Coal to Ammonia

Presented at the
Iowa Energy Center Meeting
Ammonia-The Key to a Hydrogen Economy

By
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Presentation

• Rentech Introduction
• Producing Ammonia from Coal/Petroleum Coke Gasification
• What is Fischer-Tropsch?
• East Dubuque, Illinois
• Environmental Benefits
• Food Security and Energy Security-Fuel for First Responders, and the US Military
Rentech – A Brief History

• A 23 year old Denver, Colorado Energy Technology Company
  – Traded as “RTK” on the American Stock Exchange

• Engaged in the Fischer-Tropsch Development
  – Coal-to-Liquids (FT/CTL) business
  – NG-to Liquidss (FT/GTL) business

• Licenses its patented and proprietary technology
  – 20 U.S. and 1 foreign process and materials patents

• Rentech Development Corporation
  – Subsidiary of Rentech Inc.
  – Responsible for ownership and development
  – Gas-to-Liquid and Coal-to-Liquid Projects
Coal to Ammonia a New Concept?

- Not really but for the United States, yes
- Today, in the US there are two projects operating
  - North Dakota Gasification
  - Coffeyville Resources
- World Wide a number of facilities
  - China (2500 small local facilities)
  - Portugal (uses refinery bottoms)
  - Germany, Czech, India, Brazil all have ammonia plants from coal
- Key driver, high NG costs
Syngas Derived Products

- Hydrogen + Carbon Monoxide (H₂+CO)
- Electricity (IGCC)
- Methanol/DME/Propylene
- Synthetic Natural Gas
- Hydrogen
- Carbon Dioxide

Ammonia
UAN
Urea

Ultra-Clean Fischer Tropsch Transportation Fuels

Synhytech – Pueblo, Colorado, 1992
Gasification Ideal for Syngas Derived Products

- Hydrogen + Carbon Monoxide ($H_2+CO$)

Coal → Coal Gasification → Syngas → Electricity (IGCC)

- Methanol/DME/Propylene
- Synthetic Natural Gas
- Hydrogen
- Carbon Dioxide

Ammonia → UAN → Urea

Ultra-Clean Fischer Tropsch Transportation Fuels

Synhytech – Pueblo, Colorado, 1992

Rentech, Inc.
A Look Inside the Process
Illinois Coal to Corn Project
First Mover Opportunity: Producing Fertilizer, Ultra-Clean Fuels & Electricity From Coal

Deploy gasification to save and create jobs while increasing energy and food security through the production of ammonia and FT liquids using Illinois coal as the plant feedstock.
Fischer-Tropsch (FT) Synthesis

• **Invented by German chemists** Franz Fischer and Hans Tropsch in 1923. Used by Germany during WWII to produce 600,000 bbl/year of fuels from coal and coke

• **Commercially proven worldwide**
  197,000 BPD Current Production
  • Since 1950s ~ currently 160,000 bbl/day from coal by Sasol
  • Since 1993 ~ 23,000/bbl/day from natural gas by Petro SA using Sasol technology
  • Since 1995 ~ 15,000/bbl/day from natural gas by Shell in Malaysia
FT is Commercially Proven Worldwide

**SASOL (S. Africa)**
- 45 years commercial
  - 160,000 b/d+
  - Feedstock Coal

**MossGas (S. Africa)**
- 11 years commercial
  - 22,500 b/d+
  - Feedstock Natural Gas

**Shell (Malaysia)**
- 9 years commercial
  - 15,000 b/d+
  - Feedstock Natural Gas
Why Rentech?

Feedstocks
- Petroleum Coke
- Coke
- Coal
- Naphtha
- Vacuum Resid.
- Fuel Oil
- Asphalt
- Natural Gas (low BTU)
- Natural Gas
- Natural Gas + Steam

Catalysts
- Iron
- Cobalt

H₂:CO Ratio

Catalyst Flexibility

CTL
RENTECH
SASOL

GTL
CONOCO
EXXON
SHELL
CHEVRON/SASOL

World’s Largest FT Slurry Reactor – Synhytech, 1992
Rentech CTL with Fertilizer

ASU

Nitrogen (N₂)

Air

Power

O₂

Gasifiers

Waste Heat Boiler or Quench

CO₂

BFW

Syngas Conditioning & Purification

Process Condensate Recycle

Exp. Sulphur

Steam

Tail-Gas to Fuel

Off-gas to Fuel

Gas Turbine

Steam Turbine

Parasitic Power

Exp. Slag

Water for Slurry or Heat for Drying

Steam

HRSG

Pet-coke or Coal

Coal Prep.

Steam

Power Sales

H₂ for FT Product Upgrade

FT DIESEL

NAPHTHA

Fertilizer Sales

Ammonia Plant

Steam

BFW

Off-gas to Fuel

H₂ Rem.

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U.S. Ammonia Production vs. Natural Gas & Coal Price

Source: Ammonia production, U.S. Department of Commerce; natural gas price - average spot-delivered-to-pipeline price, Natural Gas Week.
The RC Plant Post Conversion to Coal Feedstock Integrated Manufacturing Process

**CONVERSION**

- **Coal Gasification - Syngas Production**
- **Ammonia Synthesis**
- **Carbon Dioxide Plant**
- **FT Synthesis**
- **FT Product Upgrade**
- **Urea Plant**
- **Nitric Acid Plant**
- **Air Separation Plant**

**EXISTING PLANT**

- **Coal** 5200 tpd
- **Water**
- **Air**
- **N₂**
- **H₂**
- **CO₂**
- **NH₃**

**PRODUCTS**

- Export Power
- ULS FT Diesel
- Naphtha
- Sulfur
- CO₂ Sales
- NH₃ Sales
- Granular Urea Sales
- Urea Solutions Sales
- Nitric Acid Sales
- UAN Sales

**Internal Power**

**External Power**

**CO₂ Sales**

**Power Plant**

**Urea Solutions Sales**

**Granular Urea Sales**

**Nitric Acid Sales**

**UAN Sales**

**Ammonium Nitrate/Blending Plant**

**Rentech, Inc.**
Coal Gasification Yielding Rentech FT Fuels & Power & Ammonia
(Simple Recycle FT Process, 1 Gasifier)

Coal Handling

Slurry Gasifier

Process Boiler

SynGas Cooling/Cleaning

AGR (Rectisol)

Claus Unit

Gasification/FT Steam

Naphtha Turbine

Parasitic Power

Slag

Export

ASU

Air

O₂

N₂

BFW Steam

Hot BFW

SynGas

H₂/CO - 0.68

Guard Beds

CO₂

Fuels & Power & Ammonia

Power - 40 MW

Parasitic Power

Steam Turbine

Parasitic Power

Gasification

FT Unit

Coal

NH₃

Misc

CO₂

H₂S

Air

N₂

H₂ to Prod
Upgrade

Purge to Fuel
450 MMbtu/h

Existing CO₂ Removal

New LTS Rctrs

New HTS Rctrs

Purge to Vent

NAPHTHA Storage/Loading

Diesel - 4700 bpd

Naphtha - 900 bpd

Naphtha- 900 bpd

NH₃ - 920 stpd

FT Water & Ox

Product Upgrade

H₂ to Prod
Upgrade

H₂

H₂

Purge to Vent

NH₃ Loop

NAPHTHA Storage/Loading

NH₃ - 920 stpd

Diesel - 4700 bpd

Power - 40 MW

NAPHTHA Storage/Loading

H₂ to Prod
Upgrade

H₂

Indicates units that may or may not be needed.
East Dubuque Plant Polygeneration Model
Estimated Inputs and Production

- Coal feedstock 5,200 TPD

**Products (45% Increase in Tons Shipped)**

- Ammonia production 920 TPD
- FT Fuels (80% diesel) 5,600 BPD
  - 248,000 gallons per day
- Electricity production 160 MW(e)
- Electricity export 40+ MW(e)
Benefits of Polygeneration from Coal

• Standard pulverized coal power plant: 35%

• Combined cycle natural gas power plant: 45%

• Coal gasification to produce fertilizer, ultra-clean fuels, & electricity: 50+%
Coal Cleaner?
Plant Regulated Emissions

With a Production increase of 45% in Tons Shipped

Total Emissions of:
- PM10
- VO
- CO
- NO\textsubscript{x}
- SO\textsubscript{2}

>30% Decrease in Criteria Pollutant Emissions
**Ultra-Clean FT Diesel Fuel from Coal**

- Biodegradable
- < 1ppm Sulfur
- High Cetane
- Stable long storage life

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**FT Diesel**

**Conventional Diesel**

FTD from coal is an "alternative fuel" under 1992 Energy Policy Act (EPACT)

**Source:** An average of several government funded studies by NREL & SwRI
OSD Clean Fuel Initiative

Vision: DoD catalyze the commercial industry to produce clean fuels for the military from secure domestic resources using environmentally sensitive processes that create jobs and wealth in the United States

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DoD Impact

- Secure and reliable sources of energy
  - Currently dependent on foreign oil
  - Becoming dependent on foreign refined fuels
- Supply chain vulnerability
  - Dependent on mega refineries - Gulf Coast
  - Natural disasters or Terrorist threats
- Need for cleaner fuels
  - DoD exempt from some EPA regulations
- Potential limits on deployments
  - Possible conflict with EU rules
Total Energy Development (TED)

- Use all secure indigenous sources of energy
  - Coal, shale oil, petroleum coke, renewables
  - Dispersed production facilities

- Minimize government funding—focus on qualification and certification

- Make a better fuel from coal and petroleum coke (Fischer Tropsch fuels) and oil shale
  - Low (or no) sulfur, cleaner burning, bio-degradable, low (or no) aromatics, reduced particulate emissions
  - Blends near term, neat fuel future goal
  - Stable fuel for long term secure storage of refined fuel for emergency use

- **Use Environmentally sensitive processes to produce fuel**
  - Clean Coal Technologies such as the Fischer-Tropsch process, Mahogany Shale Research Project
  - CO₂ sequestration for enhanced oil recovery (EOR)
Reduced Exhaust Emissions with FT Fuel Relative to Low-Sulfur Diesel Fuel

Over 50% reduction in particulate emissions in transient mode.

FT fuel burns more completely and emissions are significantly cleaner than EPA certified low-sulfur diesel fuel tested in 6.5L diesel engine.

Transients test cycles

*Non-Road Transient Composite

Hot Start

NRTC*

% Reductions

0%

-10%

-20%

-30%

-40%

-50%

-60%

-70%

-80%

HC

-62%

-72%

CO

-45%

-60%

CO2

-4%

-17%

NOx

-13%

15%

PM

-55%

-52%

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Even moderate fractions of FT fuel blended in JP-8 significantly reduce exhaust emission particulates in T63 turbine engine testing.

96% reduction* in particulate emissions at idle conditions.

* Note: Results are highly dependent on engine model/year and composition of baseline fuel.
Summary

- Coal to Ammonia is not a new concept
- The Poly-generation concept improves plant efficiency and diversifies product mix
- Conversion of exiting facilities improves project schedule, reduces cost and utilizes existing plants
- The Ammonia and Fuels provide for Food and Fuels security for the United States
- Both Ammonia and FT liquids are a steps toward the Hydrogen Economy
- Polygeneration provides diversity and stability to ammonia plants during market swings.
Questions