

# **Rectisol® Wash Units**

## **Acid Gas Removal for Polygeneration Concepts downstream Gasification**

Ulvi Kerestecioğlu, Thomas Haberle  
GTC Conference, Washington DC, USA, November 3rd, 2010

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# Polygeneration Concepts using Linde's Rectisol® Wash Process

## Agenda of the Presentation



### 1. General Information about the Rectisol® Process

- Products downstream Acid Gas Removal Systems
- The Rectisol® Process

### 2. Basic Schema of the Rectisol® Process

- Block Flow Diagram and Simplified Process Flow Diagram
- Achievable Product Quality of the Rectisol® Process

### 3. Polygeneration Concepts with the Rectisol® Process

- Multi Products with one Acid Gas Removal System

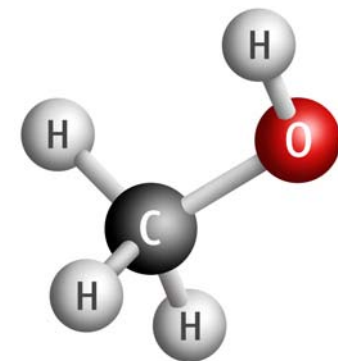
### 4. CO2 Emissions & Clean Energy

- CO2 Capture with the Rectisol® Process

### 5. Polygeneration & IGCC Projects in the USA

- TCEP & HECA Project

### 6. Miscellaneous



Methanol Molecule

## General Information about the Rectisol® Process

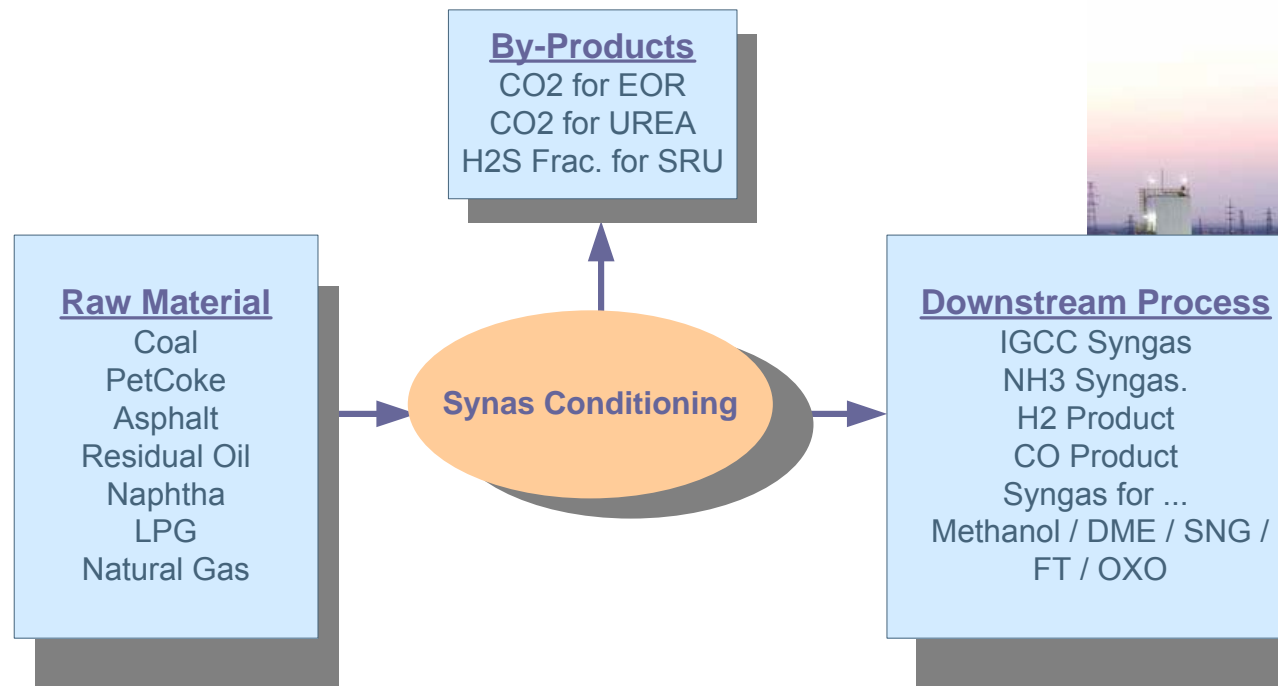


**RWU in Shanghai, China**

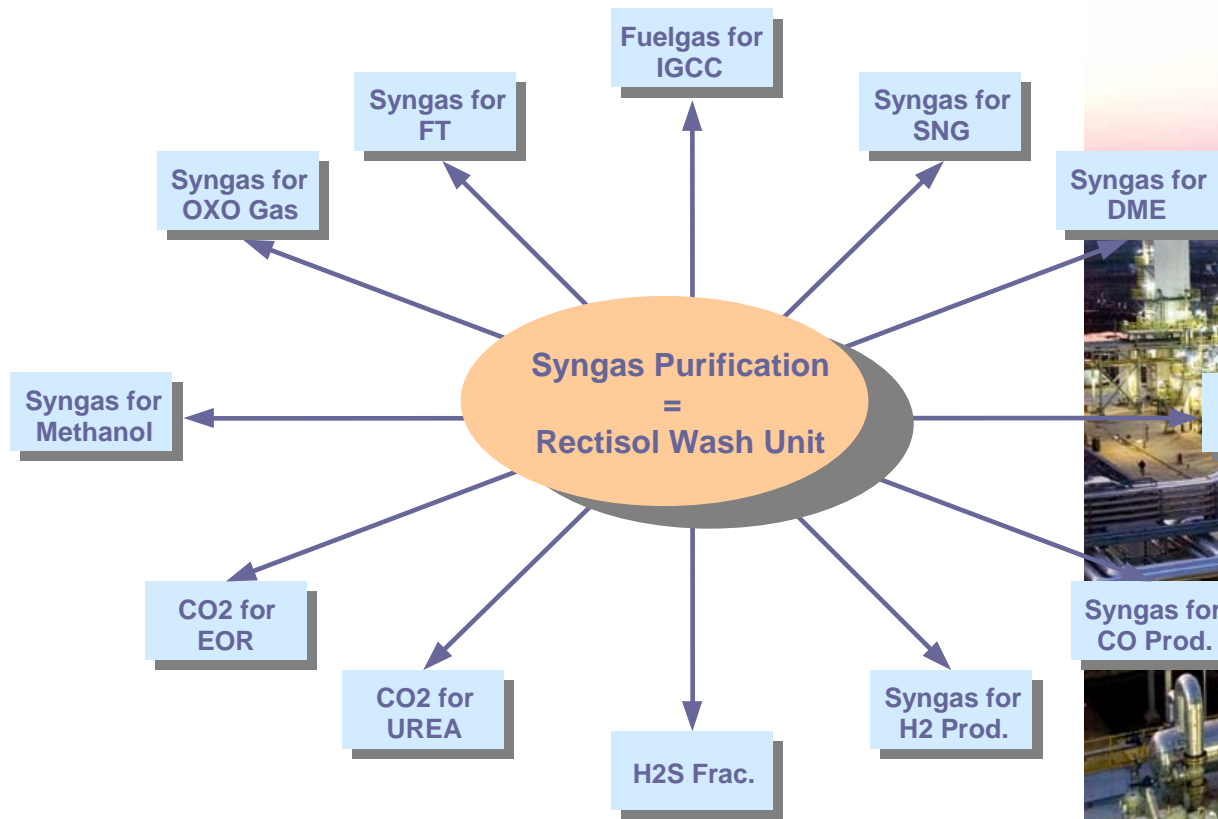
# Polygeneration Concepts using Linde's Rectisol® Wash Process Acid Gas Removal is an Essential Process Step in the entire Gasification Unit.

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# Polygeneration Concepts using Linde's Rectisol® Wash Process Acid Gas Removal is an Essential Process Step in the entire Gasification Unit.



# Polygeneration Concepts using Linde's Rectisol® Wash Process

## Rectisol® Offers lots of Benefits for Polygeneration Concepts Downstream Gasification Units.



### Requirements for plant and products

- Highest product quality
- Simultaneous production of several products
- Flexible switches between different products and product flow rates
- Stable in operation
- Safe for operators and environment

**The Rectisol® Process meets above requirements and offers lots of benefits for polygeneration concepts downstream Gasification Units.**



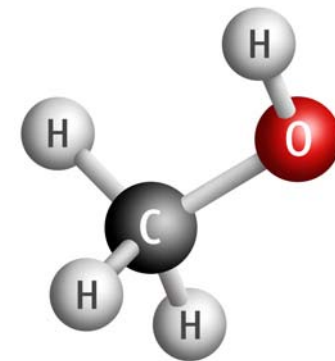
## Polygeneration Concepts using Linde's Rectisol® Wash Process Rectisol® is a Well Proven Wash Process.



### What is Rectisol®?

- The Rectisol® process is a physical wash process where acid gas compounds are solved in methanol and thus removed from the syngas
- Rectisol® was developed jointly by Linde and Lurgi in the late 50th
- Methanol is cheap, readily available and thermally and chemically stable

Methanol Molecule



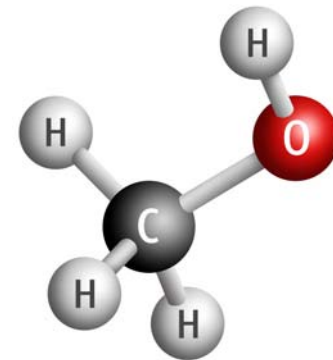
## Polygeneration Concepts using Linde's Rectisol® Wash Process Linde is Well Experienced in Rectisol® due to its Own Running Plants.



### Experience with Rectisol®

- More than 60 Linde Rectisol® Units are engineered world wide by Linde
- Linde is owning and operating three plants (Singapore and the United States)
- Each Rectisol® Wash Unit is developed hand tailored for customers needs and requirements
- Linde is well experienced in handling of different feed gas compositions and production of different products.
- Improved trace component handling guarantees a safe and stable operation.

Methanol Molecule





**Polygeneration Concepts using Linde's Rectisol® Wash Process  
Linde has Rectisol® Wash Unit References  
Downstream of a lot of Different Gasification Types.**



Downstream GE (Texaco)  
Coal Gasification

**15**  
max. capacity 997,000 Nm<sup>3</sup>/h

Downstream Shell  
Coal Gasification

**10**  
max. capacity 544,000 Nm<sup>3</sup>/h

Downstream other Coal Gasific.  
e.g. Koppers, HTW Lignite, ECUST, Chinese  
Fixed Bed, ConcoPhillips E-Gas, etc.

**15**  
max. capacity 1,070,000 Nm<sup>3</sup>/h

Downstream Heavy Fuel Oil,  
Residuals or Asphalt Gasification

**18**  
max. capacity 448,000 Nm<sup>3</sup>/h

Others  
e.g. Natural Gas

**4**  
max. capacity 235,000 Nm<sup>3</sup>/h

## Basic Schema of the Rectisol® Process



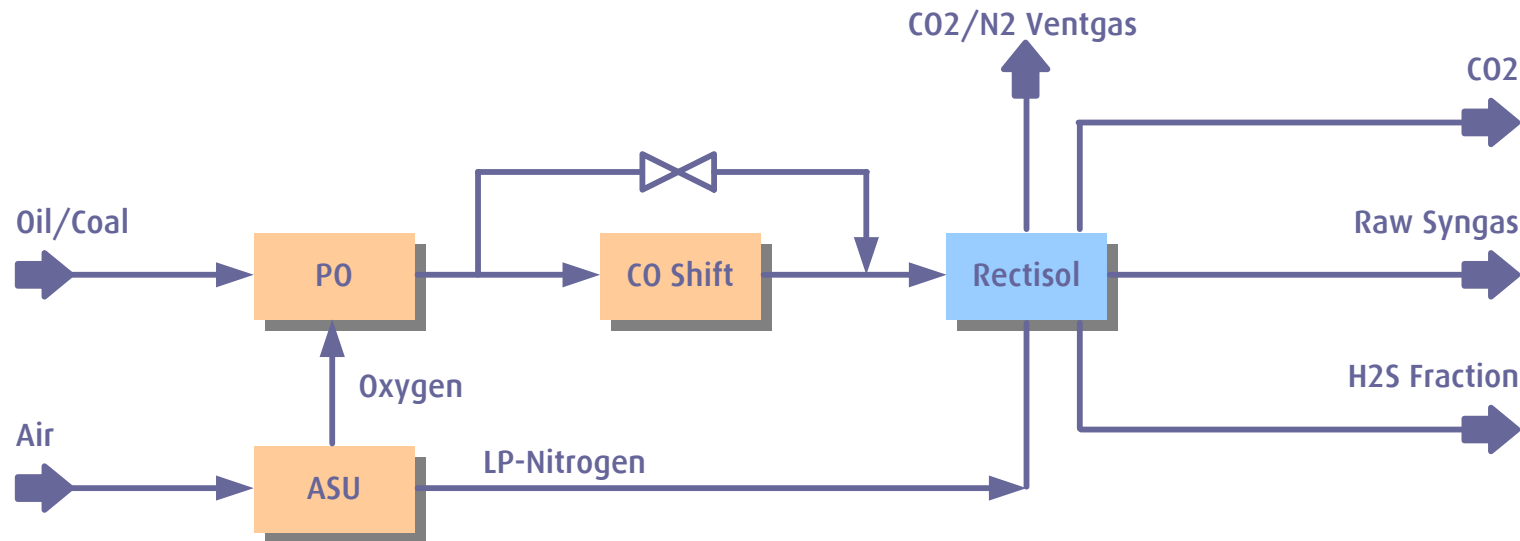
**RWU in Yunnan, China**

# Polygeneration Concepts using Linde's Rectisol® Wash Process

## Rectisol® is a Flexible Process to Achieve a Wide Range of Products and By-Products and Qualities.

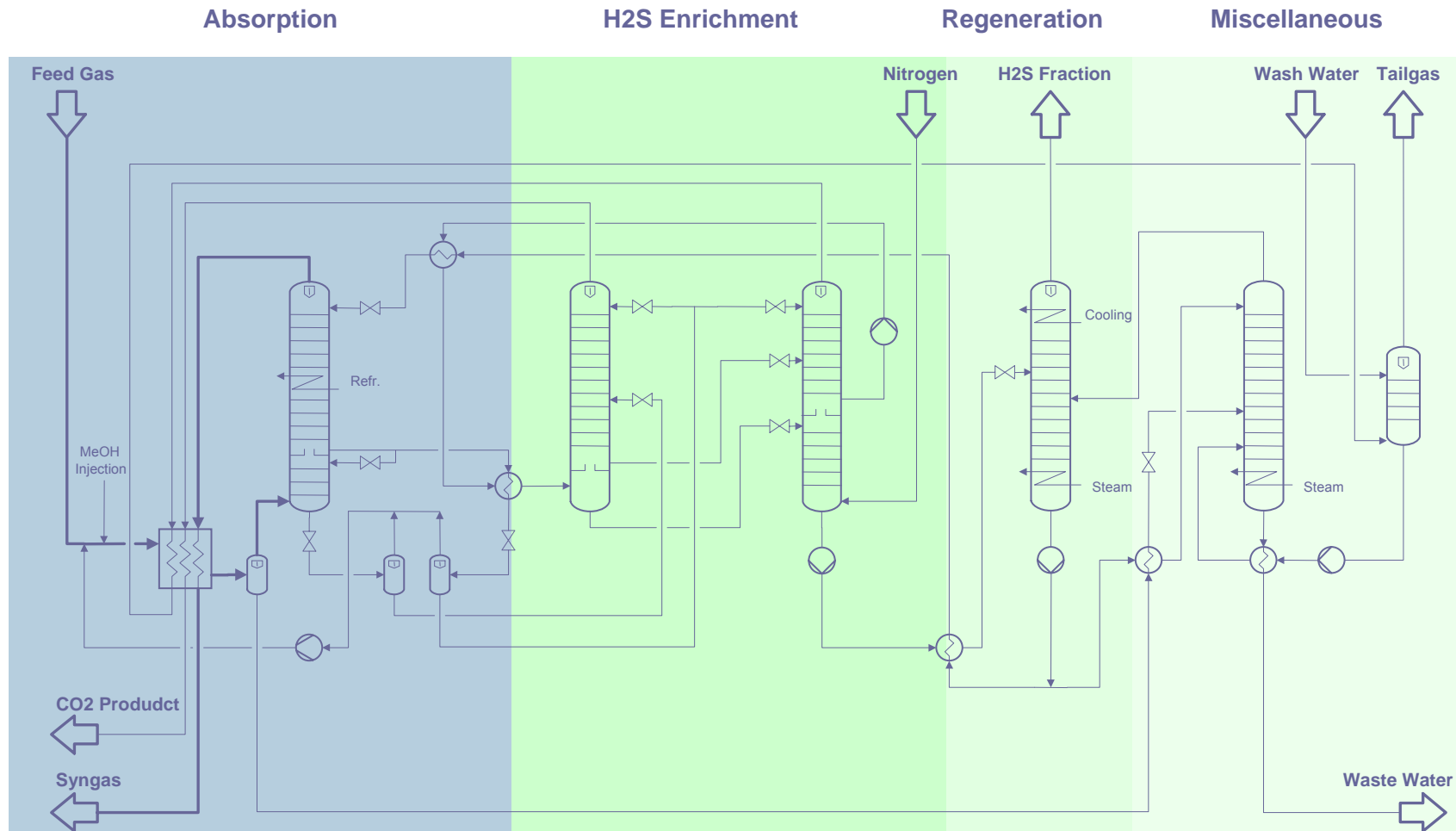


### Block Diagram of a Rectisol® Wash Unit with Nitrogen Stripping



# Polygeneration Concepts using Linde's Rectisol® Wash Process

## The Wash Process consists of Four Major Sub-Units.



# Polygeneration Concepts using Linde's Rectisol® Wash Process Highest Product Qualities can be Guaranteed.



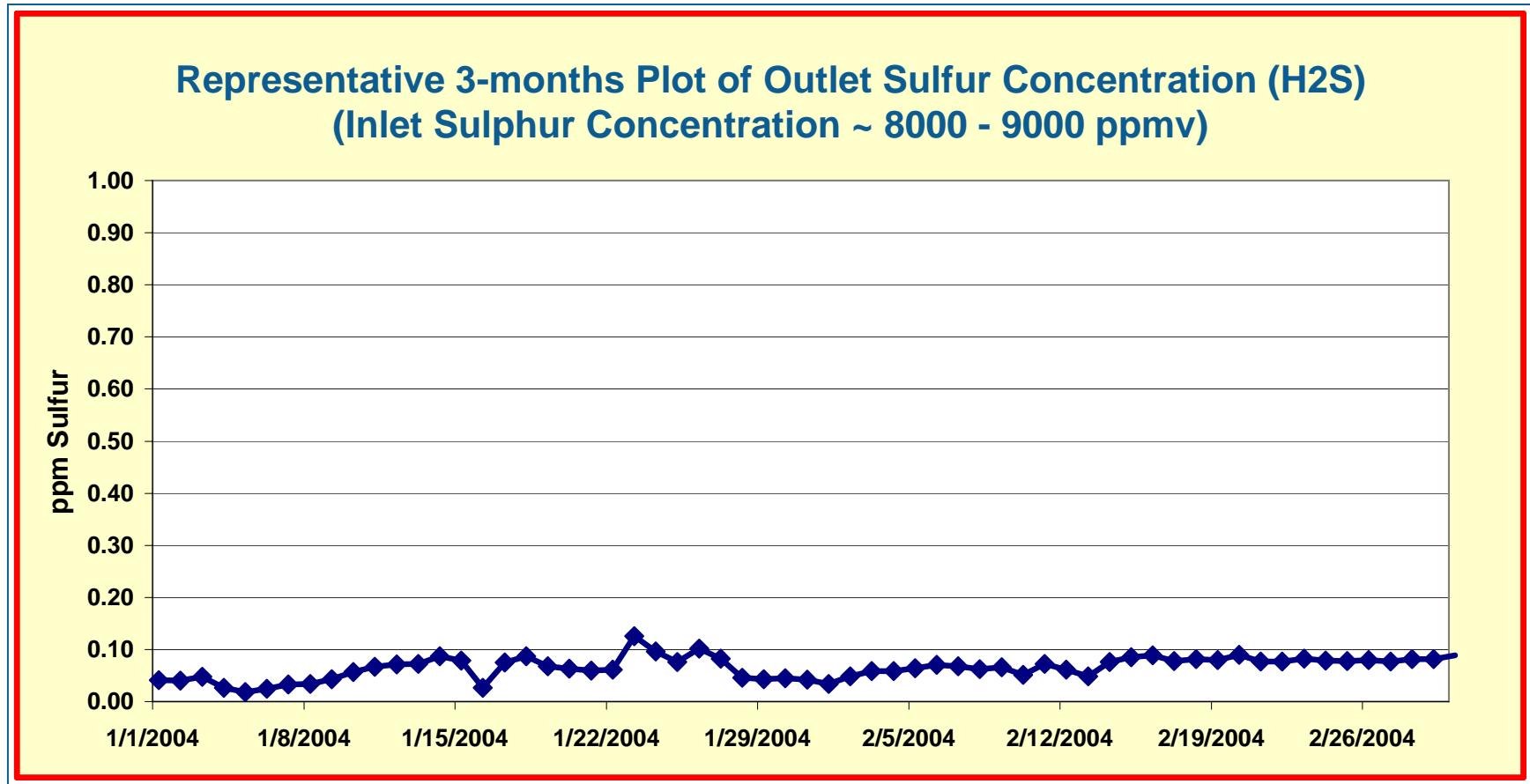
## Typical Product Qualities

	Purified Gas	CO2-Product	H2S-Fraction	Tailgas
CO2	< 5 vppm up to 5 mol%	≥ 98.5 mol%		
H2S + COS	< 0.1 vppm	2 – 10 mg/Nm <sup>3</sup>	Suitable for SRU/Claus	5 - 25 vppm
H2O	< 0.1 vppm	< 1 vppm	< 1 vppm	< 1 vppm
Methanol	15 – 30 vppm	250 – 300 vppm 20 vppm *)		100 – 200 vppm 20 vppm *)
Pressure	Δp ~ 2 bar	1.7 – 3.3 bar(a)	1.5– 3.0 bar(a)	1.05 bar(a)

\*) with Additional Water Wash Column

# Polygeneration Concepts using Linde's Rectisol® Wash Process

## Lowest and Stable Sulphur Contents in the Treated Syngas are Achieved.



From Presentation of David L. Denton "Eastman Chemical Company – Rectisol Plant Operation Experience" at the Linde Hydrogen Production Symposium in Calgary July 2007

## Polygeneration Concepts with the Rectisol® Process

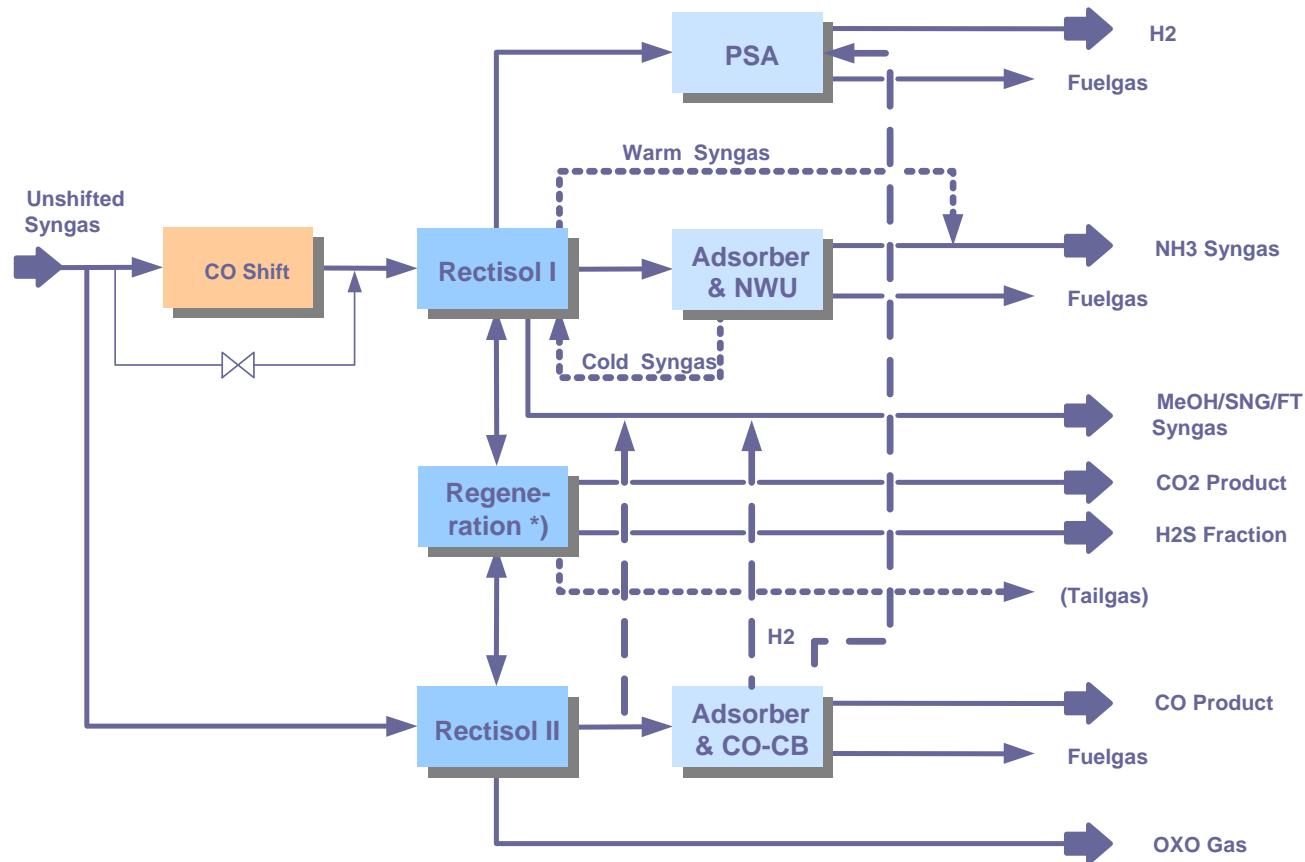


# Polygeneration Concepts using Linde's Rectisol® Wash Process

## Linde's Rectisol® Process can Favourably be Combined with Several Further Purification Steps.



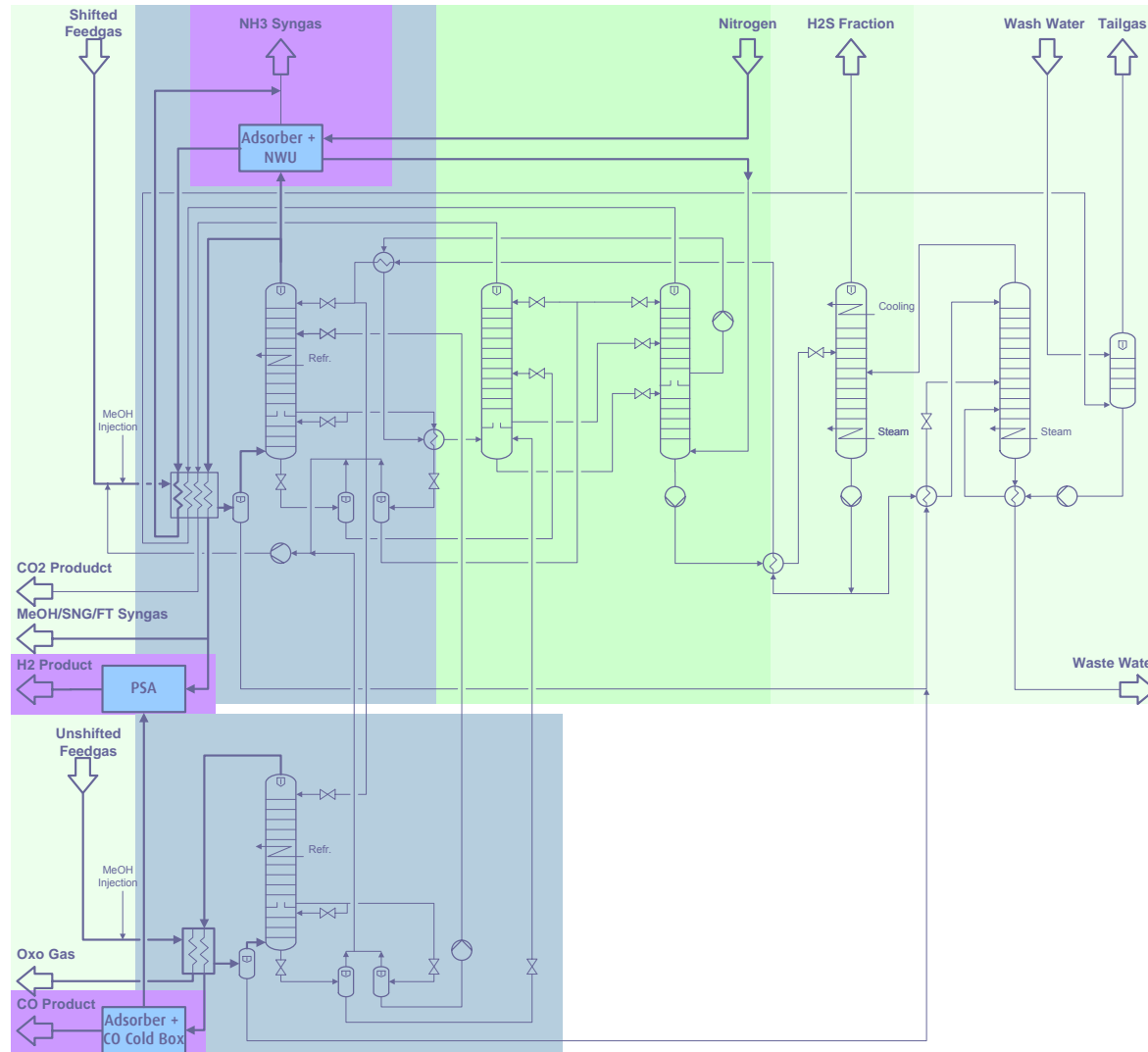
### Block Diagram of a Rectisol® Wash System for Polygeneration Concepts



\*) One common regeneration system for both Rectisol Wash Units

# Polygeneration Concepts using Linde's Rectisol® Wash Process

## Linde's Rectisol® Process can favourably be Combined with Downstream Units.



# Polygeneration Concepts using Linde's Rectisol® Wash Process The Nanjing Plant in China – Successfully in Operation with Fluctuations in the Product Quantity.

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## Products

- Methanol Syngas
- CO Product downstream CO Cold Box

## Operational Flexibility

- Switch between the product types  
CO Product ↔ Methanol Product
- Switch between the product flow rates
  - \* Part load operation only for unshift section  
(w/o CO Product)
  - \* Part load operation only for shifted section

**Successful in operation since 2008.**

## CO2 Emission & Clean Energy



**RWU in Berrenrath, Germany**

# Polygeneration Concepts using Linde's Rectisol® Wash Process CO2 Emission is Nowadays an Upcoming Issue.



## CO2 Emission

- Today and in the near future CO2 emission is getting a more and more important issue.
- “Clean Energy” is an upcoming market.
- Nowadays the whole world is looking for reduced CO2 emission.

## Carbon Capture means capture of mainly CO and CO2

The carbon capture rate can be increased:

- by a deeper shift (CO converted to CO2)
- by nearly 100% CO2 removal within the Rectisol® Process

⇒ **Rectisol® Plants can be designed for nearly 100% CO2 capture, and therefore for a nearly CO2 emission free plant.**



## Polygeneration Concepts using Linde's Rectisol® Wash Process The Captured CO2 Fulfills the required Specifications.



### CO2 Product

- The CO2 can be recovered without Nitrogen stripping and is fulfilling pipeline and product specification
- The captured CO2 can be used for UREA and/or EOR
- The CO2 is free of water and nearly free of sulphur

**The design of the required CO2 capture rate within the Rectisol® Wash Unit is driven by the overall required carbon capture rate.**



## IGCC/Polygeneration Concepts in the USA



RWU in Nanjing, China

## Polygeneration Concepts using Linde's Rectisol® Wash Process The Texas Clean Energy Project (TCEP)



### Key Figures for the TCEP:

Polygeneration Concept:

Power, UREA, CO2 for EOR, Sulphuric Acid

400 MW IGCC Project, 1,350 MTD UREA (= 1,485 STPD)

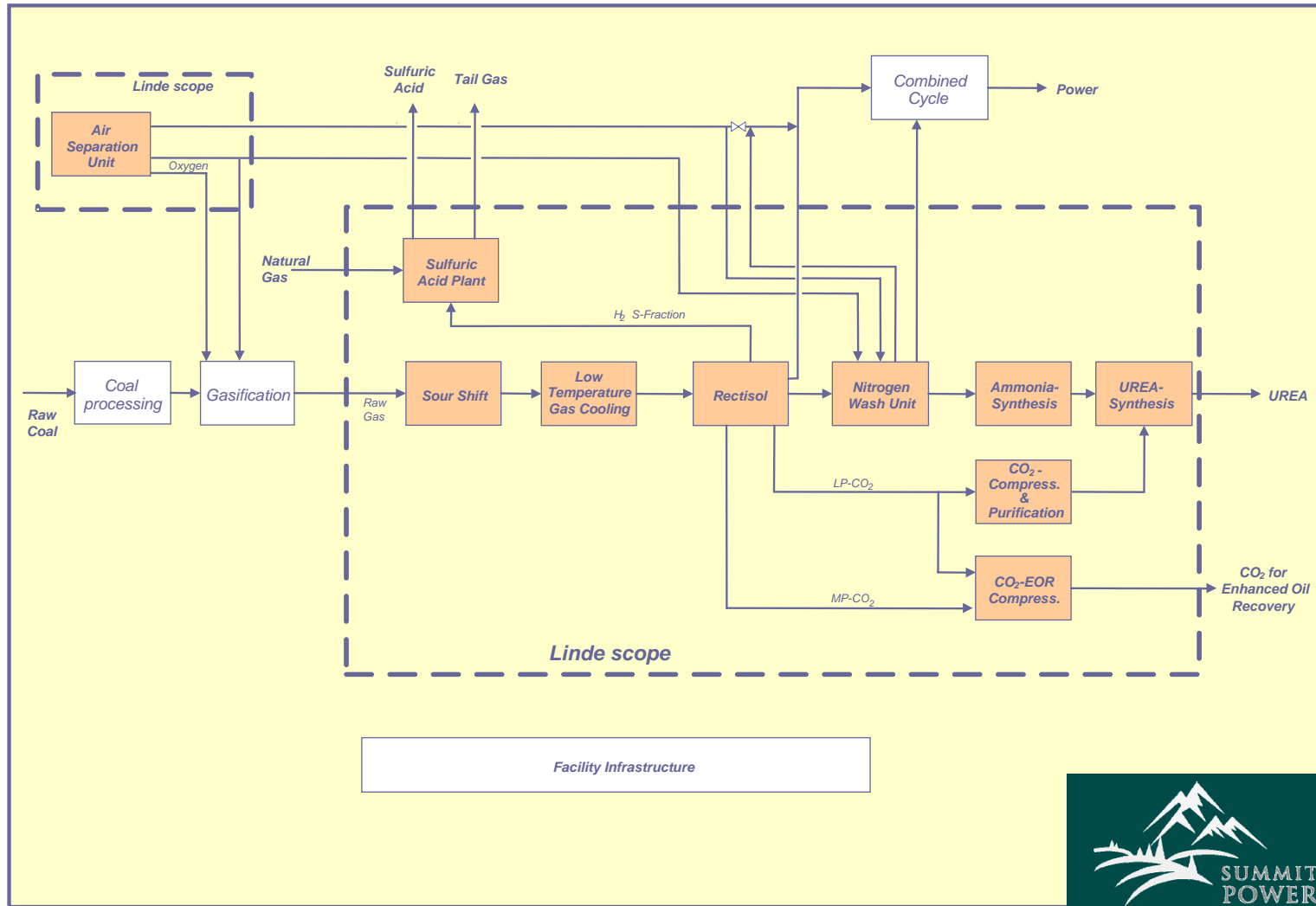
FEED launched to Linde, Siemens, Fluor

Overall: 90% Carbon Capture  $\approx$  2.9 million t/year CO2 capture

Nearly 100% sulphur removal



# Polygeneration Concepts using Linde's Rectisol® Wash Process TCEP – Overall Process Integration.



# Polygeneration Concepts using Linde's Rectisol® Wash Process TCEP – The Plant Concept offers a lot of Special Features.



## Special features realised for TCEP

### Flexible product switch from max. Ammonia to max. Power

- ⇒ the Rectisol® Wash Unit is only marginal affected by the product switch
- ⇒ the Nitrogen Wash Unit is very flexible in plant load fluctuation
- ⇒ the SRU is not affected by the product switch

### High ammonia production and high efficiency of the power plant

High H<sub>2</sub> recovery rate for the Nitrogen Wash Unit (99.5% vs. ~ 90% for PSA)

- ⇒ more high pressure syngas available

### High carbon capture rate within the Rectisol® Wash Unit

- ⇒ the CO<sub>2</sub> capture rate within the Rectisol® Wash Unit is about 98.5% driven by the overall plant carbon capture rate of 90%.



## Polygeneration Concepts using Linde's Rectisol® Wash Process TCEP – The Plant Concept offers lot of Benefits.

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### Benefits realised for TCEP

No COS hydrolysis is required

No CO<sub>2</sub> purification for CO<sub>2</sub> to EOR is required

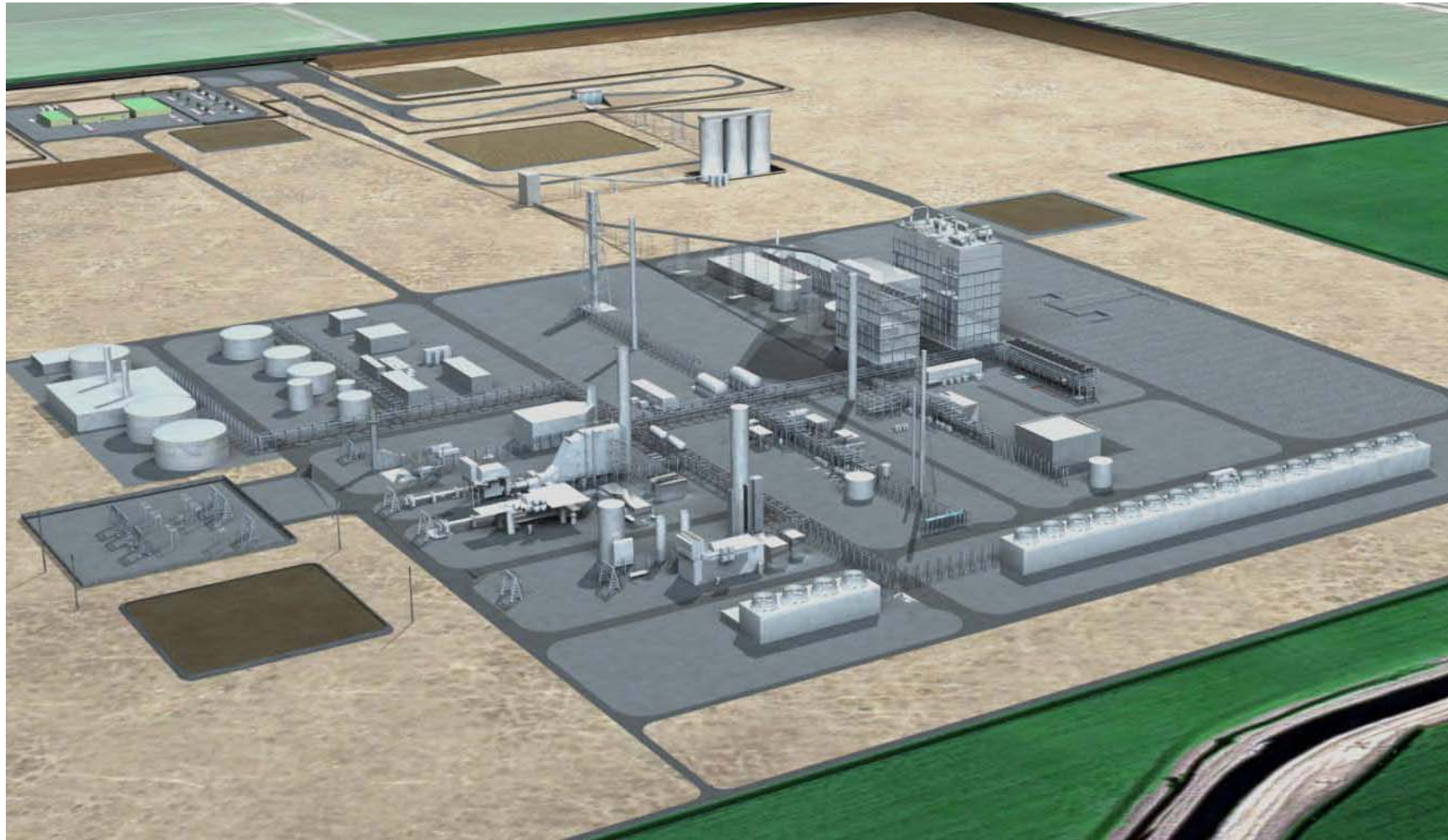
Very low sulphur content in CO<sub>2</sub> is minimizing the cleaning effort on CO<sub>2</sub> to UREA

No drying of CO<sub>2</sub> streams is required (CO<sub>2</sub> Products are free of water)  
⇒ carbon steel material for CO<sub>2</sub> compression is possible

Inert free NH<sub>3</sub> loop  
⇒ no NH<sub>3</sub> purge gas treatment is required.



# Polygeneration Concepts using Linde's Rectisol® Wash Process The Hydrogen Energy California Project (HECA) – Ground Plan



Courtesy of HECA

# Polygeneration Concepts using Linde's Rectisol® Wash Process

## The Hydrogen Energy California Project (HECA)

### - Key Figures

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### Key Figures for HECA:

- IGCC Concept:  
Power, CO<sub>2</sub> for EOR, Sulphur
- net 250 MW Power
- > 90% Carbon Capture



## Polygeneration Concepts using Linde's Rectisol® Wash Process Benefits using Rectisol®



### Benefits using Rectisol®:

- Sulphur specifications can be met without COS hydrolysis
  - \* Sulphur content in hydrogen is less than 1 vppm
  - \* Sulphur content in CO<sub>2</sub> for EOR is less than 10 vppm
- Electrical equivalent is better than with PEGE

## Summary



**RWU in Nanjing, China**

## Polygeneration Concepts using Linde's Rectisol® Wash Process

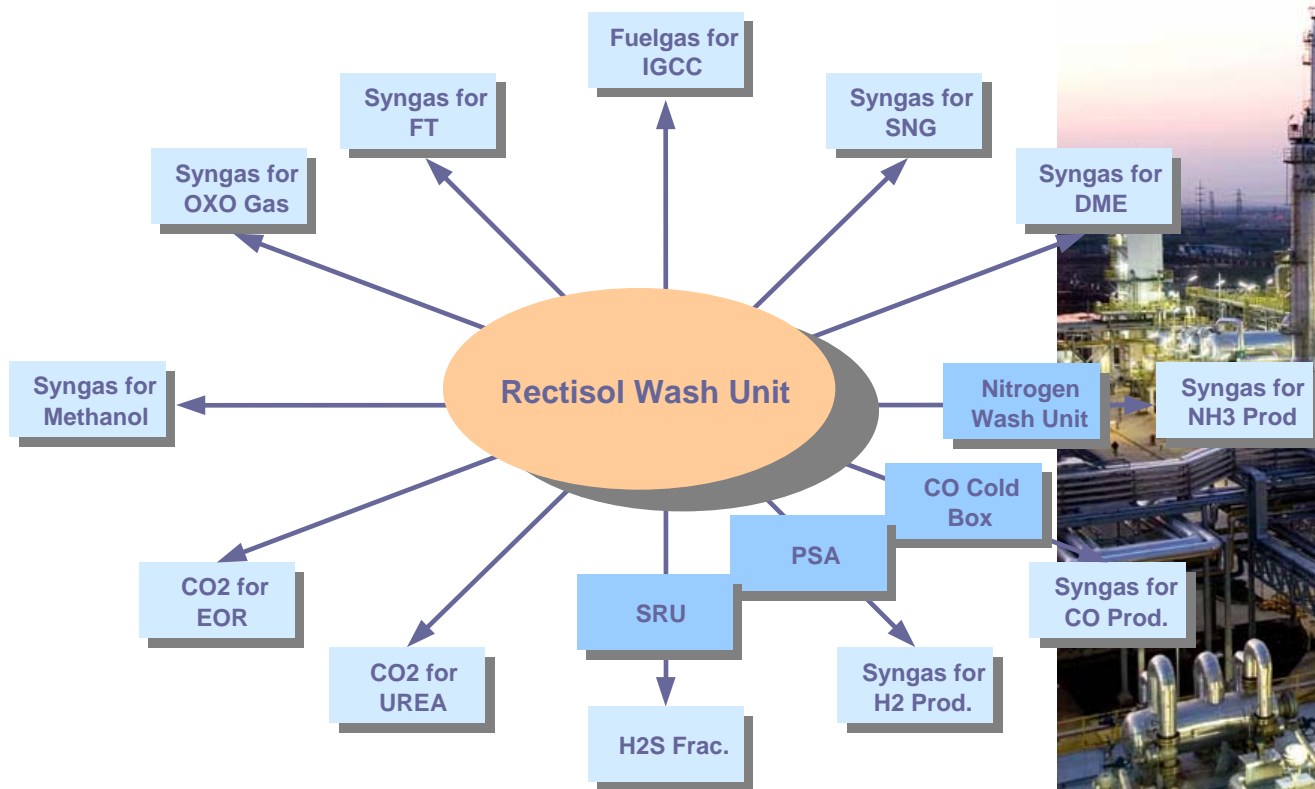
### The Rectisol® Plant is Suitable to Produce a Wide Product Range.



Product	H2/CO Ratio	Sulphur	CO2
➤ H2 Product	maximum	0.1 vppm (if required)	vppm – mol%
➤ NH3 Product	maximum	0.1 vppm	10 vppm
➤ IGCC Plant with CC	maximum	5 vppm	0 to 2%
➤ SNG Syngas	~ 3.0	0.1 vppm	0.5 mol%
➤ MeOH Syngas	~ 2.05	0.1 vppm	0.5 mol%
➤ FT Syngas	~ 2.0	0.1 vppm	0.5 mol%
➤ Oxo Syngas	~ 1.0	0.1 vppm	100 vppm
➤ CO Product	minimum	0.1 vppm	10 vppm

# Polygeneration Concepts using Linde's Rectisol® Wash Process

## The Rectisol Process – An Optimal Process for Polygeneration Concepts.



**Thank you  
for your attention.**

Ulvi Kerestecioğlu, Thomas Haberle

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