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CHOREN

and its

Vision
Vision – Fuels, Chemicals or Power from Biomass

CO₂ → Plant → Gas → Fuel → Light

Slide 3 of 38
BTL Biomass Sources

- **Timber**
- **Energy crops**
- **Straw**
BTL Biomass Sources

- Forest residues
- Saw mill residues
- Agricultural residues
BTL Biomass Sources

- Municipal solid waste
- MRF (Material Recovery Facility)
- Construction & demolition timber
- Plastics
- Yard clippings
Gasification - old technology...

...combined with biomass feedstocks

Gasification has a long history of development and use

- Murdoch (1792) coal distillation
- London gas lights 1802
- Blau gas – Fontana 1780
- 1900s Colonial power
- MeOH 1913 BASF
- Fischer Tropsch 1920s
- Vehicle Gazogens WWII
- SASOL 1955 - Present
- GTL 1995 – Present
- Hydrogen – Future?

Biomass - renewables

Circa 1898

- clean power
- chemicals
- synthetic fuels
- hydrogen
- alcohols
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 starts focusing on **gasification as core competence** *(SynGas Producer)* and builds pilot plant

- **CHOREN Industries GmbH** founded in 2000. Today over **230 employees.**
CHOREN develops proprietary biomass gasification technology called Carbo-V®

Since 1998 gasification pilot plant α (Freiberg)

Since 2002 gasification pilot plant β (Freiberg)

Beginning 2008 commercial facility (β, extended) for the production of 15,000 tpa SunDiesel® (Freiberg)

First project in China, 2*500MW coal gasifiers 2008

Process application opportunities in Biomass and/or Coal to –Liquids, Energy, -Chemicals
The Road to Synthetic Fuels...

- **Alpha Plant**: BTE with Caterpillar / Zeppelin
- **Alpha Plant**: Methanol/Sud Chemie
- **Alpha Plant**: Fischer Tropsch (FT) diesel (Volkswagen)
- **Operation of Beta plant gasifier**: 2004
- **2005**: Shell minority stake in Choren; provides SMDS FT technology (bankable!)
- **2008**: β to be the **first commercial plant worldwide** for the production of synthetic fuel from biomass
- **The future**: Σ scale facilities....
Beta plant – CarboV® in operation (2004)
Beta Plant in Freiberg

- 45 MW thermal
- 75,000 tpa biomass
- 18 Mio. liter SunFuel

- Biomass logistics commissioned
- Completion of gas production and gas conditioning: Fall 2007
- Opening Ceremony with Chancellor Merkel, Rob Routs Shell, in April of 2008
- SunDiesel® production in 2008
Our Partners

Daimler and Volkswagen

- Fuel testing
- Lobbying
- Fuel marketing

Shell

- Fischer Tropsch Technology
- Upgrading Technology
- Fuel marketing and sales

Others

- Renault, Volvo, BASF among others: cooperation under different EU research projects
CHOREN Group Structure

CHOREN Industries GmbH

Subsidiary companies

CHOREN Biomass GmbH

CHOREN Components GmbH

CHOREN Technologies GmbH

CHOREN Nord GmbH

CHOREN Export GmbH

CHOREN CNOOC JV

CHOREN Fuel Freiberg GmbH & Co. KG

CHOREN Fuel Lubmin GmbH & Co. KG

Others are being planned

Cooperation

Project Companies
SunFuel
**Biofuels/Synthetic Fuels**

**Feedstocks**
- 1. Generation
  - Plant-oils/fats
  - Soy-oil, anim.fats
- 2. Generation
  - Sugar plants
  - Sugarcane, -beat, corn
  - Ligno-cellulose
  - Straw
  - Biomass
  - Energy plants, bio-waste, wood, straw, ...
- Nat.Gas
- Coal

**Process**
- Trans esterification
- Fermentation
- Enzymat. Hydrolysis, Fermentation
- Gasification, FT-Synthesis, Product upgrading

**Product**
- Biodiesel FAME
- Bio-ethanol
- Cellulosic-ethanol
- BTL
- GTL
- CTL

* simplified; other process/product combinations possible

Source: Shell
Comparison of Biofuels

Distance driven with the yield from 1 hectare (3rd-party evaluation)

- **BtL (Biomass-to-Liquid)**: 64,000 km
- **Rapeseed Oil**: 23,300 km + 17,600 km*
- **Bio Diesel**: 23,300 km + 17,600 km*
- **Bio Ethanol**: 22,400 km + 14,400 km*

*Assuming bio-methane production from residue products: rape seed cake, straw, etc

Pkw-Kraftstoffverbrauch: Otto 7,4 l/100 km, Diesel 6,1 l/100 km

Quelle: Fachagentur Nachwachsende Rohstoffe e. V. (FNR)
NEWS: SHELL announced that they will provide the 2008 LeMans race with CHOREN's SunFuel - the first ever application of BtL Fuels in Racing History.
CHOREN Processes and Gasification Applications
Why Carbo-V®?

- Tar free syngas due to high operating temperature \(\rightarrow\) high availability of downstream equipment

- **High quality syngas**: no methane, no hydrocarbons

- **Scale-up**: no moving parts
NTV – Low Temperature Gasifier

1st Step of Gasification: Pyrolysis

Biomass

NTV- Gas (tar rich)

Char/coke

Steam, Oxygen
HTV ~ HT Gasifier with Chemical Quench

- Stationary equipment
- Pressurized 5 bar, suppressing methane formation
- Design expertise from coal gasification - slag protected refractory
- Cracking of tars separate to char – **tar-free SynGas**
- Scale-up $\alpha$ to $\beta$ 30 times
NTV ~ Low Temperature Gasifier

1998 - 1 MW Alpha Plant – air/O2

2003 - 15 MW Beta Plant - air

2005 - 30 MW Beta Plant – O2

* 15 scaleup

*2 scaleup
CHOREN Workshop (TAF)
HTV – High Temperature Gasifier

2\textsuperscript{nd} and 3\textsuperscript{rd} Step of Gasification: Cracking and Quenching
The Carbo-V® - Process

Three Phase Gasification  |  Gas Treatment  |  Fischer-Tropsch & Hydrocracking
Biomass-to-Electricity (BtE)

CO₂-Neutral (Pro-Rated) Electricity via Biomass Integrated Combine Cycle (BIGCC)

Biomass → Carbo-V® Gasification

Natural Gas → Gas Cleanup and Compression → SynGas Turbine

Heat Recovery Boiler and Steam Turbine → Electricity

Electricity
CHOREN SNG Process

Biomass

Three Phase Gasification

Gas Treatment

Methanation

SNG
CCG – CHOREN Coal Gasifier

Advantages:
- Slaging gasifier: protective temperature-controlled 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
- Up to 93% CO + H2
- Up to 35% ashcontent
- 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*500MW CCG gasifiers
Biomass and Coal SynGas Co-Feed (BCTX)

Biomass

Three Phase Gasification

Coal

Gas Cleaning

Electricity
Synthetic Diesel
Synthetic Kerosene
Chemicals
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