-7- (3) Carbon dioxide forCoal gasification and waste treatment

Gasification permit to use pipes for coal transportation

° **coal** to **Syngas** : **solid to gas**

°**Wood and biomass to syngas** **solid to gas**

° **Fisher Tropsch** **syngas** to **synfuel**

- **coal and Waste** by **plasma gasification process electricity to syngas and to synfuel**

FISCHER-TROPSCH SYNTHESIS

Basic reactions in the F.T. synthesis

Paraffins formation

$$(2n + 1)\ H_2 + n\ CO = Cn\ H_{(2n+2)} + n\ H_2O$$

Olefins formation

$$2\ n\ H_2 + n\ CO = Cn\ H_{2n} + n\ H_2o$$

Alcohols formation

$$2\ n\ H_2 + n\ CO = Cn\ H_{(2n+1)}\ OH + (n - 1)\ H_2O$$

Other reactions may occur during the F.T. synthesis

depending on catalyst conditions and working parameters of the reactor

Water gas shift

$$CO + H_2O = CO_2 + H_2$$

Bondouard disproportionation

$$2\ CO = C + CO_2$$

• Most important aspects for F.T. reactors are

1 – High reaction heats

2 – Large number of products produced by varying vapor

3 – Temperature HTFT = 340°C pressure or LTFT 220-240°C

• Main reactors developed since 1950

1 – Slurry bubble-column reactors with internal cooling tubes

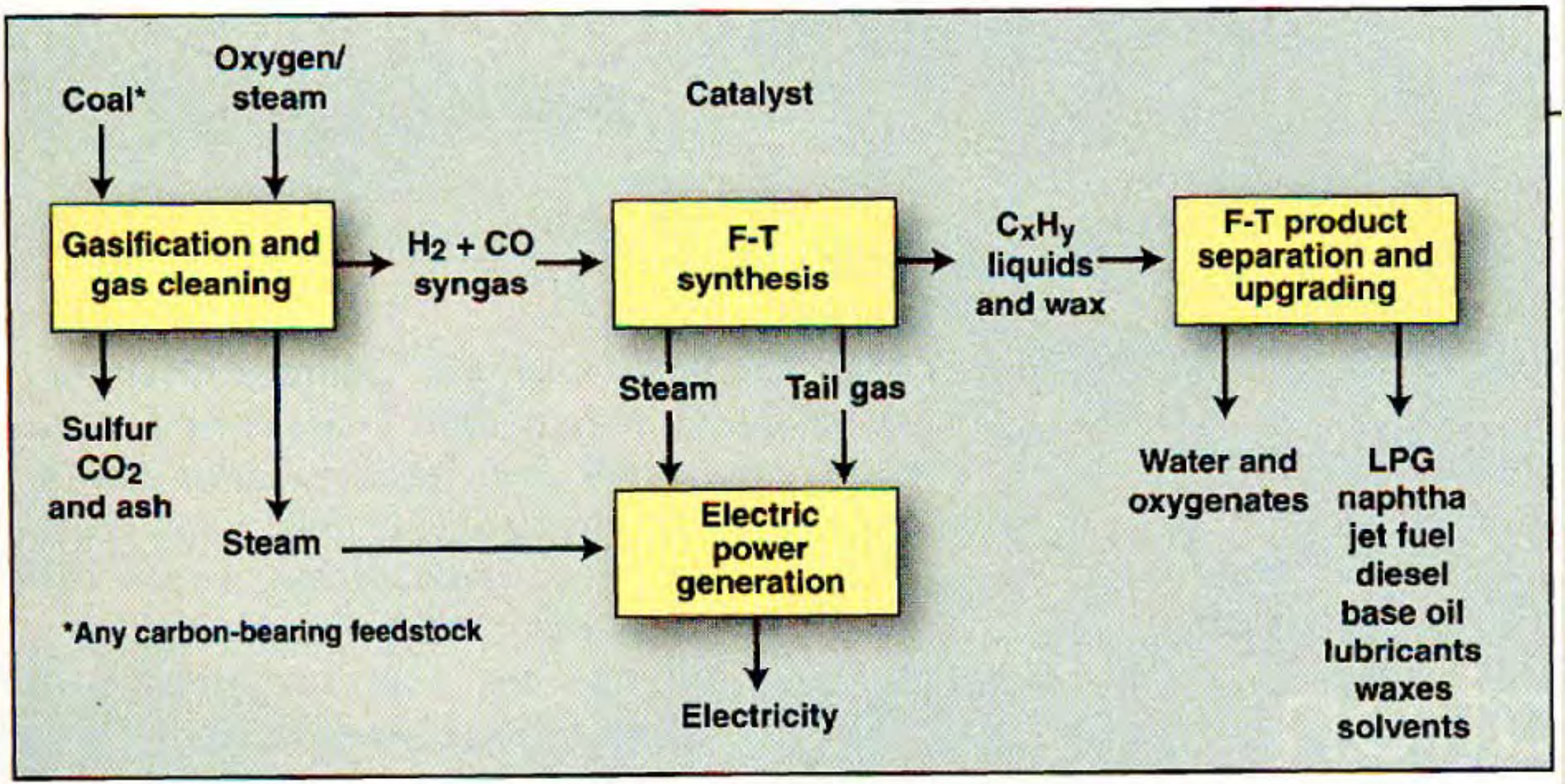
2 – Multi tubular fixed-bed reactors with internal cooling

3 – Circulating fluidized bed reactor with circulating solids, gas recycle, cooling in the gas/solid recirculation loop

4 – Fluidized bed reactors with internal cooling

Ref. Chem. Eng. January 2009 p. 23-27

Gaseification to fisher tropsch process:synfuel synthesis



For more detailed information, see: "Technology Intelligence for Coal-to-Liquids Strategies," a 550-page report recently published by SRI Consulting (Menlo Park, Calif.; see box on p. 27).

Gerald Ondrey

Coal to liquid gaséification steps

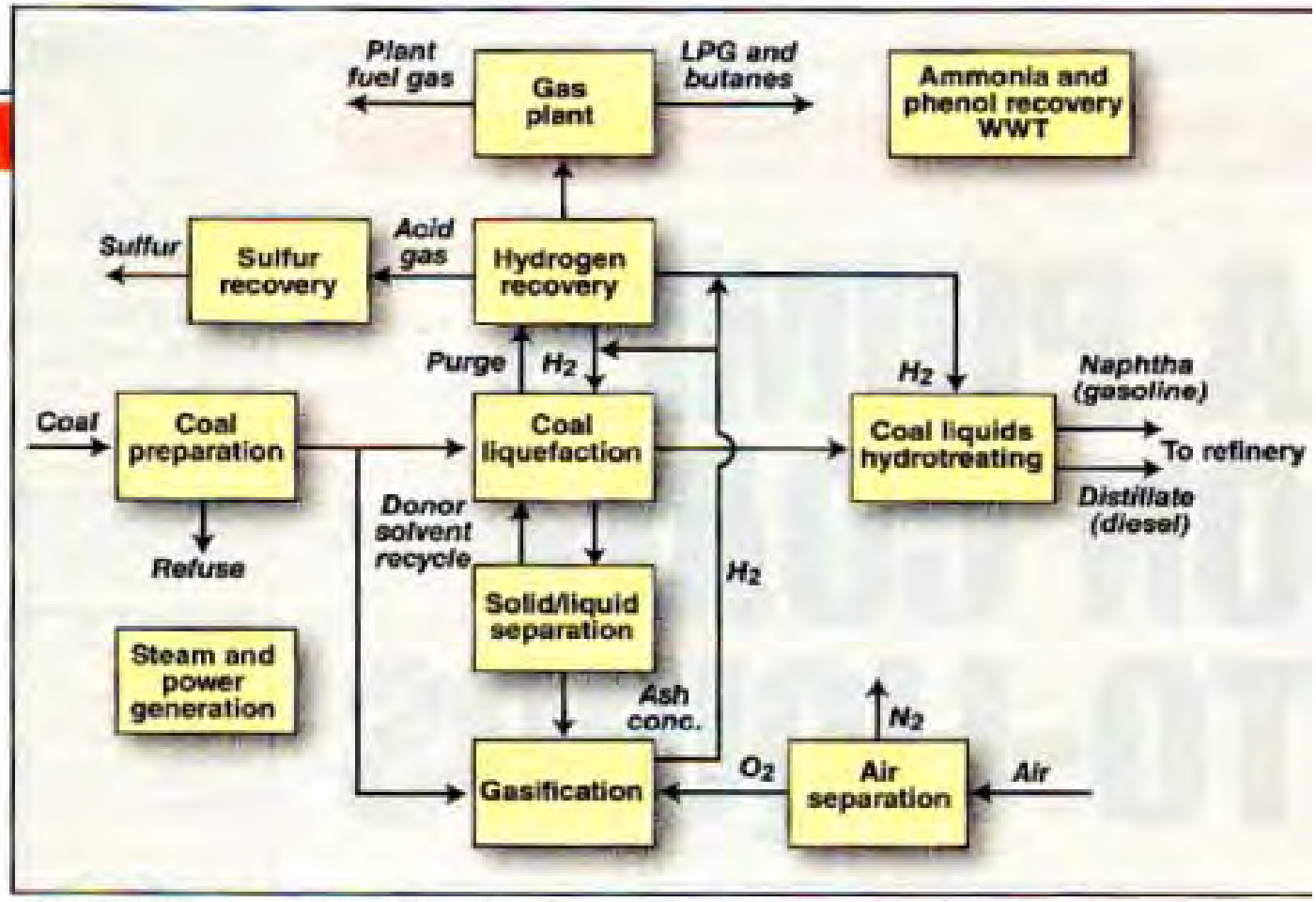


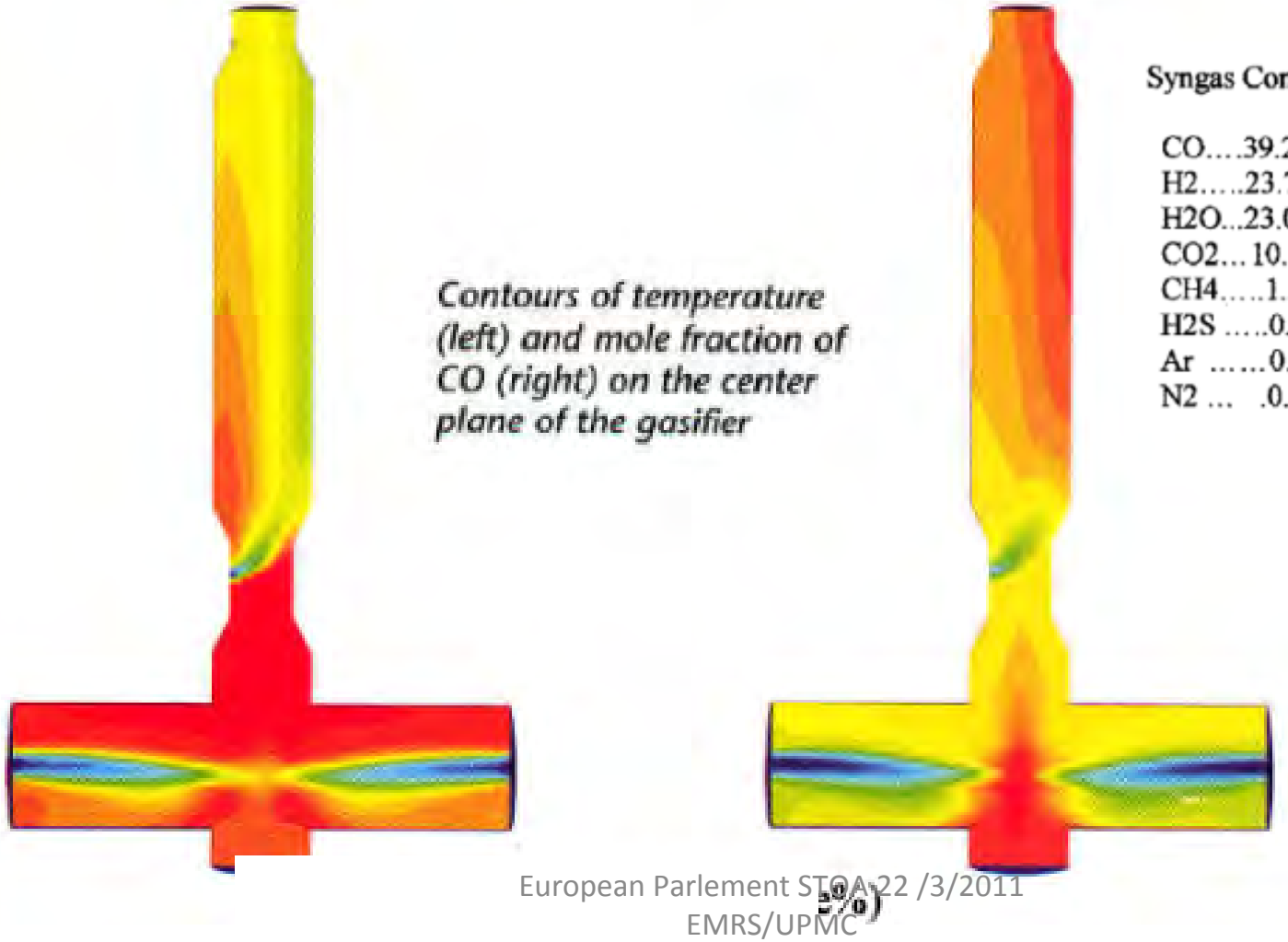
FIGURE 1. In direct coal liquefaction, coal is pulverized and mixed with oil and hydrogen in a pressurized environment. This process converts the coal into synthetic crude oil that can then be refined into a variety of fuel products

For more detailed information, see: "Technology Intelligence for Coal-to-Liquids Strategies," a 550-page report recently published by SRI Consulting (Menlo Park, Calif.; see box on p. 27).

Fluent simulation of coal gaseification(DOE/NETL)

S.Shi,M.Shaham and M.Syamlal (fluent Inc)
S.E.Zitney,W.A.Rogers (National Energy Technology Laboratory,Morgan Town

Coal Gasification for Future Power Generation Fluent News ,XIII issue 2,SII,(2004)



Contours of temperature (left) and mole fraction of CO (right) on the center plane of the gasifier

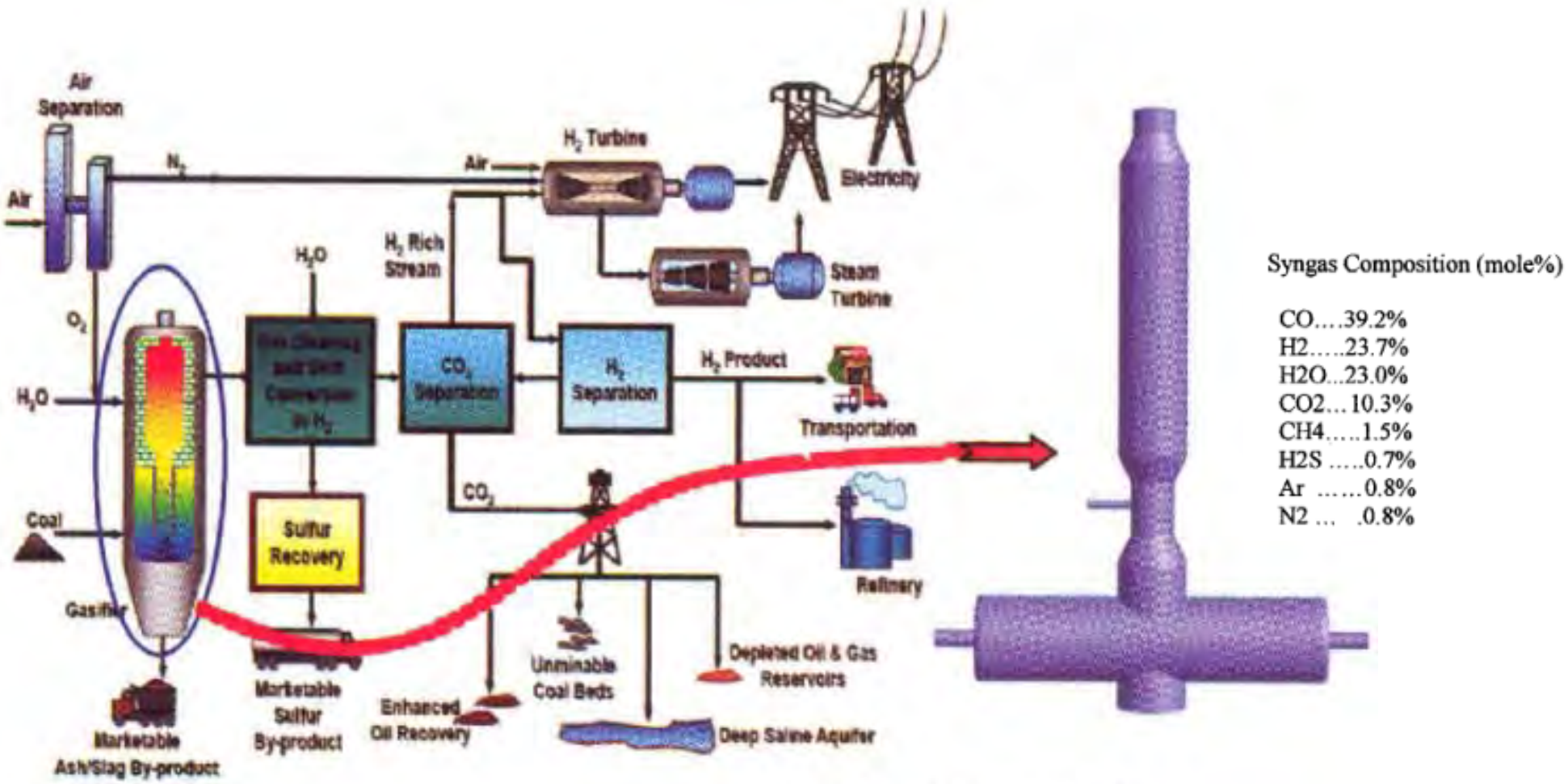
Syngas Composition (mole%)

CO....39.2%
H2.....23.7%
H2O...23.0%
CO2...10.3%
CH4.....1.5%
H2S 0.7%
Ar 0.8%
N2 ... .0.8%

FLUENT SIMULATION OF COAL GASIFICATION (DOE/NETL)

S.Shi,M.Shaham and M.Syamlal (fluent Inc)
S.E.Zitney,W.A.Rogers (National Energy Technology Laboratory,Morgan Town

Coal Gasification for Future Power Generation Fluent News ,XIII issue 2,SII,(2004)



Syngas Composition (mole%)

CO....39.2%
H2.....23.7%
H2O...23.0%
CO2...10.3%
CH4.....1.5%
H2S 0.7%
Ar 0.8%
N2 ... .0.8%

FutureGen power plant with gasifier [2]

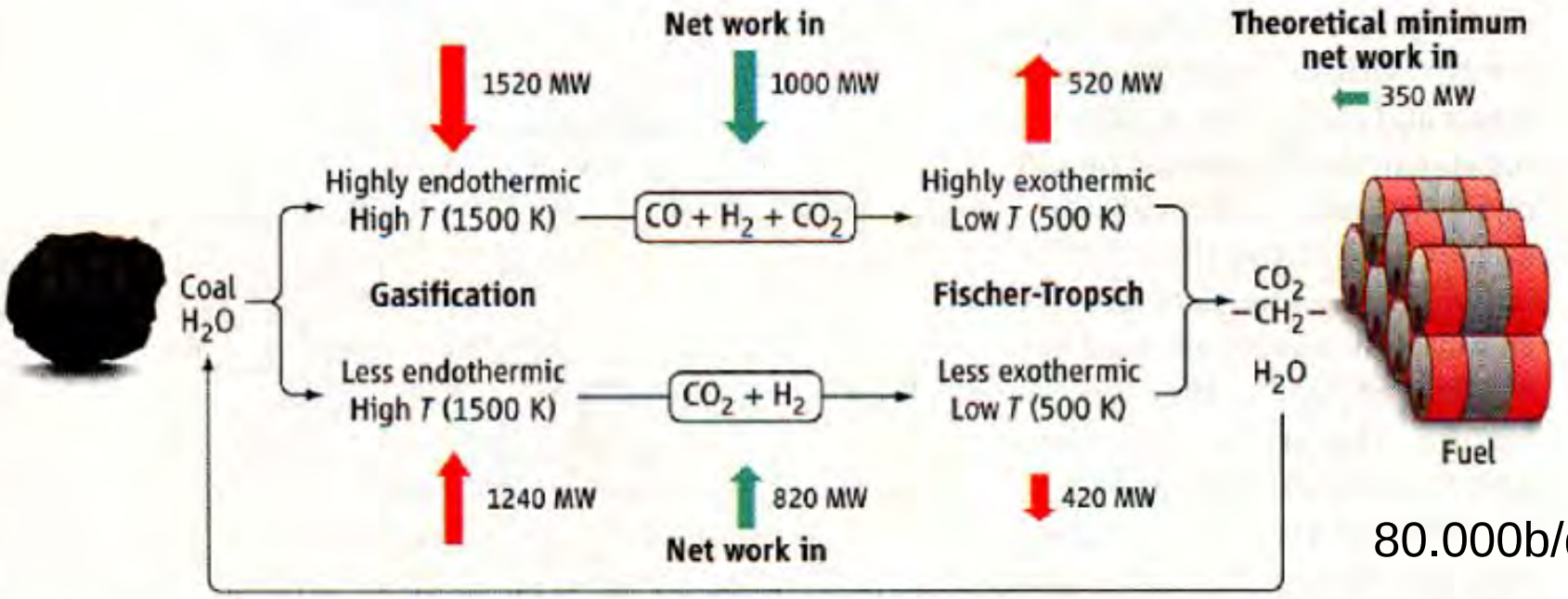
Syngas Composition (mole%)

CO ... 39.2%

CO2 to synfuel:a new process

Producing Transportation Fuels with Less Work

Diane Hildebrandt,[1] David Glasser,[1] Brendon Hausberger,[1] Bilal Patel,[1] Benjamin J. Glasser[2]



80.000b/day

Reducing the work. Improvements in efficiency of the Fischer-Tropsch process can be achieved with a carbon dioxide and hydrogen route, rather than the traditional carbon monoxide and hydrogen route. The processes shown would produce 80,000 barrels of liquid fuel per day and have a theoretical minimum work of 350 MW; the work (via heat) inputs for each stage and for the overall processes are shown as red and green arrows.

D. Hildebrandt, D. Glasser, B. Hausberger, international patent application WO/2007/122498 (2007).

D. Hildebrandt, D. Glasser, B. Hausberger, B. Patel, paper presented at the 1st World CTL Conference, Paris, 3 to 4 April 2008.

science,323,1680(2009)

INNOVATION PROCESSES FOR FISHER TROPSCH SYNTHESIS

Capacity of the Process 80.000 baril/day form coal (131.000 MWh)

▲ **Conventional route** Fisher-Tropsch and M-T-O processes (methanol to olefins) — Energy from network — Theoretical minimum 350MW

$3\ C + 4\ H_2O \rightarrow 2\ CO + 4\ H_2 + CO_2 \rightarrow 2\ (-CH_2-)\ alcane + 2\ H_2O + CO$

1000 MW

▲ **Innovation route**

$$3\ C + 6\ H_2O \rightarrow 3\ CO_2 + 6\ H_2 \rightarrow 2(-CH_2-) + 4\ H_2O + CO_2$$

820 MW → **15 % reduction of CO_2 than** the conventional route

→ **20 % less work to the gasifier**

▲ ➔ if H_2 is produced via { nuclear, wind, solar }

this process becomes a method for consuming CO_2 and may bypass the difficulties in the direct use of H_2 as a fuel

Patent WO / 2007 / 122498 D. Hildebrandt, D. Glasser, B. Hausberger

CHINA:Coal to liquid plant in Mongolia

- A new coal to liquid plant in Erdos
- Operate by Shenhua Group the biggest coal producer in China
- Production of 1 million tons per year of diesel and petrochemical products
- Capture and storage 3.6 millions tons of CO2 in oil fields

- Science 25 sept 2009 vol 325 p 1646