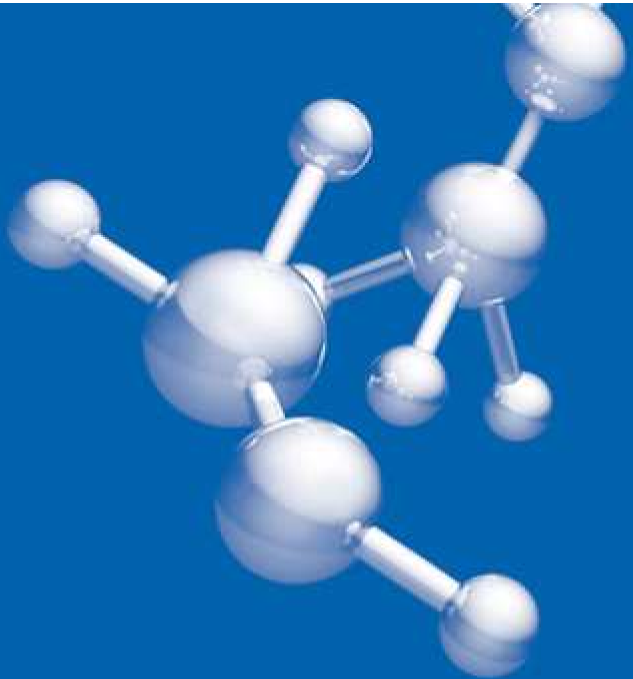

# *Lurgi's Methanation Technology for Production of SNG from Coal*


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# Overview

- Lurgi – Member of the Air Liquide Group
- Market Evaluation
- Chemistry of Methane Production
- Process Concepts
- Factors for Optimum Process Design
- Case study of SNG Production
- Summary

# Lurgi – member of Air Liquide Group

AIR LIQUIDE

Lurgi

Founded in **1902**,

Present in **75 countries**,

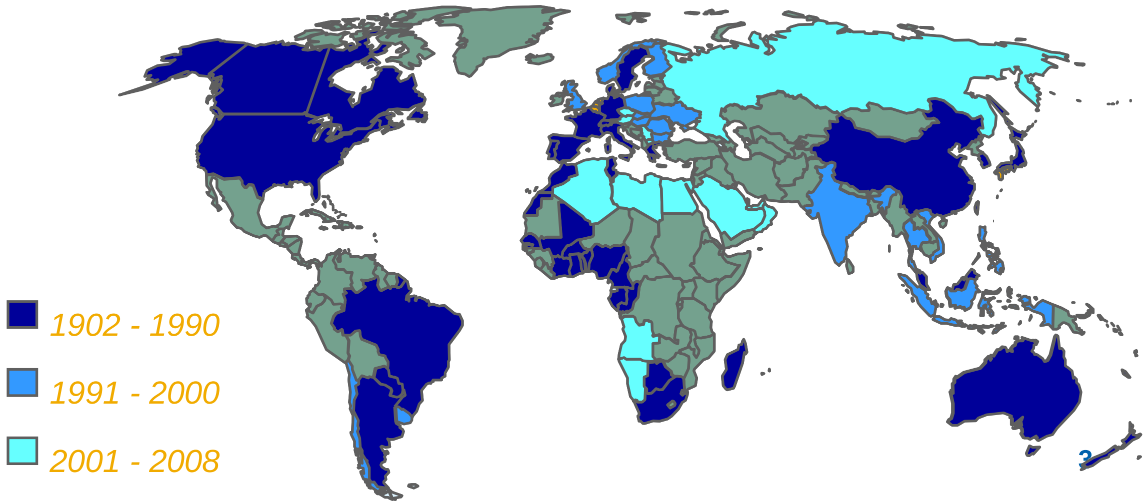
**More than 40,000** employees,

**8 R&D centers**: each year **200 patents** registered,

**1 million** customers across various industries and healthcare activities

**€11 800 million** in sales (2007)

**Lurgi** joined the group in 2007



# Solutions provider for gasification: diversity of technologies

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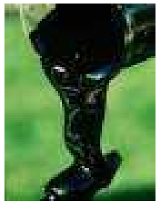
FEEDS | SYNGAS GENERATION | SYNGAS PURIFICATION | MANUFACTURING FROM SYNGAS | PRODUCTS

**FEEDS**

- Heavy Residues
- Petcoke
- Coal
- Biomass



**SYNGAS GENERATION**

Gasification

ASU

**SYNGAS PURIFICATION**

- CO2 Removal (Rectisol Stage 2)
- PSA / Membrane
- CO Cold Box
- Sulfur Removal (Rectisol Stage1)
- CO shift
- Sulfur Recovery

**MANUFACTURING FROM SYNGAS**

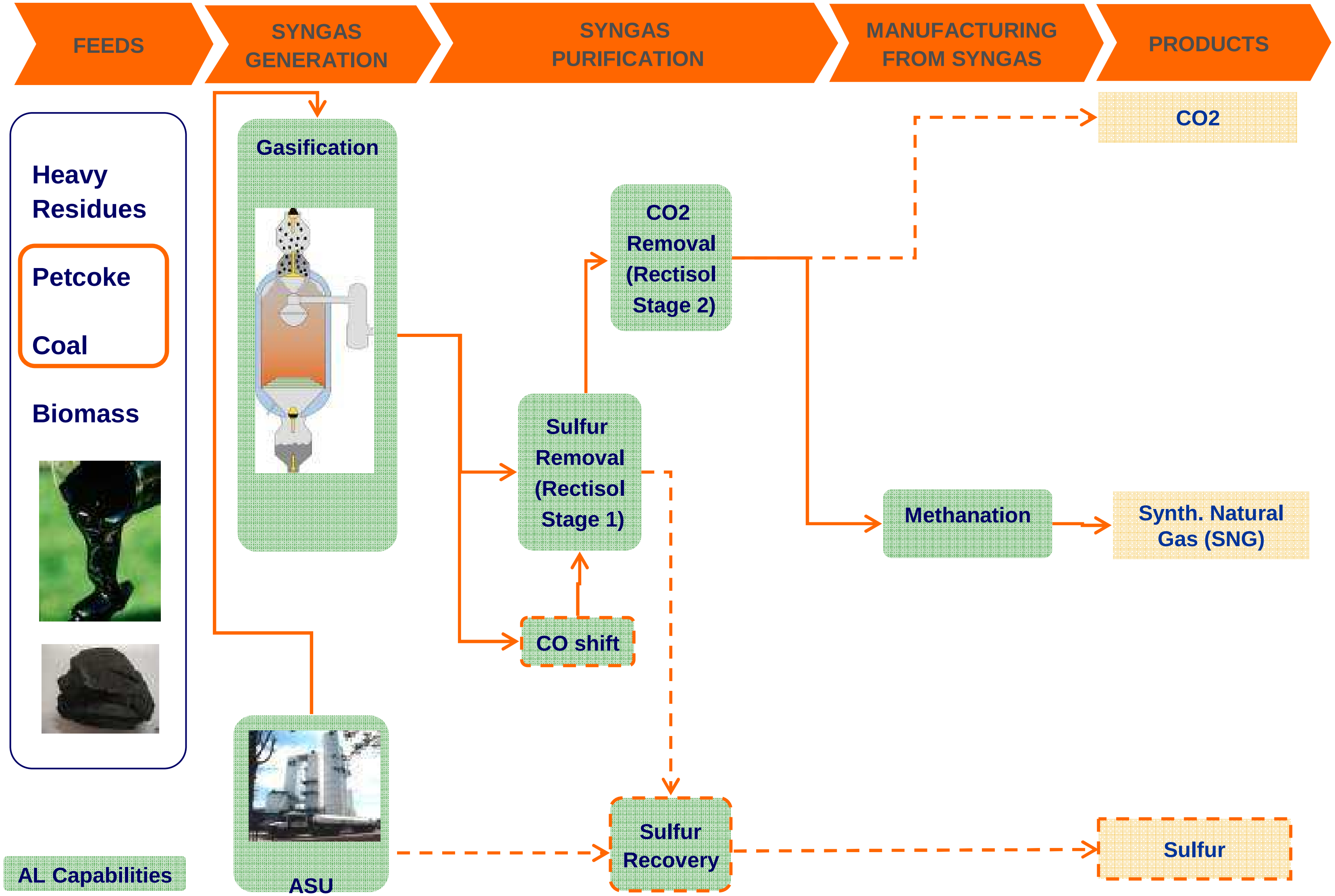
- Chemicals Synthesis
- Methanol Synthesis
- Nitrogen wash + Hydrogen
- Methanation
- Turbine
- Fischer Tropsch

**PRODUCTS**

- CO2
- Hydrogen for Refineries
- Chemicals
- Fertilizers
- Synth. Natural Gas (SNG)
- Power
- Synfuels
- Syngas for DRI
- Sulfur

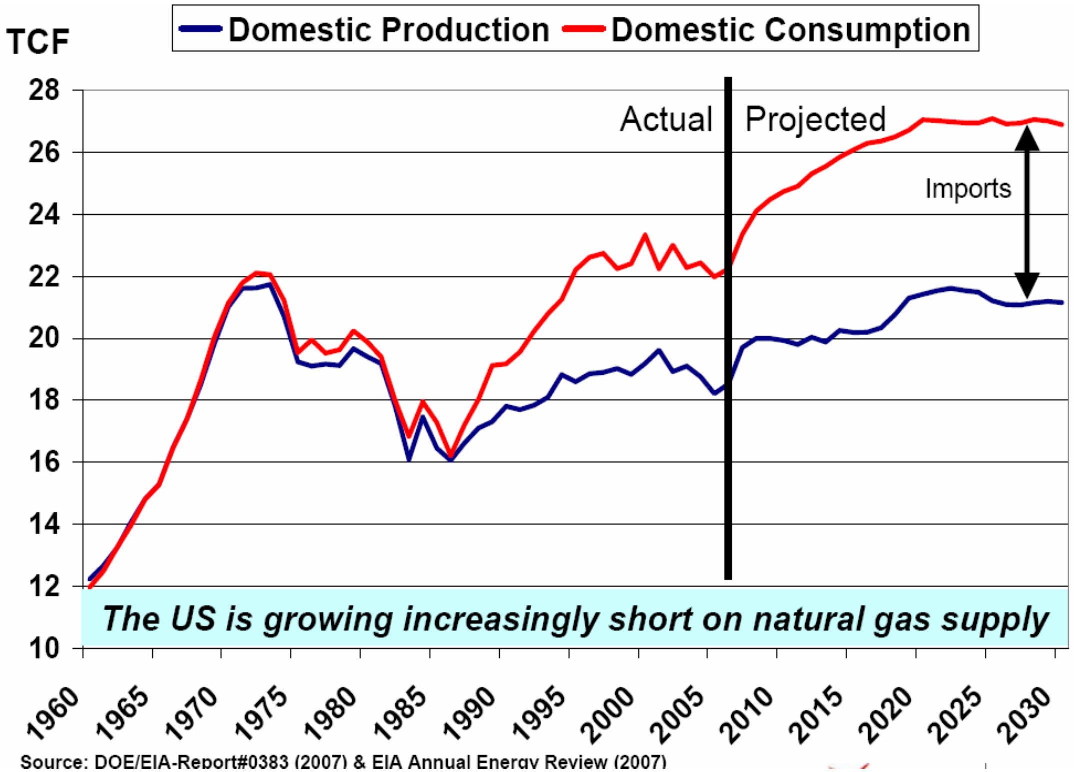
AL Capabilities

# Optimized solutions provider for the SNG route



# Market Evaluation – U.S.
# Project Drivers

- *USA is short on natural gas and very long on coal*
- *Gasification technology can augment North American natural gas supplies and LNG imports*
- *Adds value to US coal reserves*
- *Increased energy diversity*
- *National energy security implications*
- *Existing Infrastructure of pipelines and combustion turbines*
- *Method to reduce carbon penalty associated with coal*



# SNG by Methanation
# Main Chemical Reactions

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Methanation Reactions

$$CO + 3H_2 \Leftrightarrow CH_4 + H_2O \quad + \Delta H$$

$$CO_2 + 4H_2 \Leftrightarrow CH_4 + 2H_2O \quad + \Delta H$$

CO Shift Reaction

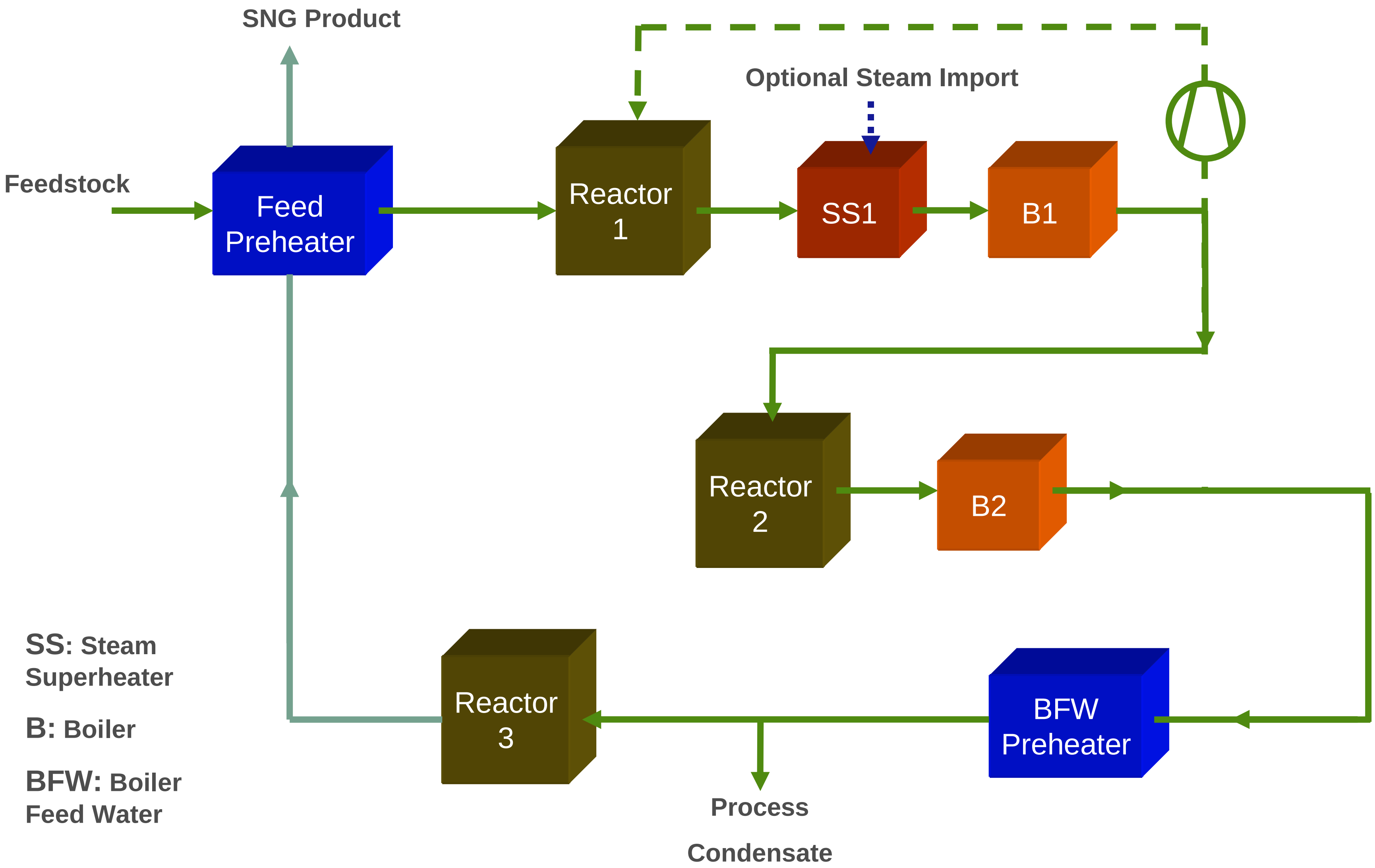
$$CO + H_2O \Leftrightarrow CO_2 + H_2 \quad + \Delta H$$

All reactions appear simultaneously. Methanation reactions are highly exothermic. Lower temperatures are favorable for methane yield.

*One-stage synthesis would lead to adiabatic temperature increase ΔT of 400℃ (720℉) to 600℃ (1080℉) depending on initia l methane content*

***Staged Recycle Process necessary***

# Block Flow Diagram for Superheating Steam Production

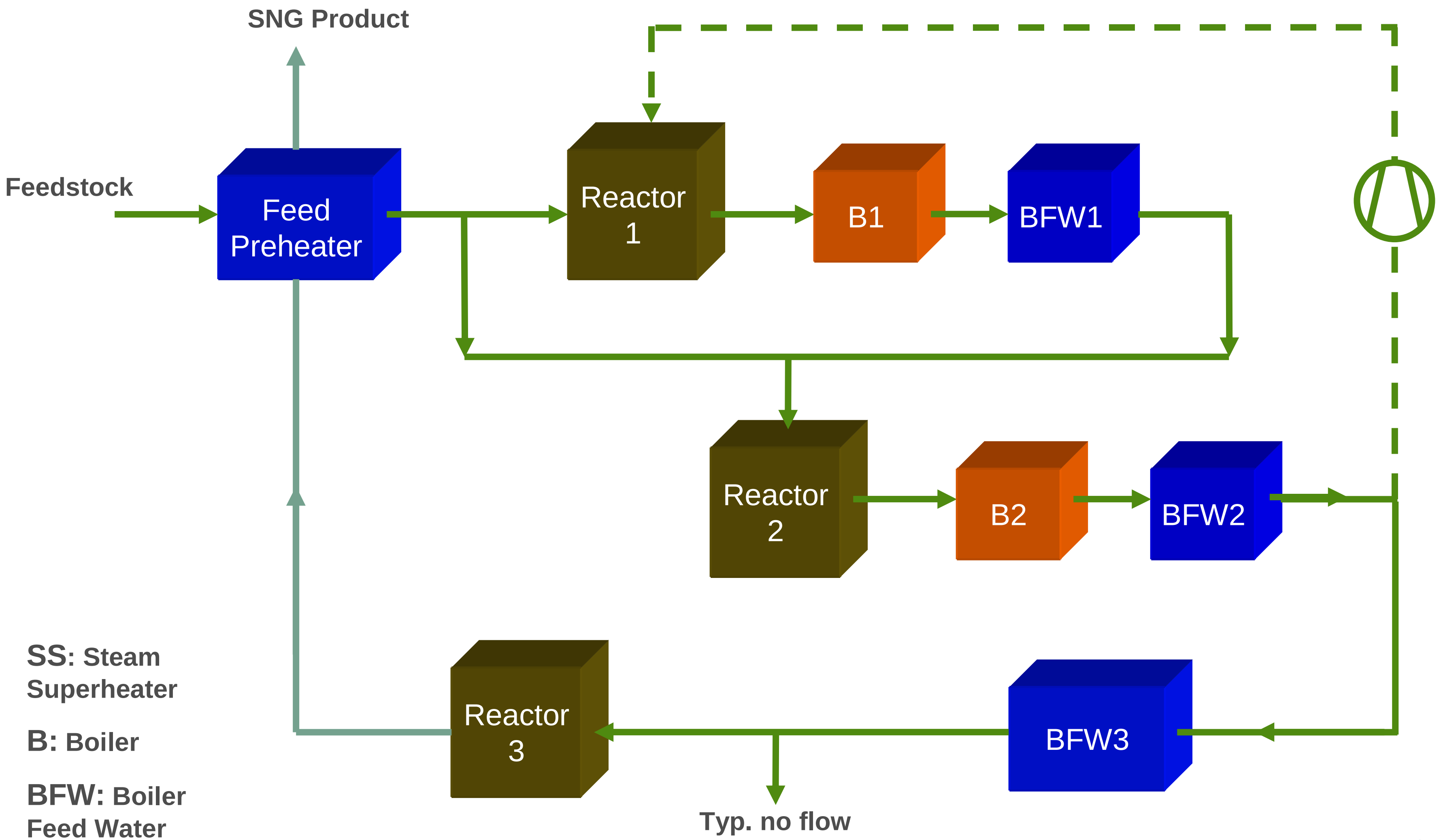



**SS**: Steam Superheater

**B**: Boiler

**BFW**: Boiler Feed Water

# Block Flow Diagram for Saturated Steam Production




**SS:** Steam Superheater

**B:** Boiler

**BFW:** Boiler Feed Water

## Methane Yield vs. Steam Value

- High process temperatures require advanced compressor design
- High process temperatures require refractory lining, expensive reactor material or special reactor design
- High process temperatures are favorable for maximum energy usage via HP steam and electrical energy production in turbines
- High process temperatures are achieved by higher CO content in the gas to the first Reactor

# Factors for Optimum Process Design (cont'd)

## Pressure

- Higher process pressures favor methane formation, however the influence is not as pronounced as lower process temperatures
- Lower process pressures can reduce exothermal reaction slightly
- Lower process pressure are limited by equipment size (transportation limit) or limit the capacity respectively (parallel trains)

## Methane content from gasifier

- Less methane from gasifier results in higher CO concentration and thus more produced water by the methanation reaction
- Water concentration has only marginal effect on SNG quality
- High concentration of methane in feed gas reduces methane of the product gas (applying the same configuration)

# Basis for Methanation Case Study

## SNG product specification:

- Product flow rate = 100 MM SFCD
- HHV > 975 BTU / SCF
- Methane content > 95% (mole)

## Feed gas composition

- $H_2$/CO = 3.4 mole/mole
- $CO_2$ = 1,5 % (mole)
- Inerts = 0,6 % (mole)
- $CH_4$ depending on gasifier type (0.0%; 7.5 %; 16.2%mole)

## Superheated Steam condition

- 900 °F @ 885 psig

# Considered configurations

**The following variations have been considered:**

Feed gas composition produced in different gasifier types:

1. High Temp Gasifier ***(HTG)***
2. High Temp. Gasifier with Chemical Quench ***(HTGwCQ)***
3. Fixed Bed Dry Bottom Gasifier ***(FBDB)***

Type of steam production:

A. Saturated HP steam only

B. Only HP steam produced in Methanation is superheated

C. HP steam is imported to maximized superheated HP steam production

Comparison of final reactor design

I. Isothermal Reactor

II. Adiabatic shaft Reactor

## Results of Case Study

Utility figures vs. produced saturated steam:
(for feed gas coming from Fixed Bed Dry Bottom Gasifier)

| | | |
|---|---|---|
| Saturated steam (Ex boiler): | 580 000 | lb/h |
| HP BFW: | 590 000 | lb/h |
| Power for Compressor: | 10 100 000 | HP |
| Recycle flow rate: | 500 MM | SCFD |

# Superheated steam production

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## Amount of steam superheated in Methanation unit:

| | High Temp Gasifier | High Temperature Gasifier with Chemical Quench | Fixed Bed Dry Bottom Gasifier |
|---|---|---|---|
| Steam produced only in Methanation unit | **910 000 lb/h** | **690 000 lb/h** | **480 000 lb/h** |
| Additional steam imported and superheated in Methanation unit | **1 450 000 lb/h** | **1 080 000 lb/h** | **740 000 lb/h** |

# Results of Case Study (cont'd)

General results:

- The methane quality can either be achieved by:
  - 2 Shaft reactors plus 1 Isothermal reactor
  - 4 Shaft reactors
- Up to 100 % more HP steam can be superheated compared to HP steam produced inside Methanation unit
- 20 % more saturated HP steam compared to superheated HP steam is produced (for ***FBDB***)

In case HP steam is superheated *(scenario B. and C.)*:

- The recycle flow rate increases by 142 % (for ***HTG*** vs. ***FBDB***)
- The first Methanation Reactor Diameter is 43 % bigger (for ***HTG***)
- 60% more steam are produced for ***HTG*** vs. ***FBDB*** *based on CO intake*

## Summary of Case Study

- SNG quality most sensitive to reactor inlet temperature
- Sufficient heat is available to superheat more HP steam than produced inside Methanation
- The more methane is produced in the gasifier, the less HP steam is produced.
- A final Isothermal reactor reduced the number of reactors
- Increased CAPEX for superheated steam production due to :
  - Refractory requirement in first reactor for superheated steam production
  - Bigger diameter of first reactor

## Design Know-How
## (not detectable by simulation)

- Soot formation is catalyzed by nickel and soot itself
- Metal dusting tendency (increases by pressure and CO content)
- Higher process temperatures favor deactivation of active nickel sites on catalyst
- Higher CO partial pressures favor formation of nickel carbonyl, i.e. minimum temperature limit is shifted to higher temperatures

## Summary

- Optimal Methanation process concept depends on type of feed gas as well as plant utility integration
- Design of a proper Methanation plant needs a lot of know-how and catalyst experience
- Lurgi has designed and licensed the only industrial scale SNG plant from coal
- The DGC reference is the only commercial CCS application
- SNG from coal is a viable option!

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# Thank you

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