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Thermal & Catalytic Conversion from Biogas to Hydrogen

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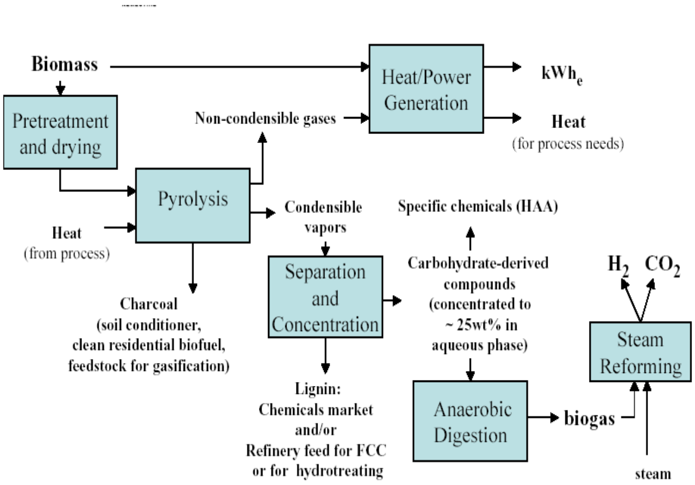
INTRODUCTION

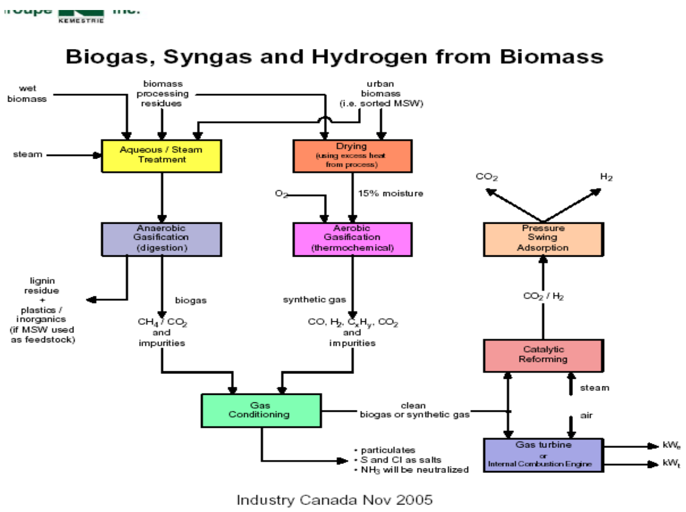
The objective of this project is to develop economically viable process for the production of high purity hydrogen from locally available fossil and renewable feed stocks with minimal environmental impact.

The innovative approach is based on the development of a feedstock catalytic process that allows converting both fossil (e.g., natural gas) and renewable feedstock into high-purity hydrogen production: 1) catalytic pyrolysis of methane



Why Hydrogen?

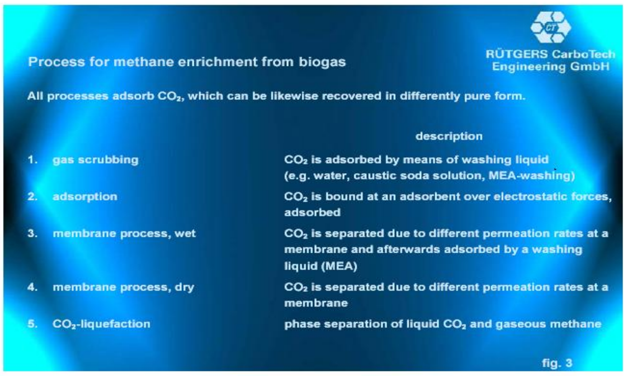
- Hydrogen can be produced from many sources
  - Multiple renewable sources (wind, solar, and biomass)
- Air Quality Benefits at End Use
  - Hydrogen is a clean burning fuel or in the case of fuel cells zero emission fuel
- Greenhouse Gas reduction
  - Zero carbon fuel
- Fuel Economy
  - Fuel economy improvements possible with fuel cell vehicles could allow hydrogen to compete with lower cost fuels.



COMPOSITION & QUALITY OF BIOGAS

BIOGAS: It is the gaseous reaction product from anaerobic digestion of waste water having a high BOD value. Biogas: 60-70 volume% methane 30-40 volume% co_2

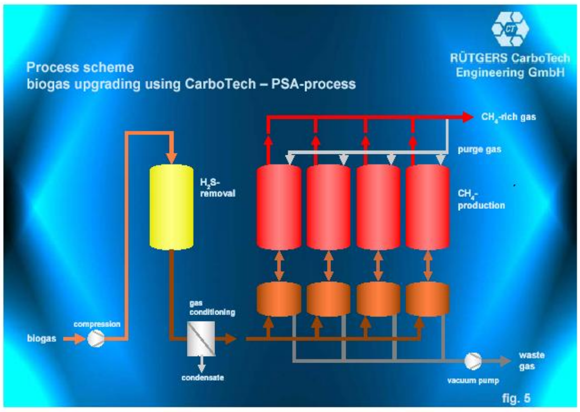
BIOGAS UPGRADING PROCESSES

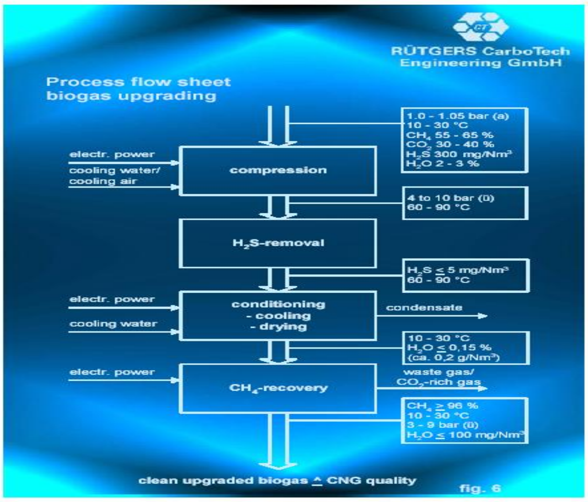


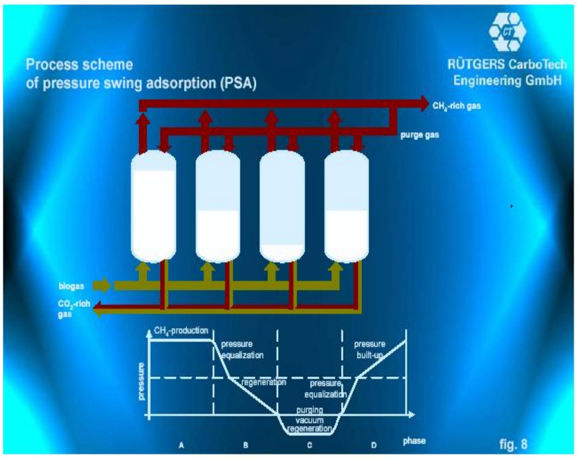
INDUSRIAL PROCESS OF ADSORPTIVE BIOGAS UPGRADING:

steps of this process are:

1. raw gas compression
2. H_2S removal stage
3. biogas conditioning
4. methane production.







ADVANTAGES OF ADSORPTIVE BIOGAS UPGRADING:

DRY PROCESS:

1. no process water
2. no chemicals
3. no corrosion problem
4. removal of water up to a dew point of –40°c
5. partial removal of nitrogen and oxygen
6. low utility consumption
7. compact and space-saving design
8. Simple and automatic operation

CATALYTIC STEAM REFORMING: PROCESS OF CONVERSION OF BIOGAS TO HYDROGEN:

REFORMER

"methane as the main component of natural gas and also of biogas is usually catalytically cracked at high temp. & pressure in a special type of reactor , called Reformer"

REFORMATE:

"The cracking products, a gas containing namely H_2, CO, CO_2, H_2O and residual methane is known as reformate."

HYDROGEN PRODUCTION:

There are two major steps :

1) steam reforming of CH_4 in a catalytic reactor.

2) Purification & upgrading of the reformate via adsorption.

PROCESS:

1) pressure increase of methane rich feed gas and dematerialized water

2) blending of methane rich feed gas and water followed by water evaporation in counter flow with reformate stream

3) conversion of the methane-steam-mixture at approx.900^{0}c

$CH_4 + H_2O \rightarrow CO + 3H_2$

$CO + H_2O \rightarrow CO2 + H_2$

4) cooling of the reformate stream in counter flow with the incoming methane-steam mixture, followed by
an external cooling step to ambient temperature.

5) separation of water condensate from reformate stream

6) separation of H2 from CO, CO_2, N_2, CH_4 and H_2O by means of adsorption into a pure hydrogen stream by a Pressure Swing Adsorptive plant(PSA)

7)recycling of PSA tail gas as fuel gas for the reformer burner.

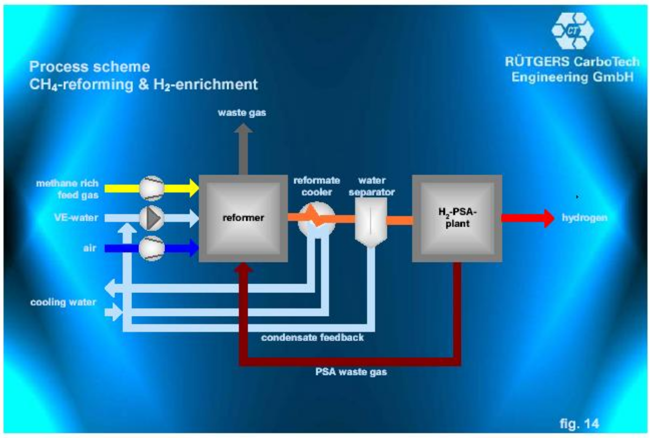


fig. 14

(2) CO_2 REFORMING OF METHANE:

main reaction:

$CH_4 + CO_2 \rightarrow 2CO + 2H_2$

side reaction:

$CO_2 + H_2 \rightarrow CO + H_2O$

(3)PARTIAL OXIDATION OF METHANE:

main reaction :

$CH_4 + 0.5O_2 \rightarrow CO + 2H_2$

side reaction:

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

$CO + H_2O \rightarrow CO_2 + H_2$

LIMITATIONS:

1) problem of the removal of high exothermic heat

2) Requirement of a complicated reactor e.g., fluidized bed reactor.

3) High possibility of run-away conditions and hence the process is highly hazardous

TO OVERCOME THE LIMITATIONS THE IMPROVED SUPPORTED CATALYST IS USED:

Aa.Cob.NiOc. (X)/Mod(Y)/S

ADVANTAGES OF IMPROVED CATALYST:

1) A protective layer of the oxide is formed between support and the oxides of nickel & cobalt with or without noble metal.

2) Ni & CO is present together producing a synergetic effect.

3) The improved supported catalyst is thermally very stable & also has high mechanical strength & attrition resistance.

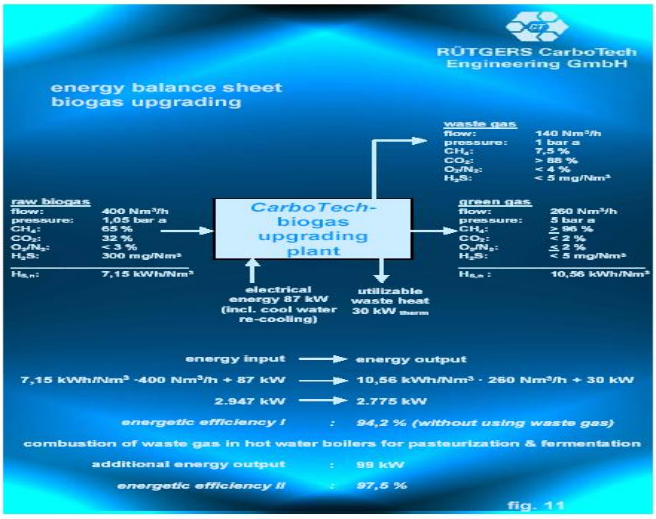
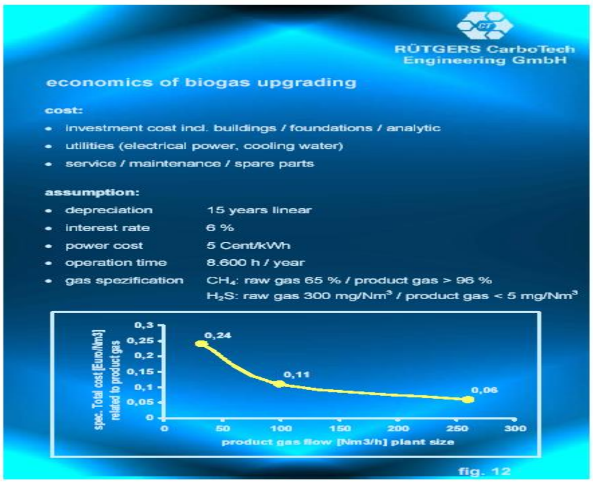


fig. 11



APPLICATIONS:

1) The process is operated in a most energy efficient manner.

2) The process is operated in a very safe manner with no possibility of run-away

3) No need to remove heat from the reactor or to provide heat to the reactor.

4) Process control are simplified and the capital & operation of cost for the process is much lower

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