capture Economic Model – Part II

PEP Report 180I

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Glossary

aMDEA	Activated MDEA
aAMP	2-amino-2-methyl-1-propanol
ASU	Air separation unit
ATR	Autothermal reforming
bara	Bar absolute pressure
barg	Bar gauge pressure
Bcf	Billion cubic feet
BECCS	Bioenergy with carbon capture and storage
BFW	Boiler feedwater
bhp	Brake horsepower
BLI	Battery limits investment
°C	Degree Celsius
CaL	Calcium looping
CAPEX	Capital expenditure
CAS	Chemical Abstracts Service
CCGT	Combined cycle gas turbine
CCS	Carbon capture and storage
CCUS	Carbon capture, utilization and storage
CFZ™	Controlled Freeze Zone™
¢/kg	Cents per kilogram
¢/kWh	Cents per kilowatt-hour
¢/lb	Cents per pound
¢/Mgal	Cents per thousand gallons
COTC	Crude oil to chemicals
CRC	Canyon Reef Carriers
CW	Cooling water
DAC	Direct air capture
$/h	Dollars per hour
$/kg	Dollars per kilogram
$/lb	Dollars per pound
$/Mgal	Dollars per thousand gallon
$/Mlb	Dollars per thousand pound
$/t	Dollars per metric ton
EOR	Enhanced oil recovery
EPC	Engineering procurement and construction
°F	Degree Fahrenheit
ft	Feet
ft dia	Feet diameter
G&A	General and administrative
gal	Gallon
GHG	Greenhouse gas(es)
GHR	Gas heated reformer
GJ/t	Gigajoules per metric ton
gpm	Gallons per minute
g/scm	Grams per standard cubic meter
$GtCO_2$	Billion metric tons of CO_2
$GtCO_2e$	Billion metric tons of CO_2 equivalent
h	Hours
HSS	Heat-stable salts
HVAC	Heating, ventilating and air conditioning
kg	Kilograms
kg/s	Kilograms per second
kg/t	Kilograms per metric ton
kJ/kg	Kilojoules per kilogram
KO	Knockout

kPa	Kilopascals
ktpa	Kilotons per annum
kW	Kilowatt
kWh/kg	Kilowatt-hour per kilogram
kWh/t	Kilowatt-hour per metric ton
lb	Pound
lb/h	Pounds per hour
LEL	Lower explosive limit
l/m^3	Liters per cubic meter
lb/MMscf	Pound per million standard cubic feet
LP	Low-pressure
m	Meter
MDEA	Methyldiethanolamine
MEA	Monoethanolamine
MEG	Monoethylene glycol
m^{3}h	Cubic meter per hour
MMBtu/h	Million British thermal units per hour
MMlb/y	Million pounds per year
MMscf	Million standard cubic feet
MMtpa	Million metric tons per annum
MMt/y	Million metric tons per year
mol	Mole
mol%	Molar percent
mol/mol	Mole per mole
MP	Medium-pressure
MW	Megawatt
NFPA	National Fire Protection Association
NGCC	Natural gas combined cycle
Nm^3/h	Normal meter cube per hour
PCC	Pulverized coal combustion
PEM	Proton exchange membrane
PFD	Process flow diagram
POX	Partial oxidation
ppb	Parts per billion
ppm	Parts per million
ppm wt	Parts per million weight
PSA	Pressure swing adsorption
psia	Pounds per square inch absolute
psig	Pounds per square inch gauge
PZ	Piperazine
ROI	Return on investment
SAF	Sustainable aviation fuel
SMR	Steam methane reforming
SOC	Solid oxide cell
SOEC	Solid oxide electrolysis cell
sq ft	Square feet
SS	Stainless steel
syngas	Synthesis gas
t	Metric ton
TEG	Triethylene glycol
TFC	Total fixed capital
tpa	Metric tons per annum
t/tCO_2	Metric ton per metric ton of CO_2
t/tH_2	Metric ton per metric ton of hydrogen
t/y	Metric tons per year
US DOE	United States Department of Energy
UEL	Upper explosive limit

vol%	Volume percent
VSA	Vacuum swing adsorption
v/v	Volume per volume
WHB	Waste heat boiler
wt%	Weight percent
y	Year

Abstract

The PEP Report 180H *Carbon Dioxide Capture Economics Model (Part) I* [October 2023] looked at carbon capture from flue gases from coal-fired equipment and combined cycle gas turbines (CCGTs). This Excel-based Economics Model Part II looks at two more critical aspects: compression of captured CO_2 and CO_2 capture from synthesis gas (syngas) for blue hydrogen.

The compression of CO_2 is modeled for a typical carbon capture hub that will compress 1 million metric tons per annum (MMtpa) to 3.5 MMtpa of dry CO_2 to a pressure of 150 bar gauge pressure (barg). The user only has to provide the amount of CO_2 to be compressed and the model will display critical process parameters, such as the power and water consumed along with the economic data of the capital and operating costs. The user may note that only the compressor with CO_2 drying using triethylene glycol (TEG) is modeled while the pipeline and sequestration are not.

Carbon capture from syngas from a typical steam methane reforming (SMR) reformer is modeled using a blend of methyldiethanolamine (MDEA) and piperazine (PZ), also known as activated MDEA (aMDEA). The flows of syngas from 4 kilograms per second (kg/s) to 64 kg/s [CO_2 capture of 0.074 MMtpa to 1.179 MMtpa or hydrogen ex-Absorber of 17 kilotons per annum (ktpa) to 280 ktpa] are modeled. The user only needs to provide the amount of syngas processed and the model will display the key process parameters, such as regeneration duty, diameters of the absorber and regenerator, and the amine flow rates. The economic data of the capital and operating costs per kilogram of hydrogen is also displayed. This will be useful to evaluate the minimum premium that blue hydrogen will command.

For Economic Modeling, an Excel-based dashboard is presented to analyze the key operating and economic parameters for varying gas flows. This will allow the user to quickly estimate the major utility consumptions, key parameters and capital and operating expenditures.

Apart from the technical and economic analysis, we have also included for one case each a material balance table, a sized equipment list and process flow diagrams for CO_2 compression and CO_2 capture from syngas.

The technological and economic assessment of the process is the Process Economics Program (PEP)'s independent interpretation of a potential commercial process. Each of these 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 designs.

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