Coal Gasification in Indiana

Solutions for a Low Carbon Footprint Environment

December 2008
CHOREN Fact Sheet

- C-Carbon, H-Hydrogen, O-Oxygen, REN-Renewable → CHOREN

- Private Company in partnership with Shell, Daimler and Volkswagen (minority shareholders)

- Based in Germany in Freiberg, Saxony with offices in Hamburg, Beijing, Houston

- Founded 1990 by Dr. Bodo Wolf and 3 employees from DBI

- 1997 company focuses on gasification as core competence (SynGas Producer) and builds pilot plant

After German Reunification former DBI know-how employees accumulate around Dr. Bodo Wolf including leading engineering and operating competence of Gas Kombinat Schwarze Pumpe

Research targets the improvement in development of the gasifier for sludge and organic waste drying

R&D work leads to improved coal gasification system and development of proprietary Carbo-V® biomass gasification system

Component manufacturing for 3rd parties (e.g. vessel and component fabrication for Sustec/Future Energy (today SIEMENS))

2007 First CCG project in China, 2*400MW coal gasifiers for repowering project in Yankuang Ammonia facility commissioning in 2010
Fuels, Chemicals or Power from Biomass Gasification
Biomass Feedstock Selection

Category I
- Timber/P&P Industry Woodchips
- Energy Crop Plantations
- Saw Mill Residues

Category II
- Forest Residues
- Construction / Demolition Timber
- Agricultural Residues

Category III
- Waste Streams
- MSW
- Sludge

Increasing Logistics Challenges
Decreasing Political Challenges
Calorific value Biomass & Coal

Biomass: 15,650 Kj/Kg

Coal: 30,975 Kj/Kg

Carbon: 76%
Hydrogen: 5%
Oxygen: 6%
Nitrogen: 1%
Sulphur: 3%
Ash: 8%
Water: 1%

Carbon: 44%
Hydrogen: 5%
Oxygen: 38%
Nitrogen: 0%
Sulphur: 0%
Ash: 10%
Water: 10%

Biomass

Coal
CHOREN Carbo-V® 1MWth Alpha Pilot Plant

Early Years: Methanol / Electricity Production

1995: Beginning of Carbo-V® patent application and filing

1997/8: Construction and Commissioning of 1MWth Carbo-V®-Pilot plant

1998-2001: Diversified testing program with variety of feedstocks (timber, recycle wood, organic waste, bone meal, straw, etc.)

2001: Production of first volumes of BtL fuels from SynGas on lab scale, demonstration of Caterpillar gas engine with wood derived SynGas

April 2003: stable Methanol production from woody biomass feedstock in pilot scale

May 2003: After producing 11,000 liters (3,000 gal) of methanol R&D program completed
CHOREN Carbo-V® 1MWth Alpha Pilot Plant FT

Later Years: Fischer-Tropsch Liquids Production

June 2003: First FT-Product from woody biomass

Until 2003: 12,000 hrs of operations

2004: Process and product optimization during 6th EU testing program, various tests by automobile industry

In 2004: 5,300 hrs of operations

2005: 3,800 hrs of continuous operation

2006: various testing cycles

Accumulated Hours of Experience: 22,500 hrs

FT-Products (2004-2005): 27,000 liters (7,000 gal)
Technology Scale-Up Alpha to Beta

1998 - 1 MW Alpha Plant – air/O2

2003 - 15 MW Beta Plant - air

* 15 scaleup

2005 - 30 MW Beta Plant – O2

*2 scaleup
HTV – High Temperature Gasifier

2nd and 3rd Step of Gasification: Cracking and Quenching
28.11.2002 Foundation for first ever commercial scale biomass gasification plant

Sept. 2003 to December 2004: Commissioning of gasifier island with test runs

May 2005: Obtained first permits for the construction of synthetic fuel plant

July 2005: Shell joins CHOREN as technology, strategic and equity partner

2005-2007: Integration of Shell SMDS FT Technology

April 2008: Mechanical completion

Currently: Commissioning of BtL plant
**SPECIFICATIONS:**
- 45 MWth capacity
- 65,000 bdt wood
- 0-50% recycled wood
- 18 mio liter SunFuel (4.8 mio gal)

**Mechanical Completion**
- Apr. 17th 2008

**Start of production**
- Q4 2008

**CHOREN β-Plant**
- October 2007
CHOREN Gasification Application Overview

Feedstock Prep and Handling
- Biomass
- Waste
- Coal
- Petcoke / Residuals

Entrained Flow Gasification Carbo-V® and CCG

Gas Cleanup

Utility Integration

Product Conversion Technologies*
- Synthesis Gas
- Methanol
- Ethylene
- Propylene
- Acetic Acid
- H₂
- DME
- Ammonia
- Ethanol
- Urea
- SNG
- FT-Products
- Power / Steam

*Non-exhaustive technologies list for clarity
CHOREN’s 160 MWth Carbo-V® Technology

- Three-step gasification: 1. low temp, 2. high temp, 3. chemical quench
- 5 bar gauge pressure
- Tar and methane free raw syngas
- High feedstock versatility
- Water-cooled high temp. section

**LTG: Low Temperature Gasifier (4x) 40MWth**
German: Niedertemperatur Vergaser (NTV)

**HTG: High Temp. Gasifier 160MWth**
German: Hochtemperatur Vergaser (HTV)

- Raw SynGas
- Tar rich LTG gas, O₂, recycle ash and biocoke
- Heat (Steam)
- LTG Biocoke
- 1500°F
- 2200-2500°F
- Vitreous Slag
- Recycle biocoke

Biomass

Tar rich LTG gas

O₂ / Steam

LTG Biocoke
Biomass Gasification for GHG Footprint Reduction and Energy Security

Exploiting Opportunities of Biomass Availability

Biomass, Recycle Wood, MSW, etc.

Feedstock Mix Carbon Content
Green 100%

Product Life-Cycle GHG Emissions
Green + CCS?

Product Conversion
Gas Clean-up

CHOREN
CHOREN’s 400MWth CCG Technology

Advantages:
- Entrained Flow
- Slagging gasifier: protective slag layer
- High ash content flexibility
- High quality synthesis gas no condensates
- Dry dust gasifier advantages

Technical Specs:
- Up to 1,500 t/d per unit
- 40 bar (580 psig)
- Up to 93% CO + H₂
- Up to 35% ash content
- Ash melting points of 1,400°C (2550°F) or higher without fluxing agents
- Burner lifetime up to 4 years (yearly inspections)
- Cooling screen lifetime up to 10 years

First Project Awarded:
- Yankuang, China – Ammonia reformer repowering
  2*400MW CCG gasifiers awarded in 2007
Biomass and Coal: Enabling Energy Security and GHG Emission Reduction

Capitalizing on Economies of Scale by Mixing Biomass and Fossil Feeds

Feasibility of blending biomass and coal for energy production, showcasing the potential benefits of using renewable resources to reduce emissions and improve energy security.
Coal Gasification in Indiana

Eastern Forests
- White - red - jack pine
- Spruce - fir
- Longleaf - slash pine
- Loblolly - shortleaf - pine
- Oak - pine
- Oak - hickory
- Oak - gum - cypress
- Elm - ash - cottonwood
- Maple - beech - birch
- Aspen - birch

Figure 2. Map of southeastern Indiana showing the active coal mines, and mined-out areas.
Currently Indiana has no specified action on climate change

- No RPS, RFS, GHG Reporting, etc.

Duke’s Edwardsport facility was asked to show FEED study targeted at understanding the costs and performance impacts of partial CCS

Vectren Corp. and Northern Indiana Public Service Co. decided too much uncertainty existed over possible federal carbon regulations to commit to a 30-year purchase agreement for the SNG of Indiana Gasification LLC proposed plant

Indiana is taking leadership role in advancing clean coal technology

Biomass gasification as alternative or supplement to CCS addressing both technology innovation and green technology leadership
The document is incomplete without reference to, and should be viewed solely in conjunction with the oral briefing provided by CHOREN.

Certain statements that are included in this presentation are forward-looking in nature. There are associated risks and uncertainties inherent in such statements and actual results may differ materially from those expressed or implied by the forward-looking statements. CHOREN doesn’t assume any liability for those statements. There is no requirement or obligation for CHOREN to update these forward looking statements.