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Process Economics Program (PEP)

November 2024

Carbon Capture Options for a Coal Gasification Plant

PEP Report 180J

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Glossary

₵	cents
₵/kWhr	Cents per kilo watt hour
₵/lb	cents per pound
°C	Degree Celsius
°F	Degree Fahrenheit
µm	Micrometer
AASHTO	American Association of State and Highway Transportation Officials
AGR	Acid gas recovery
AR	Air reactor
Ar	Argon
ASTM	American Society for Testing and Materials
ASU	Air separation unit
BFD	Block flow diagram
BFW	Boiler feed water
BGL	British gas Lurgi
BLI	Battery limit investment
BTU	British thermal unit
BTU/lb	BTU per pound
C	Carbon
CaO	Calcium oxide
Capex	Capital expense
CBM	Coal bed methane
CCP	Coal combustion products
CCR	Coal combustion residues
CCS	Carbon capture and storage
CCUS	Carbon capture, storage, and utilization
CCW	Coal combustion wastes
CFC	Chlorofluorcarbons
CH4	Methane
CLC	Chemical looping combustion
Cm2/gm	Centimeter square per gram
CMM	Coal mine methane
CO	Carbon monoxide
CO_2	Carbon dioxide
COP	UN climate change conference
COS	Carbonyl sulfide
CV	Calorific value
CW	Cooling water
DAC	Direct air capture
DEA	Diethanolamine
DGA	Diglycolamine
DIPA	Diisopropanolamine
DPEG	Dimethylether of polyethylene glycol
FBC	Fluidized bed combustion
FGD	Flue gas desulfurization
FOB	Freight on board
FR	Fuel reactor
ft^2	feet square
G&A	general and administrative
GCV	Gross calorific value
GE	General Electric
GHG	Greenhouse gases
Gpm	Gallon per minute
GT	Gas turbines
GW	Gigawatt

GWh	Gigawatt hour
H	Hydrogen atom
H2	Hydrogen
H2O	Water
H2S	Hydrogen sulfide
HC	Hydrocarbon
HCl	Hydrogen chloride
HCN	Hydrogen cyanide
HHV	Higher heating value
HP	High pressure
hP	Horsepower
HRSG	Heat recovery steam generator
HVAC	Heating, ventilation, and air conditioning
IEA	International energy agency
IGCC	Integrated coal gasification combined cycle
IGV	Inlet guide vane
IPCC	Intergovernmental Panel on Climate Change
ISBL	Inside battery limit
ISO	International Organization for Standardization
Kg/m3	Kilogram per meter cube
Kg/MT	kg per metric ton
kWhr	Kilowatt hour
Lb	Pounds
LOI	Loss on ignition
MDEA	Methyldiethanolamine
MDT	Montana Department of Transportation
MEA	Monoethanolamine
Mgal	Thousand gallon
MHI	Mitsubishi Heavy Industries
MJ	Megajoule
Mlb	Thousand pound
MMBTU/hr	Million BTU per hour
MMtoe	Millions of metric tons of oil equivalent
MoEF&CC	Ministry of Environment, Forest, and Climate Change
MOF	Metal organic framework
mol%	Mole percentage
MSU	Montana State University
MSW	Municipal solid wastes
Mt	Million tons
MTCE	Millions of tons of coal equivalent
MW	Megawatt
MW	Molecular weight
MWhr	Megawatt-hour
N	Nitrogen atom
NACE	National Association of Corrosion Engineers
NDC	Nationally Determined Contribution
NH3	Ammonia
NITI	National institute of transforming India
NMP	N-methylpyrrolidone
NOx	Oxides of nitrogen
O	Oxygen atom
OPEX	Operating expenses
OSBL	Outside battery limit
PAH	Polycyclic aromatic hydrocarbons
PEGASOS	Pan-European Gas-AeroSol climate interaction Study
PEP	Process Economics Program
Ppm	Parts per million

Psia	Pound per square inch atmospheric
Psig	Pound per square inch gauge
PVC	Polyvinylchloride
PWHT	Post weld heat treatment
ROI	Return on investment
S	Sulfur
SCM	Supplementary cementitious material
SCR	Selective catalytic reduction
SCOT	Shell Claus off-gas treating
SCWG	Supercritical water gasification
SDA	Spray dry absorption
SNG	Synthetic natural gas
SO2	Sulfur dioxide
SOx	Oxides of sulfur
Syngas	Synthesis gas
TDS	Total dissolved solids
TEG	Triethylene glycol
TFC	Total fixed capital
TPD	Tons per day
TPH	Tons per hour
TSS	Total suspended solids
UCG	Underground coal gasification
USGC	Us Gulf coast
VSV	Variable stator vanes
WGS	Water-gas shift
Wt%	Weight percentage
ZSM	Zeolite Socony mobil

Abstract

Despite the major thrust for the use of renewable energy sources such as solar, wind, hydrothermal, etc., coal remains a dependable source to meet a country's energy demand, accounting for 35% of global electricity production [CEH-Energy]. It is currently the world's second largest source of primary energy after crude oil because it is affordable, abundant, and widely distributed across the globe. Among the coal-producing markets, mainland China holds the first place followed by India in coal production and consumption, mainly because of their high population, big and growing economies, high energy demand, and abundant coal reserves but limited crude oil and natural gas reserves.

Coal-fired power generation provides affordability and energy security to developing economies, but CO_2 emissions and coal ash/slag handling and disposal are the major challenges. However, technological development has improved coal-fired power plant efficiency while carbon dioxide (CO_2) capture at source with greater efficiency has also been made possible. Apart from that, there is a lot of scope for ash utilization in the cement industry, mining, concrete production, bricks manufacturing, highway embankments, and other civil applications, which may not only overcome the environmental issues associated with the coal-fired power plant but also help improve the plant economics. These CO_2 capture and ash utilization options need considerable capital investment and utilities that not only increase the overall project cost but also reduce the plant's overall energy efficiency and increase the power generation cost.

This report presents the process economics for power generation for a coal gasification plant with an integrated coal gasification combined cycle (IGCC) operating with mainland China bituminous and sub-bituminous coals at mainland China location and with Indian high ash content coal, and blended coal feedstocks options at India location. For the above-mentioned feedstock options, the report presents the economic comparison of (a) an IGCC power plant without CO_2 capture and (b) an IGCC power plant with CO_2 capture options and ash utilization options.

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