Global Update on PRENFLO® and HTW™ Gasification Technologies and Applications

Karsten Radtke
ThyssenKrupp Uhde GmbH, Germany
201 years ago, Krupp was founded in 1811
Uhde was founded in 1921 as technology-based EPC firm
in 1941, Entrained-Flow Gasification was invented by Uhde: „Koppers-Totzek“

Today, ThyssenKrupp Uhde is a leading global engineering and technology company:
over 100 gasifiers designed, built and put into successful operation by Uhde
over 170,000 ThyssenKrupp colleagues worldwide, group turnover ~ US$ 60 bn
As integrated technology provider and EPC contractor, we provide the „wrap“
Shale Gas: will this substitute coal gasification in the U.S.?
Replacement of coal by shale gas in power plants strongly increasing

Source: EIA 2012 International Natural Gas Workshop, August 23, 2012
... it depends on the shale gas price development

Supply and Demand, a well-known dependancy

Firmer prices, $10/MMBTU ceiling with inventory (storage) shortfalls and net LNG imports?

Prices reflect supply cost and „normal“ supply-demand balance

Softer prices, $3/MMBTU lows with inventory (storage) overhang?

Lower prices discourage supply, encourage demand

Supply Shortfall

Drilling Activity increases

Supply Excess, Demand Rises

Price increases

Drilling Activity decreases

Price Decreases

Demand falls

Higher prices encourage supply, discourage demand

Supply Excess

Time

Based on: The Outlook for U.S. Gas Prices in 2020: Henry hub at $3 or $10?
Michelle Michot Foss, Ph.D., NG 58, December 2011
The Oxford Institute for Energy Studies

ThyssenKrupp Uhde
Coal will **COEXIST** to Shale Gas and Oil in the Energy Mix

Resources and Consumption in Comparison

EJ = Exa-Joule = $10^{18}$ J

**World Consumption**

- Hard Coal: 26%
- Lignite: 6%
- Oil: 36%
- Natural Gas: 30%
- Uranium: 2%

- Hard Coal: 67%
- Lignite: 18%
- Conventional Oil: 1%
- Oil Sands / Shale Oil: 1%
- Conventional Natural Gas: 9%
- Non-conventional Natural Gas / Shale Gas: 2%
- Nuclear: 2%

**Resources**

- 572,000 EJ

The energy carrier with the highest consumption is the smallest resource: **oil**

Source: Energierohstoffe 2009, Hamburg World Economic Institute, Energy Resources Strategy 2030
Different Feedstocks require Different Gasification Technology

ThyssenKrupp Uhde’s Gasification Portfolio

- Wastes
- Wood Peat
- Brown Coal
- Lignite
- Hard Coal
- Petcoke Residues
- Oil Gas

**PREFLO**
Entrained-Flow Gasification

**HTW™**
*High-Temperature Winkler*
Fluidised Bed Gasification

Oil Gasification
ThyssenKrupp Uhde’s *Proprietary* Gasification Technologies

- **PSG** | **PDQ**
  - Entrained-Flow

- **HTW™**
  - Fluidised Bed
Solid Feedstock

Low Rank Feedstock
- Lignite
- Peat
- Biomass

High Rank Feedstocks
- Hard Coal
- Petcoke
- Residues
- or multiple feedstocks

Reactivity

Ash Softening Point

H₂ rich / Chemicals

Product Gas

CO rich / IGCC

High

Low

higher (>1200 °C)

lower (<1200 °C)

HTW

PRENFLO PDQ

PRENFLO PSG

Simplified Selection Diagram

ThyssenKrupp Uhde
ThyssenKrupp Uhde’s Coal Gasification Development:

1909: Koppers Gas Generators (a total of 536 built)

1941: Invention of first Entrained-Flow Gasification:
   - **Koppers-Totzek**: dry-fed, membrane wall, multiple burners

1941-2012: Development, Design and Construction of

- **Koppers-Totzek** Coal and Oil Gasification
- **Rummel-Otto** Slag Bath Coal Gasification
- **Saarberg-Otto** Coal Gasification
- **Texaco (GE)** Coal and Oil Gasification (TGP, TCGP)
- **HTW** Coal and Biomass Gasification
- **Shell-Koppers** Coal Gasification
- **PRENFLO** Coal and Petcoke Gasification (PSG, PDQ)
Classification of Feedstocks

Entained-Flow vs. Fluidised Bed
New Projects

Sundrop Fuels Inc.
3,500 Barrels/day Natural Gas and Biomass to Gasoline Plant
Location: Alexandria, Louisiana, U.S.A.

Project Status
• Comprehensive FEED work completed
• All required License Agreements in place
• Basic Engineering for Methanol-to-Gasoline (MTG) ongoing
We have already built a gasification plant in Louisiana...

Koppers-Totzek Coal Gasification Plant, Louisiana, U.S.A., 1949
ICM Mongolia
PRENFLO® PDQ CTL Complex

Technology: PRENFLO® PDQ Gasification
Feedstock: Mongolian Hard Coal
Product: Coal-to-Liquids Complex
Capacity: 2 x 1200 MW$_{th}$
Location: Tugrug Nuur
Status: License and Basic Engineering Contract signed
ICM Mongolia
PRENFLO® PDQ CTL Complex

Signing Ceremony on Thyssen Family Castle,
Schloss Landsberg, Germany
31 March 2012
Värmlands Metanol, Sweden
HTW Biomass to Methanol Project

- Uhde selected as technology supplier and EPC contractor
- Permitting and Financing ongoing

**Plant Capacity:**
100,000 t/a of fuel grade methanol + district-heating 15 MW<sub>th</sub>

**Feedstock:**
Domestic forest residue, ~25 t/h

**Process:**
Fluidized bed gasification (HTW)
(eq. 111 MW<sub>th</sub>)

Värmlands Metanol AB
Kepco-Uhde Inc.

- ThyssenKrupp Uhde and largest utility in Korea, KEPCO, formed Joint Venture Company for PRENFLO® gasification
- “KEPCO-Uhde Inc.” established in South Korea in July 2011
- a number of SNG and IGCC projects launched for KEPCO-Uhde within Korea and globally
- JV provides strong synergy, cost and schedule advantages

Dr. Thiemann, CEO ThyssenKrupp Uhde
Mr. Kim, CEO KEPCO

ThyssenKrupp Uhde
IGCC Plant with a capacity of up to 450 MW net + optional hydrogen
Choice for IGCC with CO₂ capture, based on PRENFLO® PDQ direct quench gasification technology
Location Killingholme, UK: industrial port, synergies due to maximum integration into existing industrial network
Standardization of plant to optimize learning curve for subsequent plants
Status: Project shortlisted among EU funding of NER 300

Feedstocks:
- Unconventional hard coal
- Petcoke
- Sustainable biomass
TransGas CTG Projects
West Virginia and Kentucky Sites
GTL or CTL? Time for CTL is now:
- coal prices decrease, and can be secured on long-term basis ▼ - 18.75 %*
- gasoline prices increase, and projections continue to incline ▲ + 9.24 %*

* Sept. 2012 vs. Sept. 2011

Central Appalachian and Powder River Basin Coal Prices

Coal prices decrease, and can be secured on long-term basis. Gasoline prices increase, and projections continue to incline.

Data Source: Department of Energy Weekly report

GTL or CTL? Time for CTL is now:Coal prices decrease, and can be secured on long-term basis. Gasoline prices increase, and projections continue to incline.

GTL or CTL? Time for CTL is now: Coal prices decrease, and can be secured on long-term basis. Gasoline prices increase, and projections continue to incline.
TransGas: 3 Projects launched
Adams Fork Energy Project and Kentucky Projects

- Leading Technology Licensors and EPC contractors have teamed up for project implementation
- Ground breaking in May 2011
- All 3 projects are permitted as minor source,
- Located in a 50 miles radius, providing significant synergy effects in engineering, procurement, construction and schedule
BioTfueL Project
France
2nd generation Biofuels: the B-XTL route
Fuels and base chemicals from syngas

B-XTL route
2nd generation Biofuels: the B-XTL route

- 17 Oct 2012: EU plans new directive
  - drastic limitation of 1st Generation Biomass (e.g. new definition of effectiveness of 1G BTL, food vs. fuel, indirect land-use change, no subsidies for 1G after 2020)
  - target: enforcement of 2G BTL („non-food“) solutions
  - this directive will significantly boost biomass gasification solutions

- B-XTL route (B = Biomass, X = Fossil Fuel):
  - biomass availability fluctuates (quality, quantity)
  - Biomass collect in huge quantities is a challenge
  - high plants Stream Factors ⇒ final product cost reduction
  - large-scale plants ⇒ final product cost reduction

- Co-processing is a good opportunity
  Green carbon is introduced upstream the chain,
  GHG reduction > 90% for the green part of the product
2nd generation Biofuels: BioTfueL B-XTL process chain

Integrated Process Chain for the Production of Second Generation Synthetic Biofuels

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- Torrefaction
- Milling
- Gas Treatment
- Synthesis
  - GaseiTm Fischer-Tropsch (F-T) Synthesis and product upgrading (Hydrocracking and Hydroisomerization)
    - Bio-diesel
    - Bio-kerosene
BioTfueL: 2nd Generation bio-diesel and bio-jetfuel process chain
Coal gasification

Koppers-Totzek gasification
Modderfontein, South Africa
clean-to-ammonia/fertilisers

HTW coal gasification
Berrenrath, Germany
clean-to-methanol

Texaco (GE) coal gasification
Oberhausen, Germany
clean-to-hydrogen & oxochemicals

Over 100 Gasifiers designed, built and put into successful operation by Uhde

PRENFLO coal gasification
Fürstenhausen, Germany
clean-to-syngas

HTW MSW gasification
Niihama, Japan
waste-to-energy

PRENFLO IGCC
Puertollano, Spain
petcoke/clean-to-energy/hydrogen

ThyssenKrupp Uhde’s Gasification Experience
Summary

- In the U.S., shale gas has reduced the cost of gas and of coal significantly.
- CTL and BTL are within a new global commercialisation phase.
- Gasification can use a wide range of coal qualities, biomass and other feedstocks.
- CTL is clean – the TransGas projects are permitted as Minor Source.
- Gasification enables feasible CO₂ capture.
- 2nd Generation BTL expects new boost from most recent EU politics.
Thank you for your attention

ThyssenKrupp Uhde

PREFLO Gasification Plant, Puertollano, Spain
29 October 2012

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