CHOREN USA

Coal Gasification in Indiana

Solutions for a Low Carbon Footprint Environment

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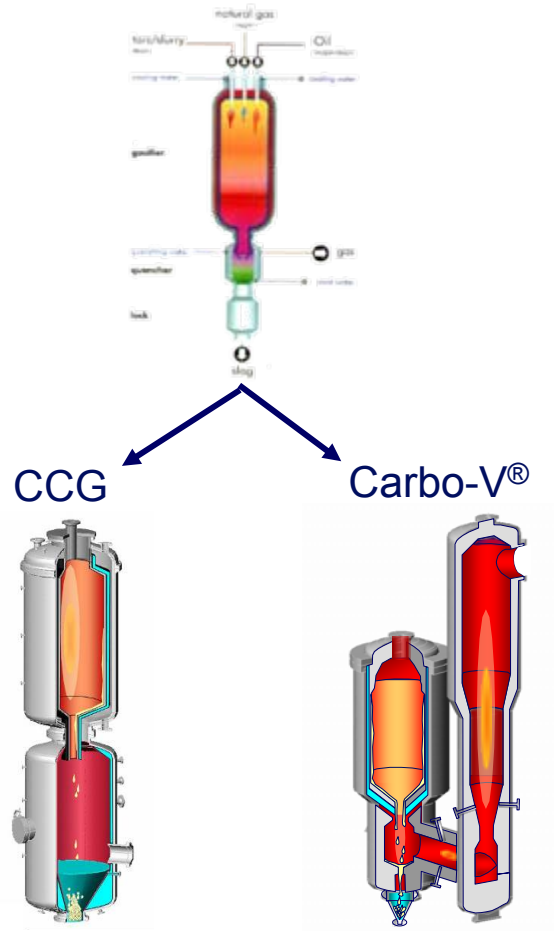
Christopher Peters
CHOREN USA, Houston, TX

CHOREN Fact Sheet

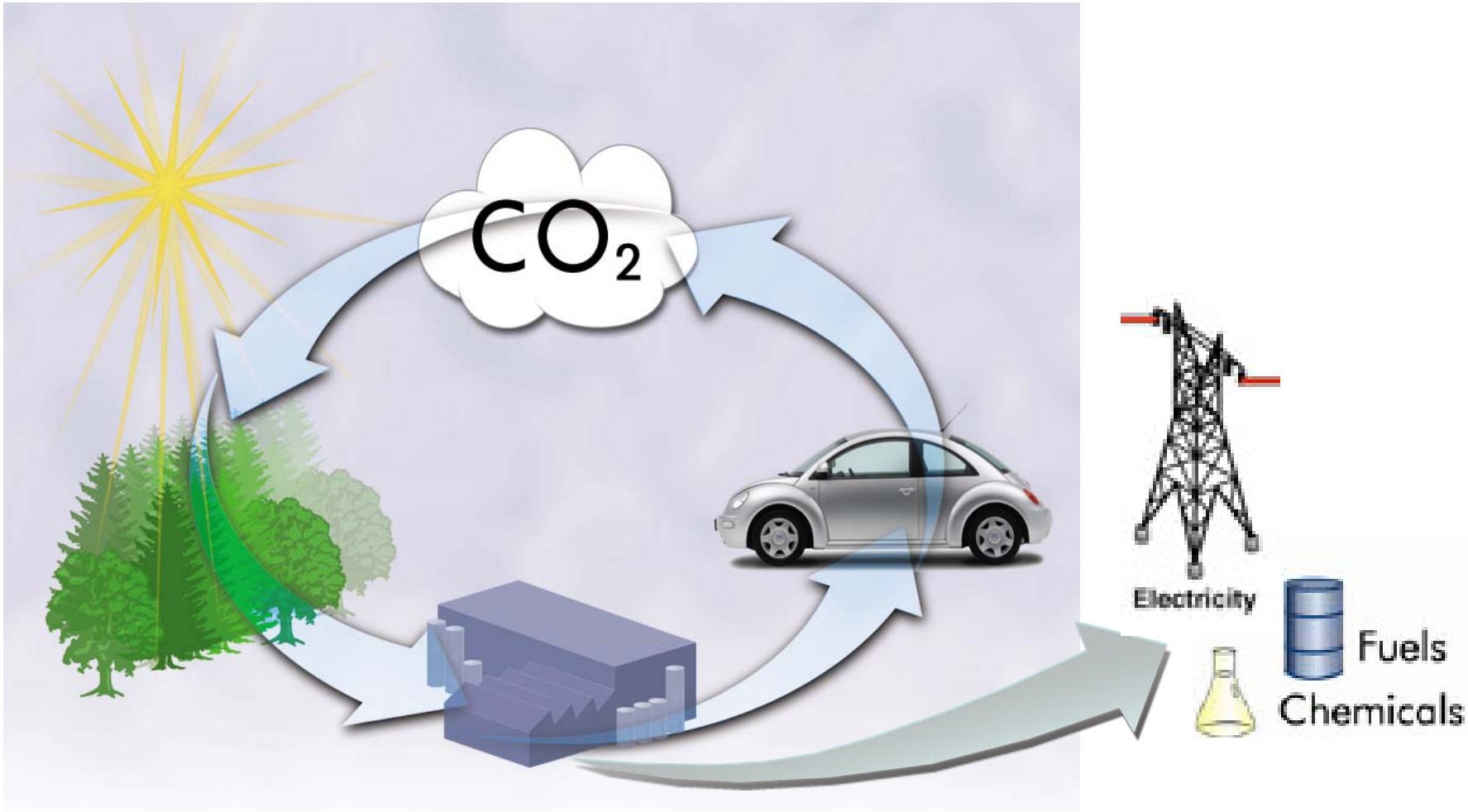
- **C**-Carbon, **H**-Hydrogen, **O**-Oxygen, **REN**-Renewable → **CHOREN**
- Private Company in partnership with Shell, Daimler and Volkswagen (minority shareholders)
- Based in Germany in **Freiberg, Saxony** with offices in **Hamburg, Beijing, Houston**
- Founded **1990** by **Dr. Bodo Wolf** and 3 employees from DBI
- 1997 company focuses on **gasification as core competence** (**SynGas** Producer) and builds pilot plant
- CHOREN Industries GmbH founded in 2000. Today over **250 employees.**

CHOREN‘s Roots: Low Grade Coal Gasification

- 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

CHOREN

Category I

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



Category II

- Forest Residues
- Construction / Demolition Timber
- Agricultural Residues



Category III

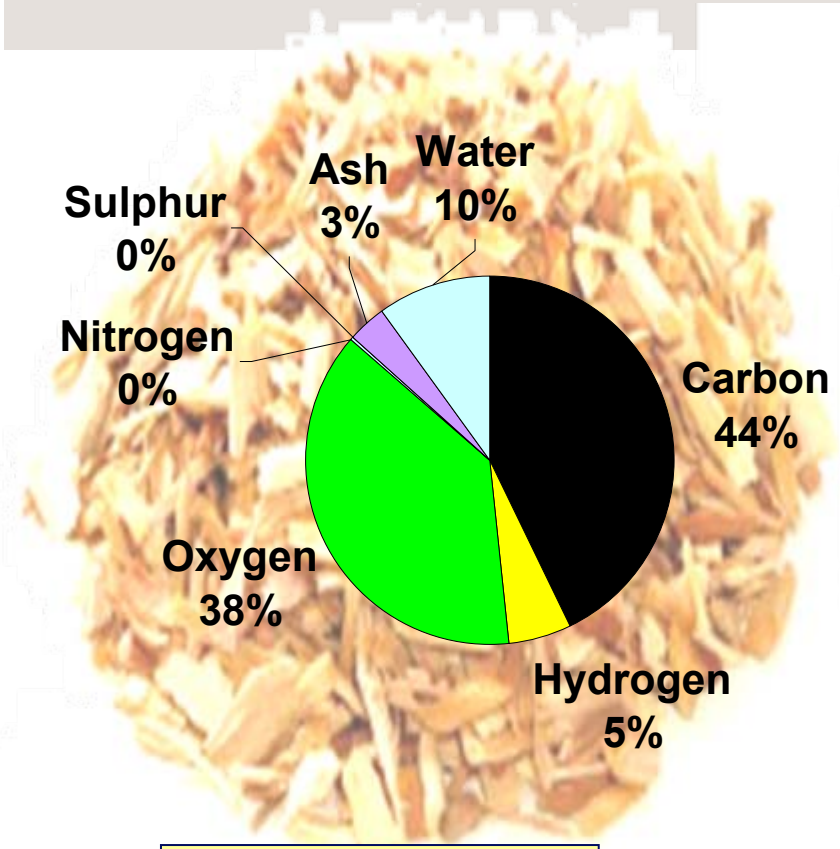
- Waste Streams
- MSW
- Sludge



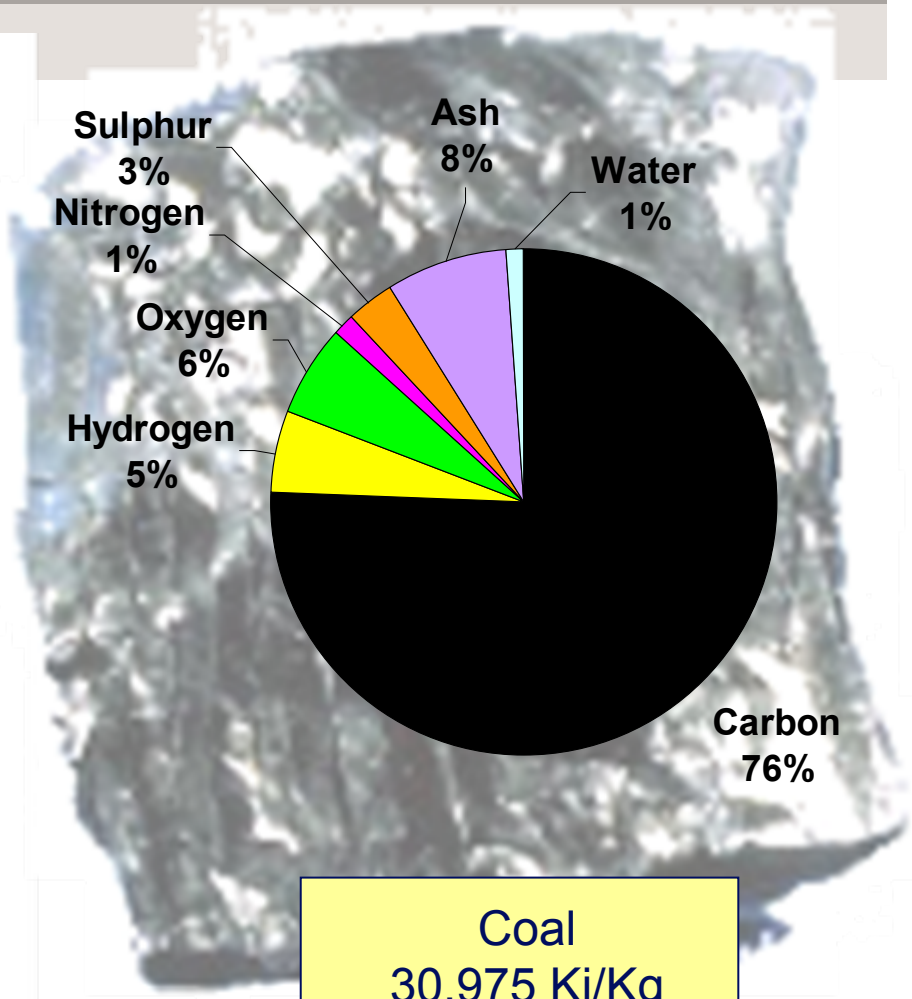

Increasing Logistics Challenges

Decreasing Political Challenges

Calorific value Biomass & Coal



Biomass
15,650 Kj/Kg



Coal
30,975 Kj/Kg

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

1998

2002

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

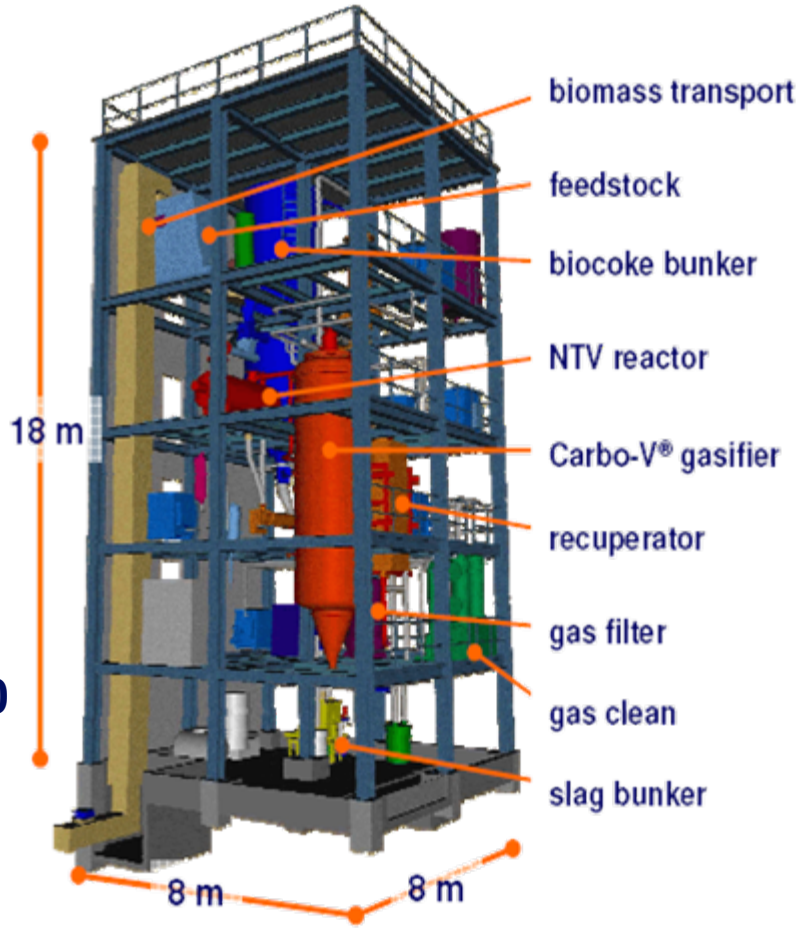
In 2004: 5,300 hrs of operations

2005: 3,800 hrs of continuous operation

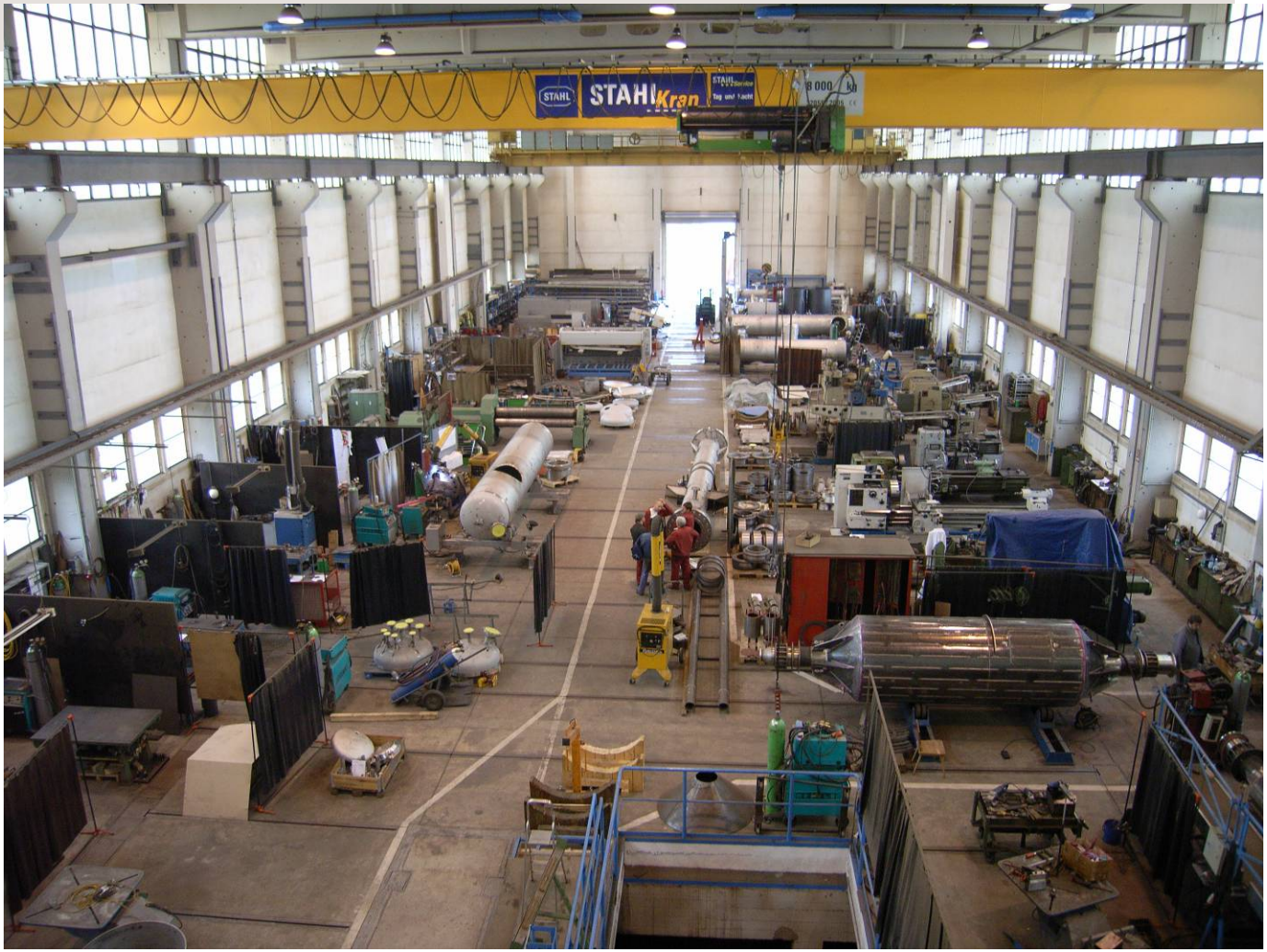
2006: various testing cycles

Accumulated Hours of Experience: 22.500 hrs

FT-Products (2004-2005): 27,000 liters (7,000 gal)



CHOREN Components Workshop



Technology Scale-Up Alpha to Beta

1998 - 1 MW Alpha Plant – air/O2

* 15 scaleup

2003 - 15 MW Beta Plant - air

*2 scaleup

2005 - 30 MW Beta Plant – O2

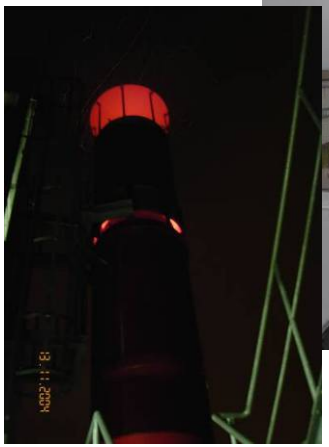
HTV – High Temperature Gasifier

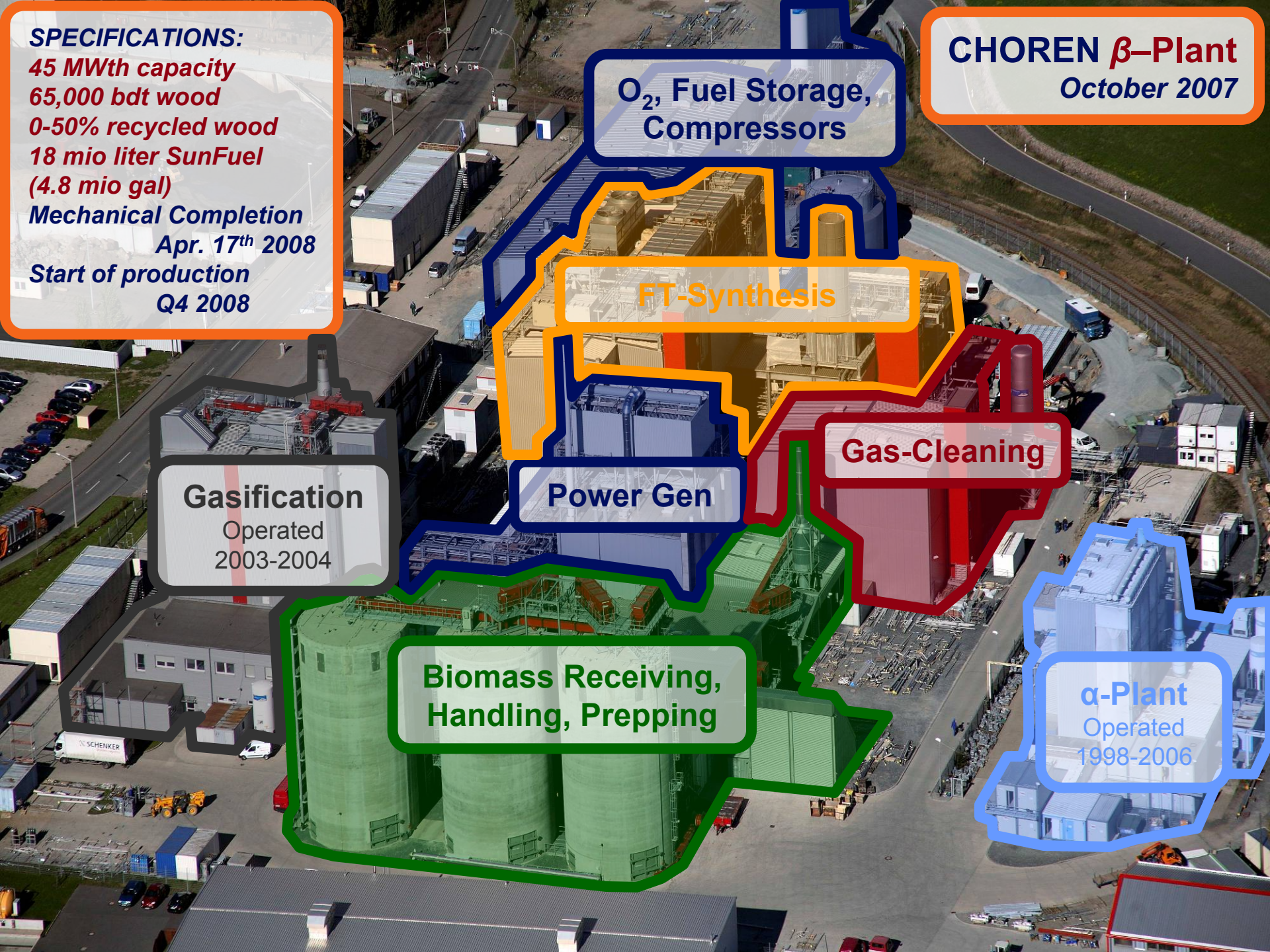
2nd and 3rd Step of Gasification: Cracking and Quenching

CHOREN Carbo-V® 45MWth Beta Commercial Pilot

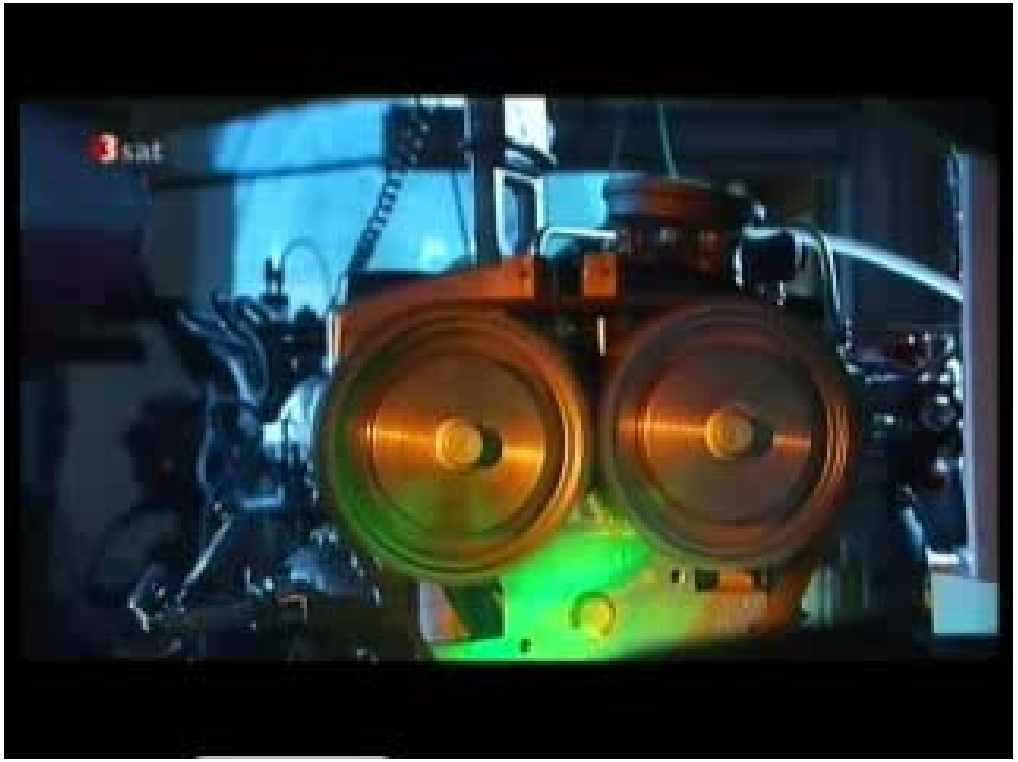
Beta Plant History

- 28.11.2002 Foundation for first ever commercial scale biomass gasification plant
- **Sept. 2003 to December 2004: Commssioning 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
O2, Fuel Storage, Compressors
FT-Synthesis
Gas-Cleaning
Power Gen
Gasification
Operated
2003-2004
Biomass Receiving, Handling, Prepping
α-Plant
Operated
1998-2006

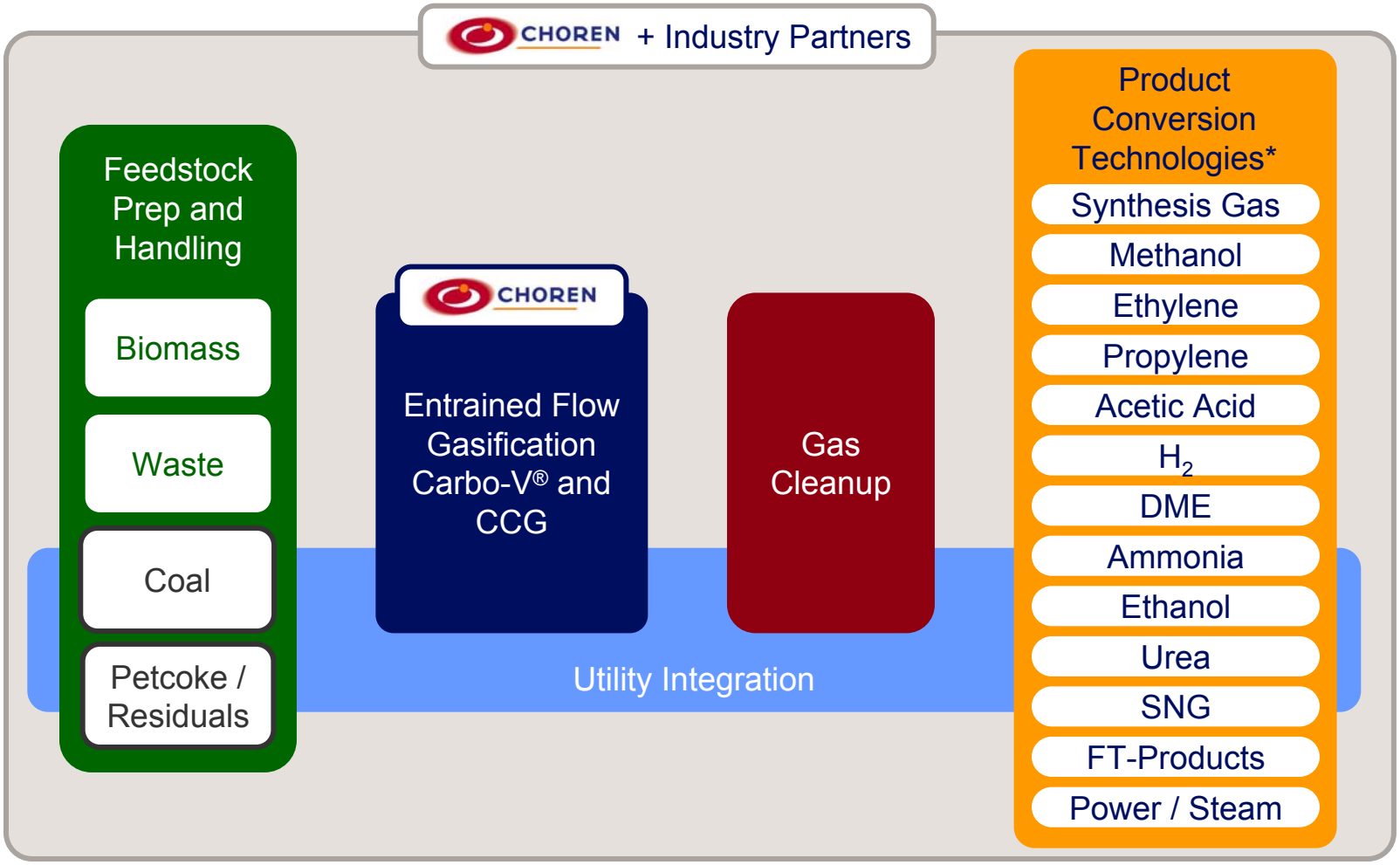
SunDiesel® - Clean Combustion



Conventional Diesel

SunDiesel
made by CHOREN

CHOREN Gasification Application Overview

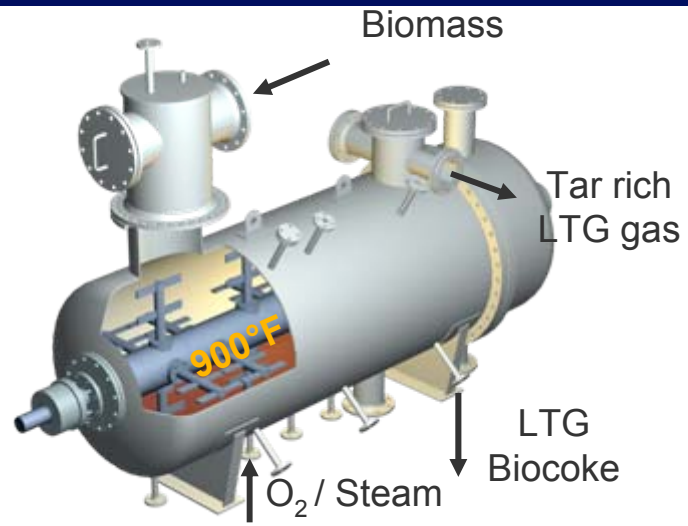


*Non-exhaustive technologies list for clarity

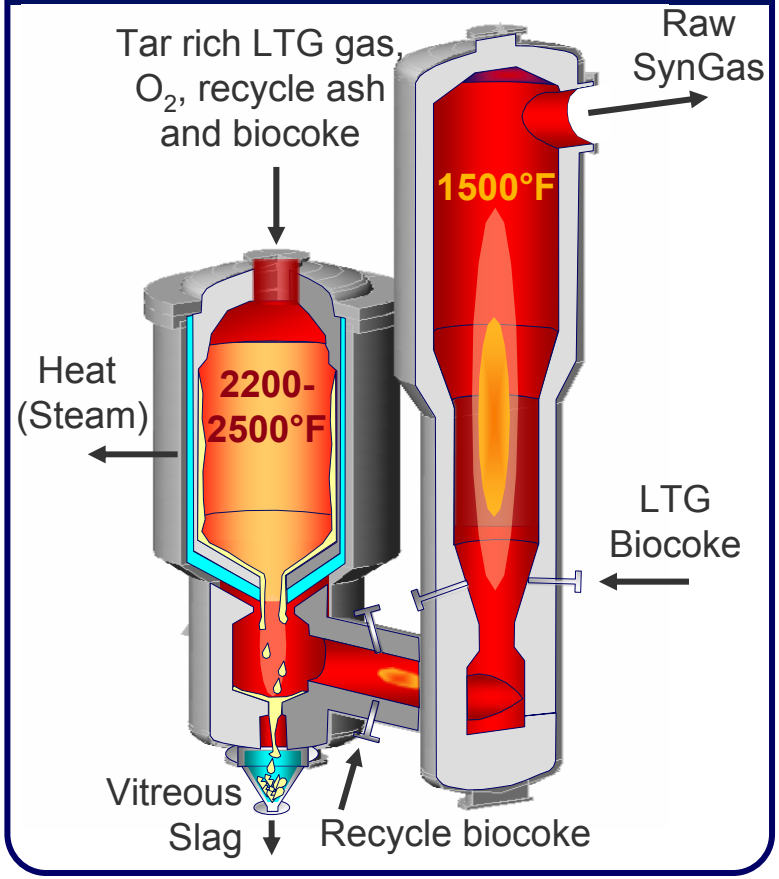
CHOREN's 160 MWth Carbo-V® Technology

- 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)



The Carbo-V® Process with FT Application

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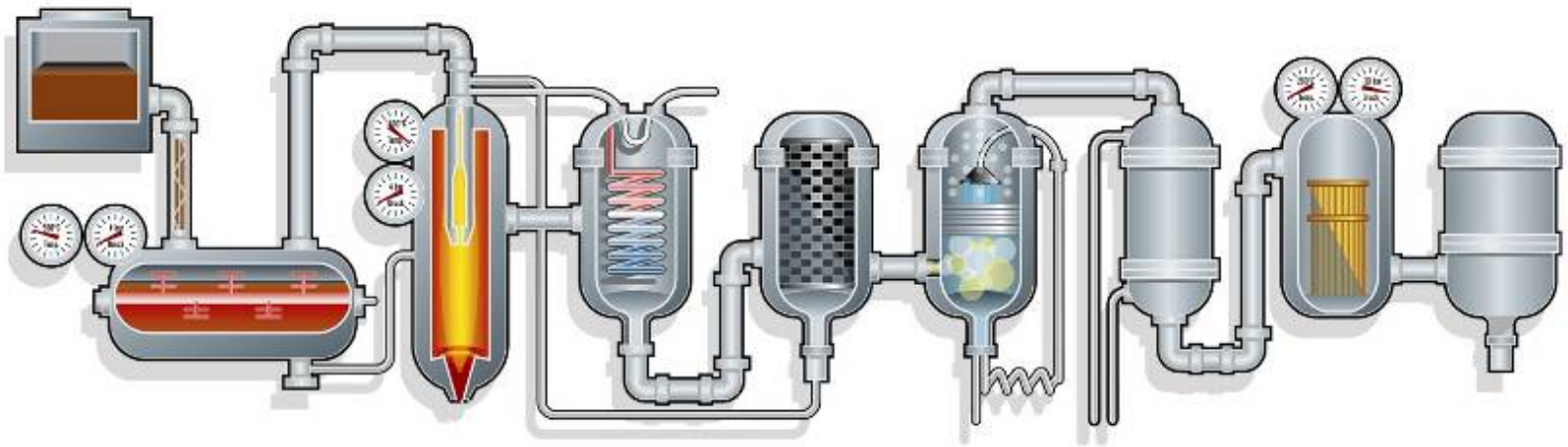
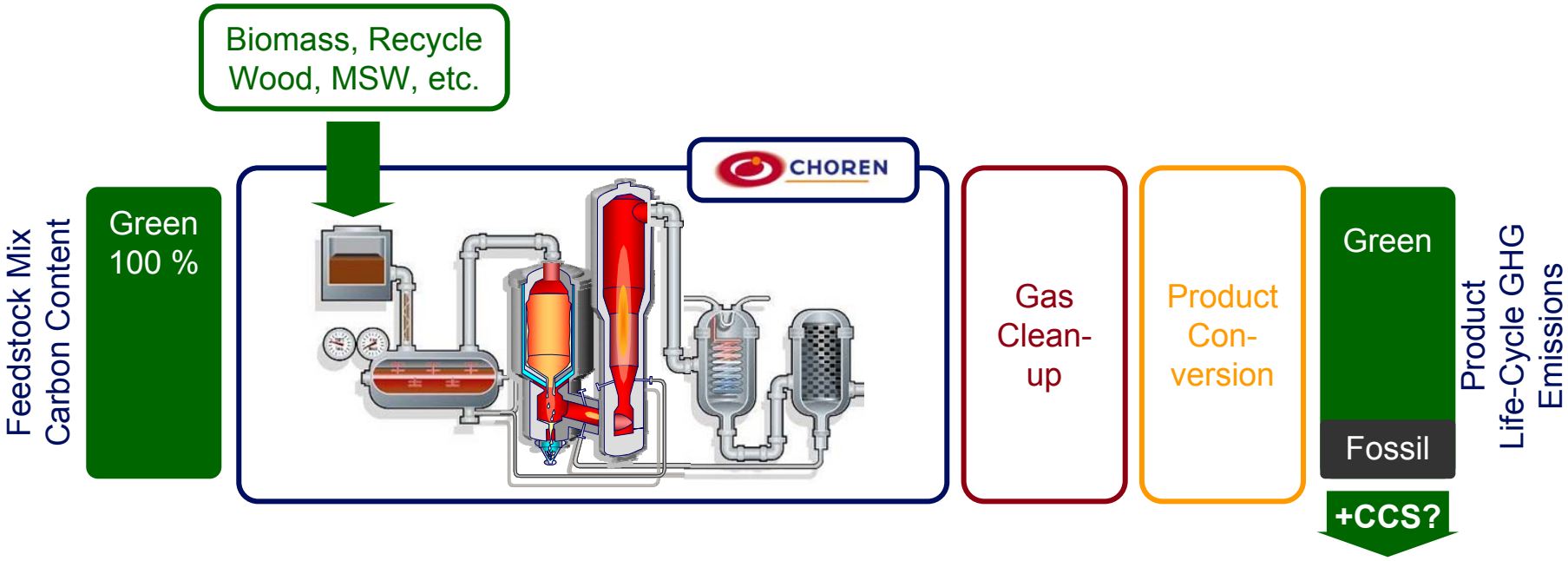


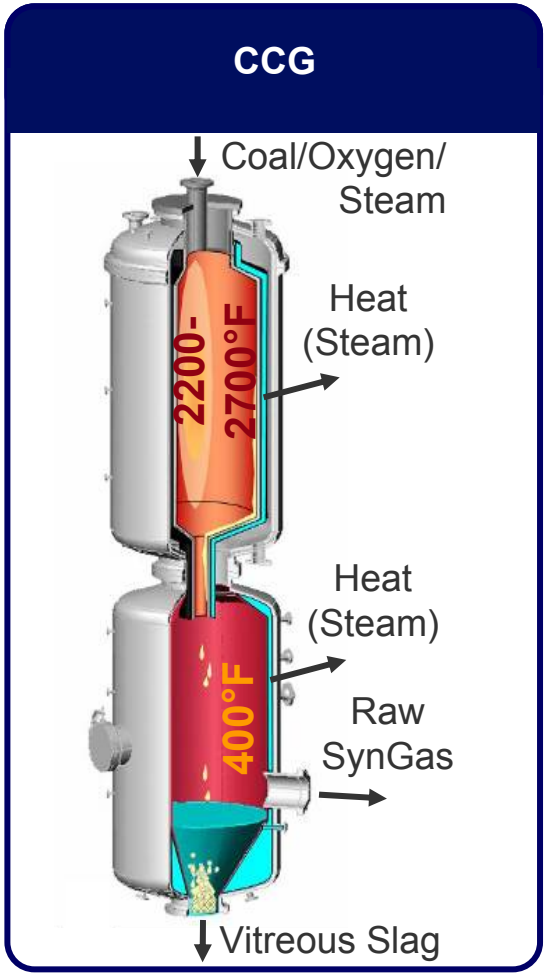
Three-Phase Gasification	Gas Treatment	Fischer-Tropsch & Hydrocracking

Biomass Gasification for GHG Footprint Reduction and Energy Security

Exploiting Opportunities of Biomass Availability



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:

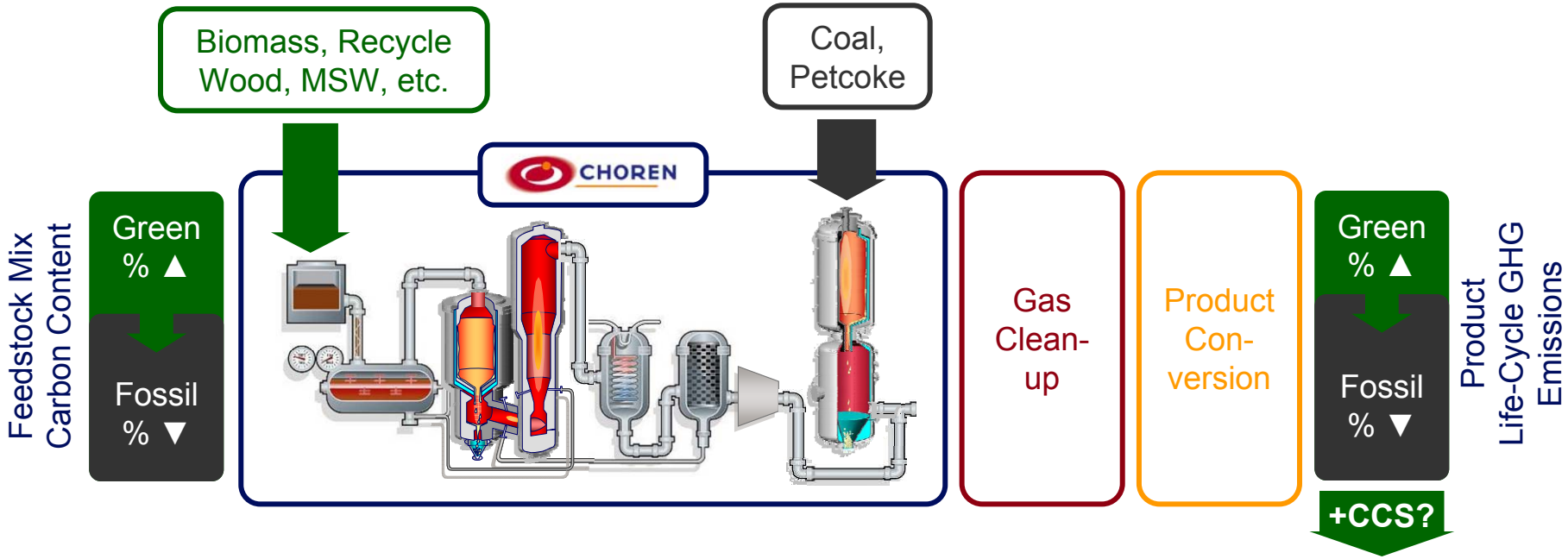
- Up to 1,500 t/d per unit
- 40 bar (580 psig)
- Up to 93% CO + H_2
- Up to 35% ash content
- Ash melting points of 1,400°C (2550°F) or higher without fluxing agents
- Burner lifetime up to 4 years (yearly inspections)
- Cooling screen lifetime up to 10 years

First Project Awarded:

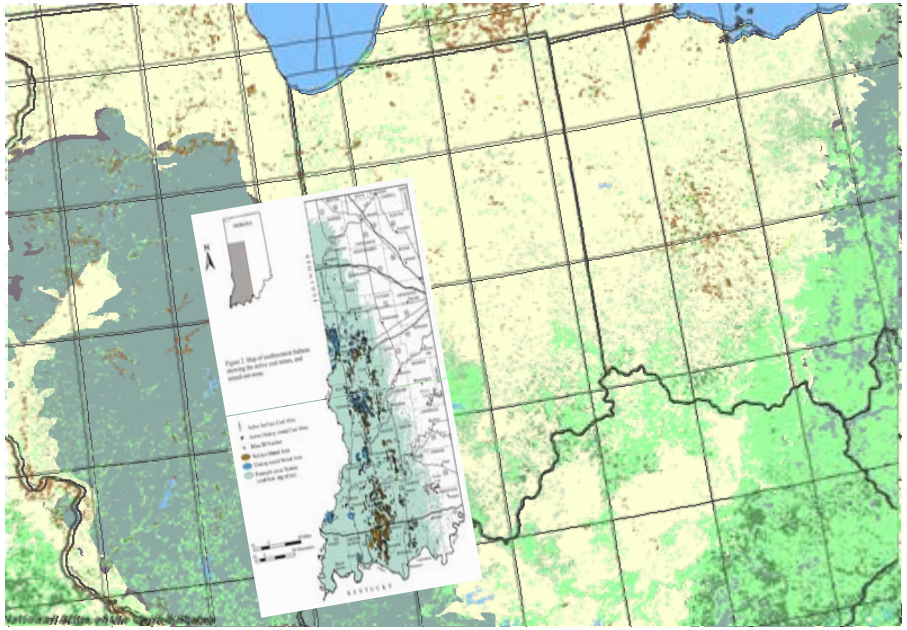
- Yankuang, China – Ammonia reformer repowering 2*400MW CCG gasifiers awarded in 2007

Biomass and Coal: Enabling Energy Security and GHG Emission Reduction

Capitalizing on Economies of Scale by Mixing Biomass and Fossil Feeds



Coal Gasification in Indiana



Medium and High Volatile Bituminous / other uses

Medium and High Volatile Bituminous / potentially minable

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

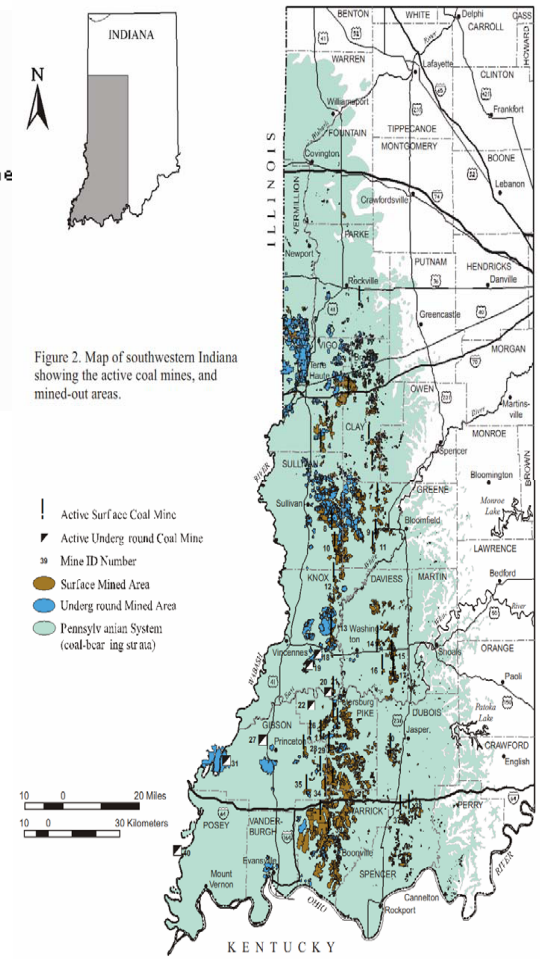


Figure 2. Map of southwestern Indiana showing the active coal mines, and mined-out areas.

No Specific Climate Action but GHG still a Driver

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

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