Lurgi

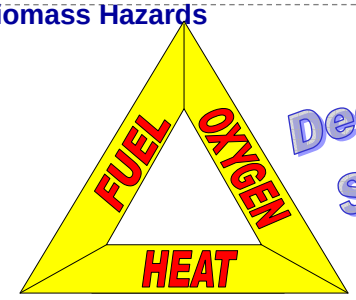
AIR LIQUIDE PROCESS & CONSTRUCTION

Safety Topic

Hazards of Handling Biomass

think SAFETY act SAFELY

KEEP SAFETY IN THE BIG PICTURE
Biomass Hazards



Decomposition
Spontaneous
Smoldering

Common Hazards:
- Combustible
- Dust or Aerosol Explosion Potential

Pathogens

Corrosion

Developing Energy Technologies Important to the Region

Common Issues For These Biofuel Pathways

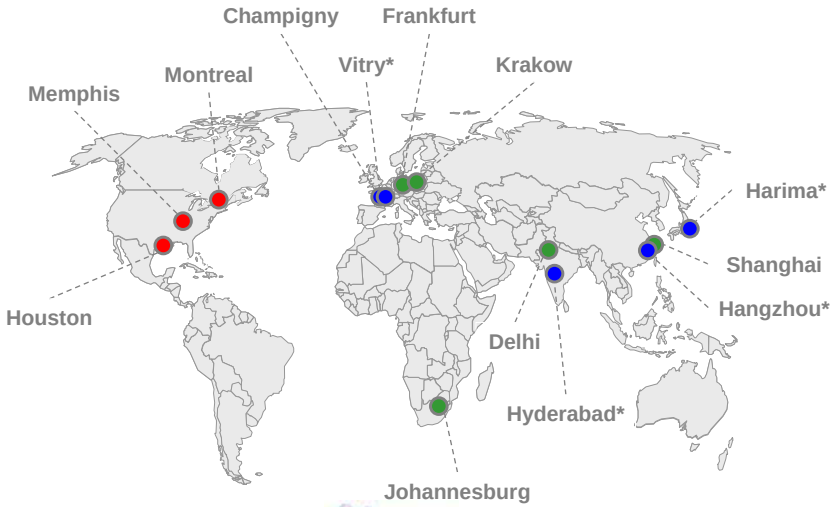
- New Technologies are being utilized
- These technologies are being developed at pre-commercial scale
- Organizations are focused on proving out Intellectual Property, not necessarily on the overall plant optimization
- Government funding has both benefits and burdens
- Many need the help of an experienced team of, industrial-focused engineers
  - Project Management experience in Both Engineering and Construction
  - Project Execution tools
  - Customizable Standardized specifications
  - Engineering support to execute the rest of the facility to make it all work together either as a part of a consortium or to lead in this area.
  - Consider both risk mitigation and construction and operational safety.

Air Liquide/Lurgi Engineering & Construction

E&C North America
3 Engineering Centers

E&C Cryogenics
*5 Engineering Centers and 4 Manufacturing Centers**

E&C Lurgi
5 Engineering Centers

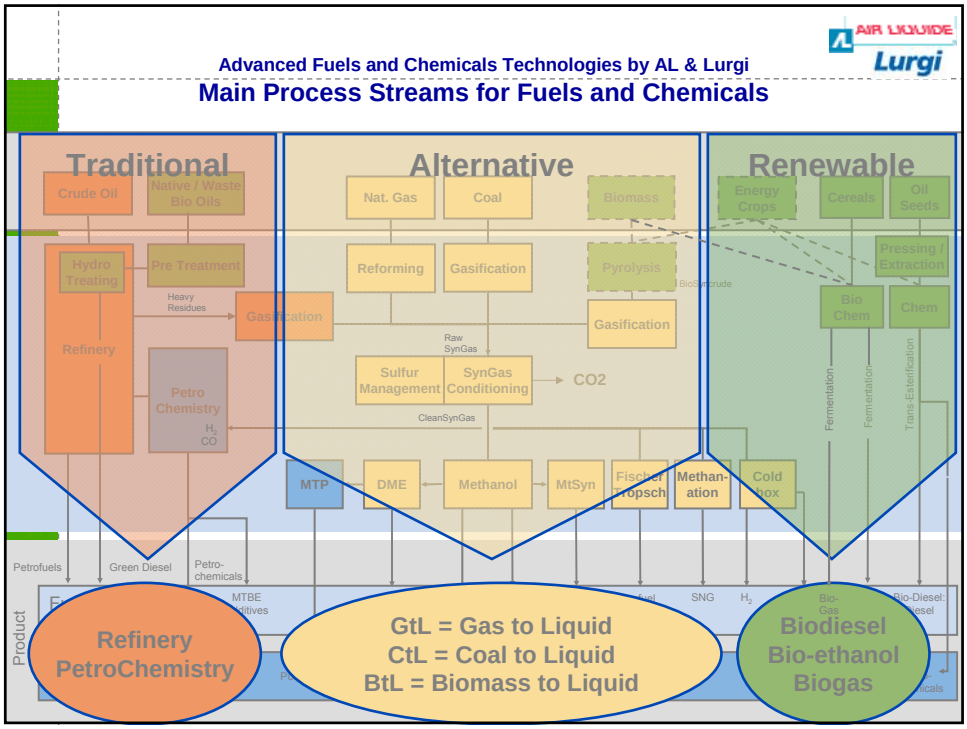


Air Liquide Group

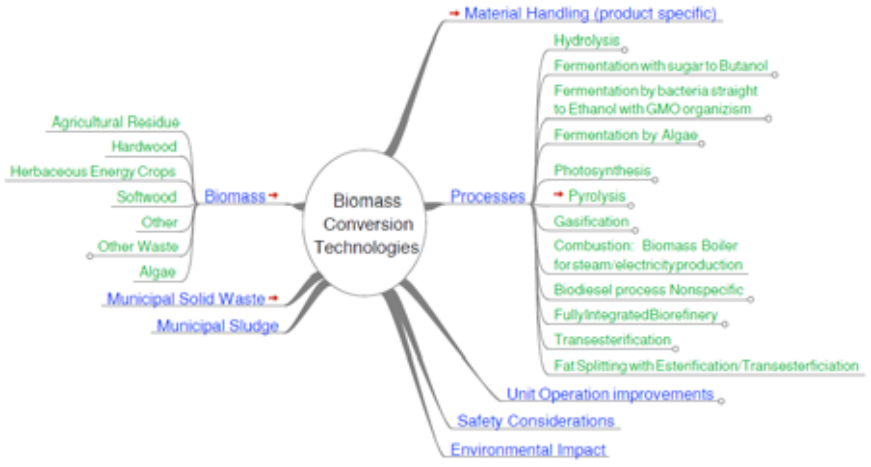
- A World Leader in Industrial Gas
  O_2, N_2, H_2, CO, Ar, CO_2,
- Sales – 13.1 Billion Euro in 2008
- Geography - 72 Countries
- Over 8,800 patents and nearly 2,700 protected inventions
- Over 40,000 employees
- 104 US Patents granted in 2008
- Engineering
  - ✓ AL has built over 1,400 plants
  - ✓ Lurgi has built over 600 plants in the last 10 years

Advanced Fuels and Chemicals Technologies by AL & Lurgi

Main Process Streams for Fuels and Chemicals



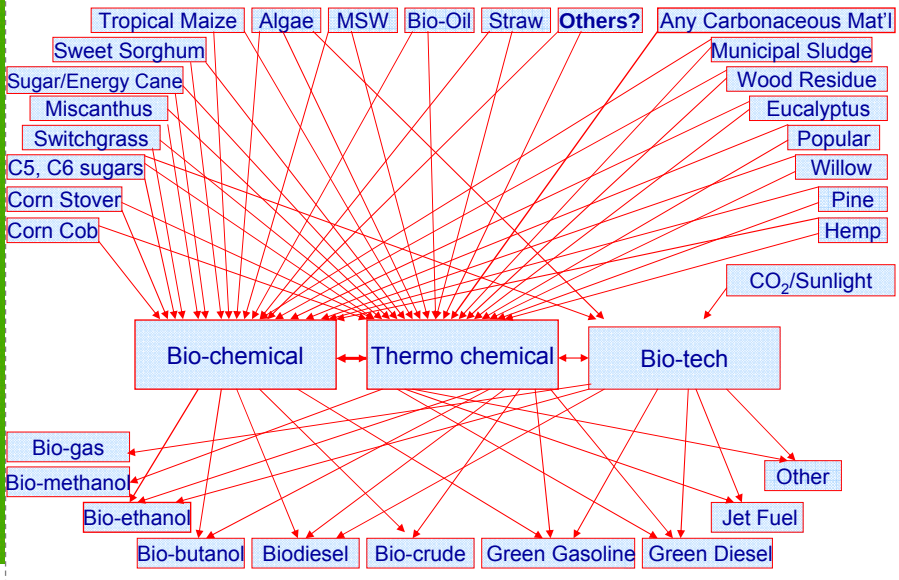
Biomass Conversion Technologies



Background - A view of the landscape

- The biofuels landscape is filled with possibilities
- There are many vantage points from which to view it
- The questions we continue to ask ourselves: What are the most logical pathways to biofuels and what technologies can we offer?

Biomass Conversion Routes



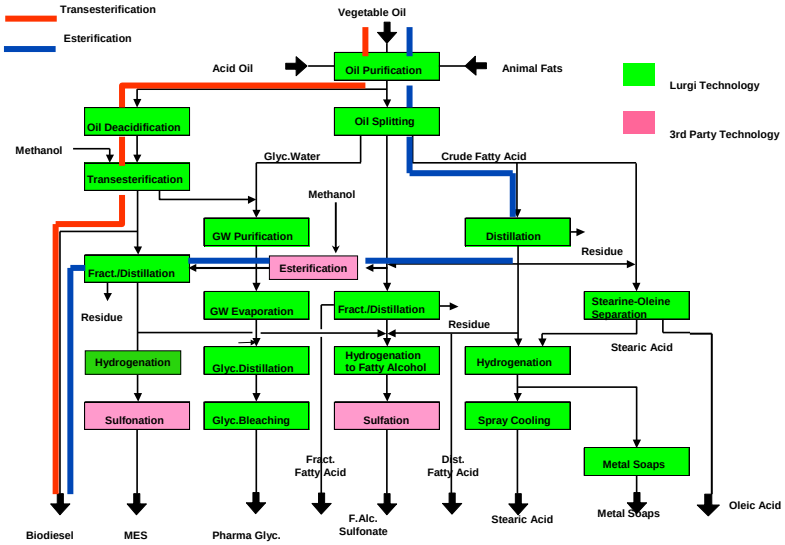
Lurgi Product Portfolio

Traditional (from crude oil)	Alternative (from gas & coal)	Renewable (from starch, oils & biomass)
		
– Sel. refinery technologies – Hydro cracker – FCC – HDS – Aromatics	– Syngas (H_2,CO) – Hydrogen – Methanol – MTP – DME – FT – MtSynfuels – MPG	– Biodiesel – Ethyl ester – Fatty Acid – Fatty Alcohol – Bioethanol

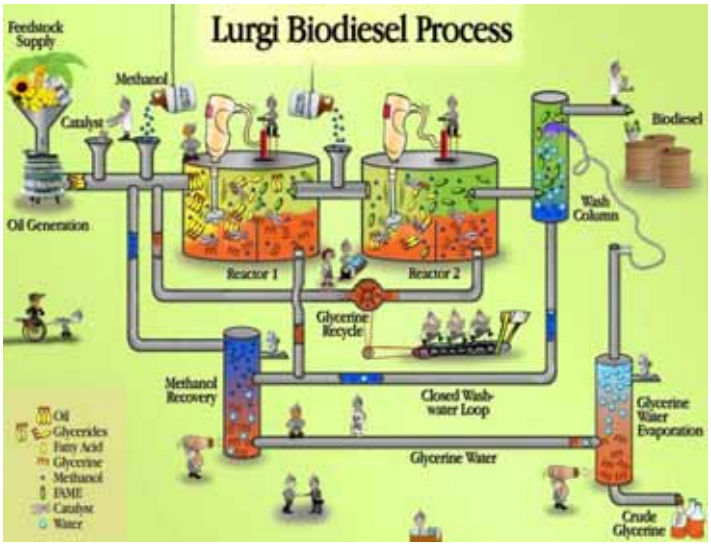
Biodiesel

Oleochemical Technologies

Two Routes to Biodiesel

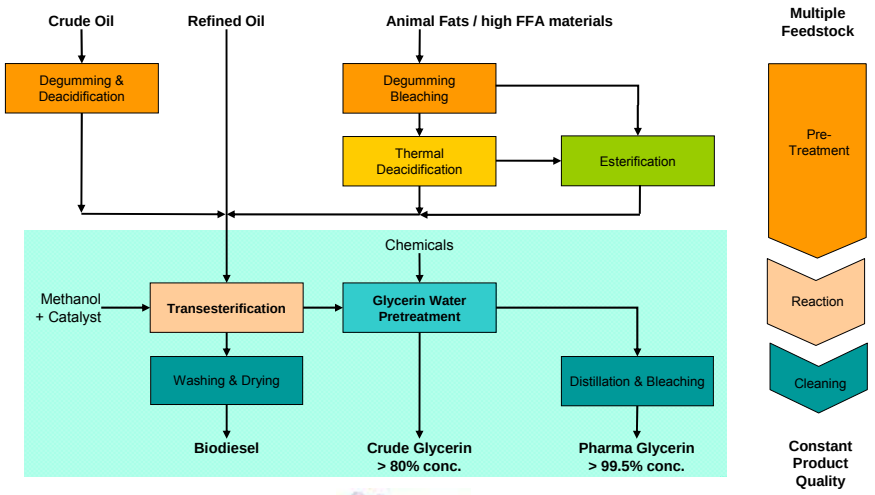


Lurgi Process



Biodiesel Process

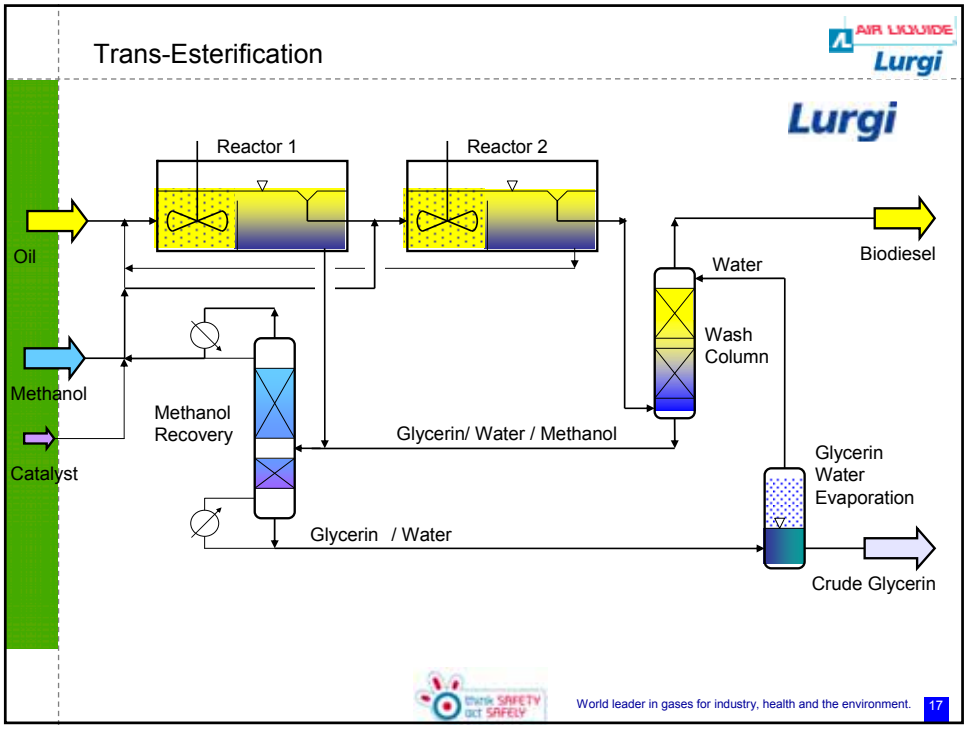
Our Pretreatment Concept(s)



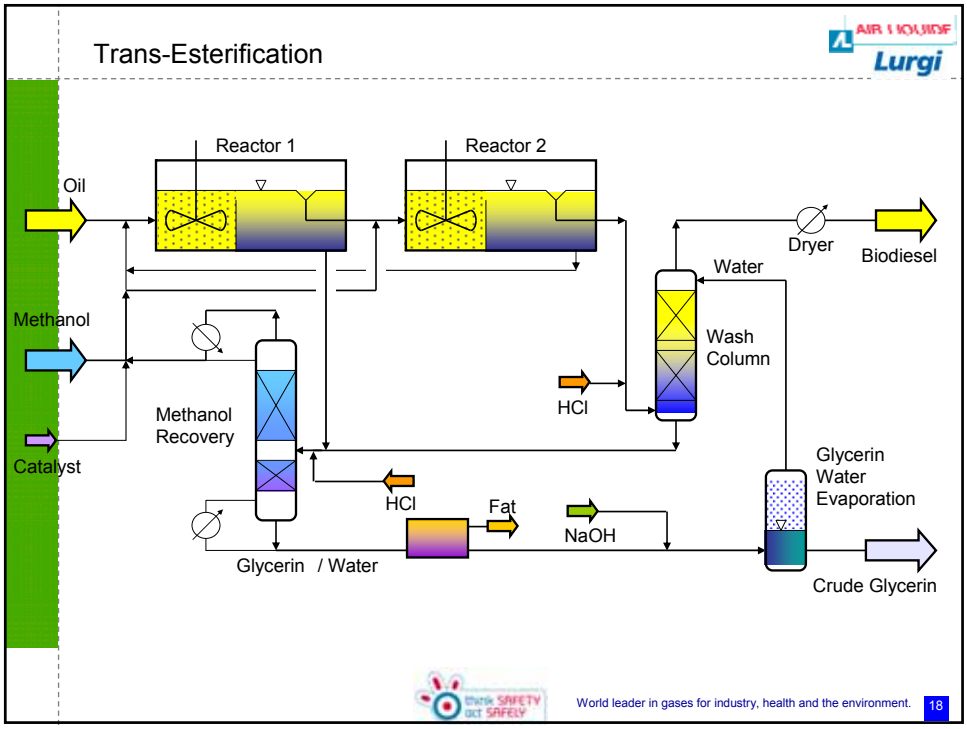
Pretreatment Technologies

- Degumming - (Removes gums, phosphorous)
- Chemical Neutralization – (Removes FFA, gums, insolubles)
- Bleaching – (Removes color, phosphorous, some sulfur)
- Thermal Deacidification - (Removes FFA)
- Winterization - (Removes Waxes)
- Deodorizing - (Removes odor & FFA)
- Pre-Esterification - (Converts FFA to FAME)
- Re-Esterification – (Converts FFA to Mono, Di, Tri Glycerides)

Trans-Esterification



Trans-Esterification



U.S. Standard 35 MM gal/yr Biodiesel Plant

REG Houston, TX

120,000 tons per year SME

Approx 35 MM gpy

Battery Limits Process Unit with Sediment Filtration

Off-Sites by 3rd Party

Utilities by Owner

Unit ready for start up 6/08

Lurgi 3 MM Gal/yr Biodiesel Skid Plant

Skid Plant Transport

Lurgi Skid Mounted Biodiesel Plant

Scope Summary, 2.8 MMGal (9,200 metric tons) per year

- Continuous Process
- Full PLC Control System
- Soy and Animal Fat Feedstock
- Up to 9.5% FFA With Skid Mounted Pretreatment
- Biodiesel Quality to ASTM, D-6751 and EN 14214
- Glycerin Treatment (Methanol & MONG < 0.1%)
- Automated Plant, PLC Controlled
- Methanol Recovery
- Vent Scrubber
- Operator Training
- Construction Time: SIX (6) MONTHS

Moving a Full Size Biodiesel Plant

Shipping a Full Size Biodiesel Plant

Yield & Consumption Figures

Based on RBD Oil Quality (metric units)

Yield calculation based on

1,000 kg dried, degummed and deacidified soybean oil:

- Biodiesel 1,000 kg
- Crude Glycerin 128 kg
- or Pharmaceutical Grade Glycerin 93 kg
- and technical Grade Glycerin 5 kg

Consumption figures per 1 metric ton soy methylester:

- Methanol 96 kg
- Catalyst(100%) 5 kg
- Hydrochloric Acid (37%) 10 kg
- Sodium Hydroxide (50%) 1.5 kg
- Steam 415 kg
- Cooling Water 25 m^3
- Electrical Energy 12 kWh
- Nitrogen 1 Nm^3
- Additional Water 20 kg

Technology Summary

Lurgi's Transesterification Process

- **Proven Process**
- **Technology Suitable for Many Feedstocks**
- **Continuous process at atmospheric pressure and low reaction temperature ± 60 °C (140 °F)**
- **High Yield Process**
- **Low Catalyst / Chemical / Energy Consumption**
- **Clear Phase Separation without Centrifuges**
- **Low Operating and Maintenance Cost**
- **High Process Reliability**
- **Biodiesel Quality to ASTM D-6751 / EN 14214**
- **Crude Glycerin Quality to BS 2621**
- **Pharma Glycerin to USP 99.5 (Kosher if Virgin Veg. Oil)**

Lurgi

AIR LIQUIDE Lurgi

PRODUCT QUALITY

Product Qualities

AIR LIQUIDE Lurgi

- Biodiesel Meets ASTM D 6751 – 09 Standard
  - Including Cold Soak Filtration Test for Soy ME & others
- Can meet EN 14214 Depending on Feedstock or Feed Blend
- Crude Glycerin Meets Brittish Standard 2621
  - Comment by Consumer
- USP Glycerin Meets U.S. Pharmacopeia Standard

Our Products

Lurgi Also Offers Downstream Processing

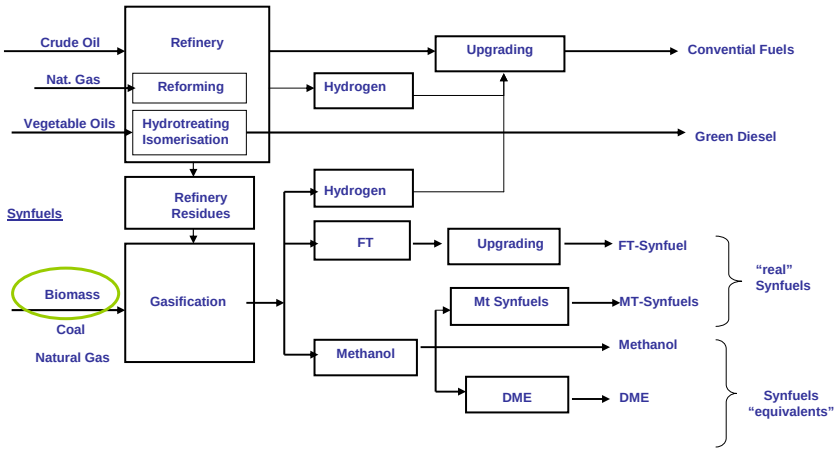
- Biodiesel Sediment Filtration
  - To meet Cold Flow Filtration Test
- Biodiesel Distillation
  - To remove impurities from low quality feedstocks
- Biodiesel Fractionation
  - To produce “Boutique” Biodiesel Blends
  - To control Cloud Point and Cetane
  - For Special Lubricant producton
- Hydrogenation of FAME
  - To produce Fatty Acid Alcohol
- Third Party Methyl Ester Sulfonation
  - For soaps and detergent manufacture

New Technology Efforts

- Lurgi is evaluating new technology with respect to biodiesel catalysts
- Lurgi is evaluating biofuel production from Algal oils
- Lurgi has access to Fischer Tropsch “know how”
- Lurgi is evaluating fast pyrolysis technology
- Lurgi is supporting 2nd generation ethanol from biomass

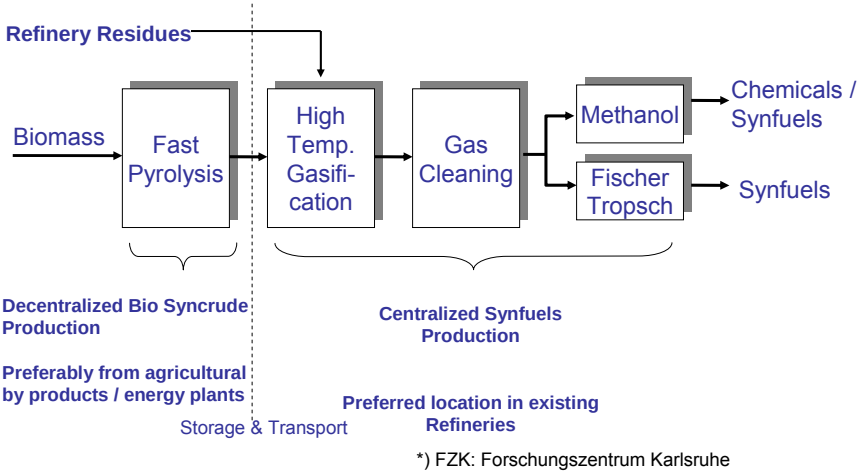
Fuel Production Technologies

Conventional fuels / Green Diesel



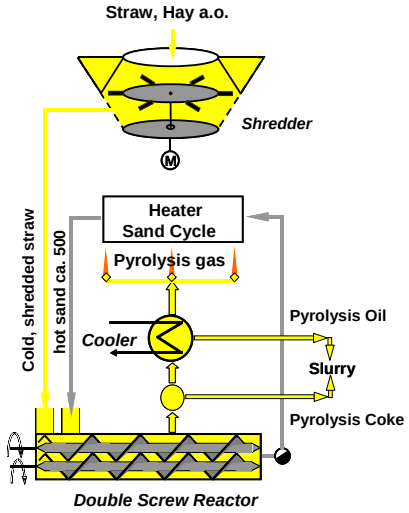
2. Generation Biofuels:
Bioliq: The thermo / chemical route

Bioliq®-Process: Joint Development by FZK *) / Lurgi and sponsored by FNR



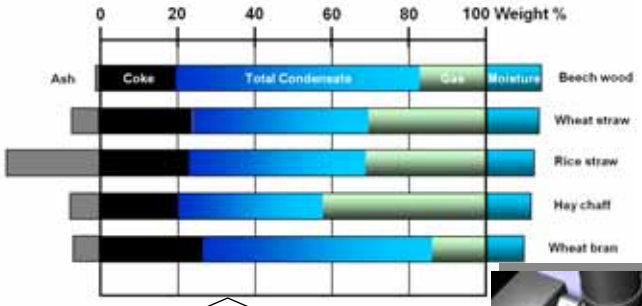
*) FZK: Forschungszentrum Karlsruhe
**) FNR: Fachagentur für Nachwachsende Rohstoffe

Fast Pyrolysis Process of Lurgi / FZK

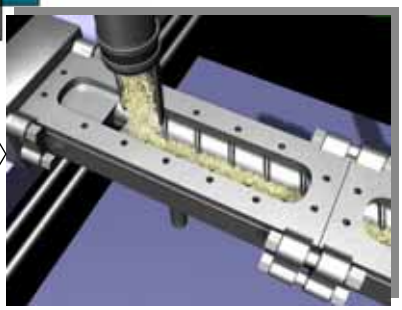


Source: FZK

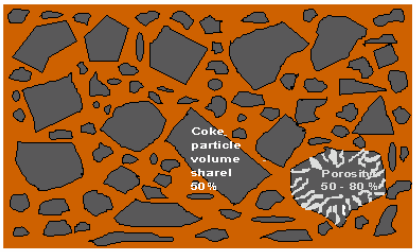
Results Fast Pyrolysis Process of Lurgi / FZK-Plant

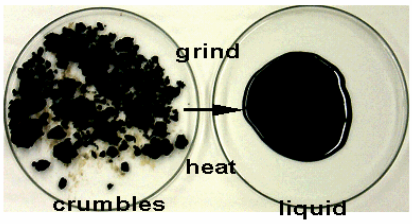


Converting different types of waste Biomass to "Bio Syncrude"

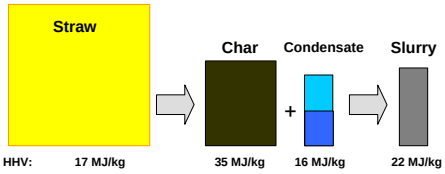


Slurry mixed with Pyrolysis coke

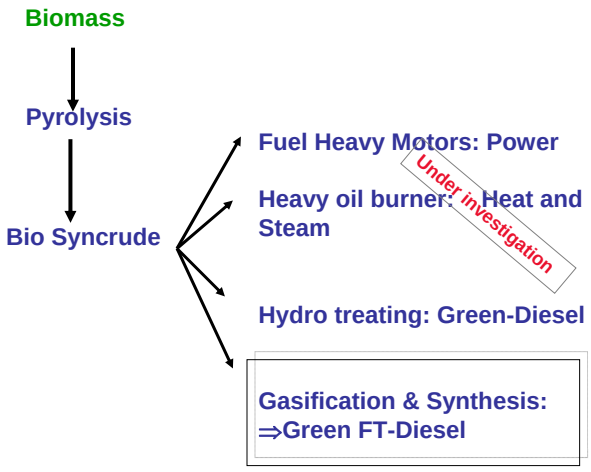




- Joint grinding of pyrolysis oil and coke give pump able/ storable slurry
- Energy concentration from biomass to slurry by factor 13
- ca. 80% of the energy content of the biomass is contained in the slurry



Application examples for Bio Syncrude

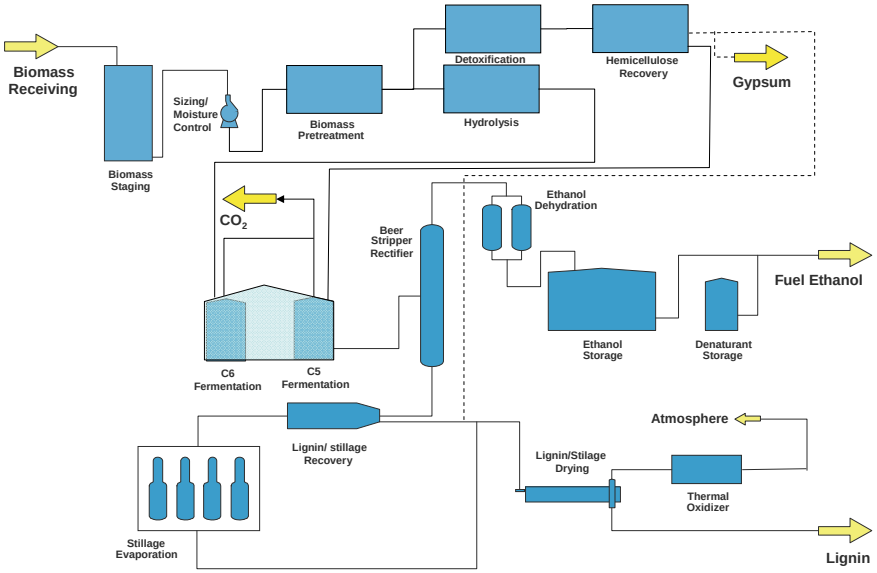


Synthetic Fuels from Biomass Pyrolysis Plant

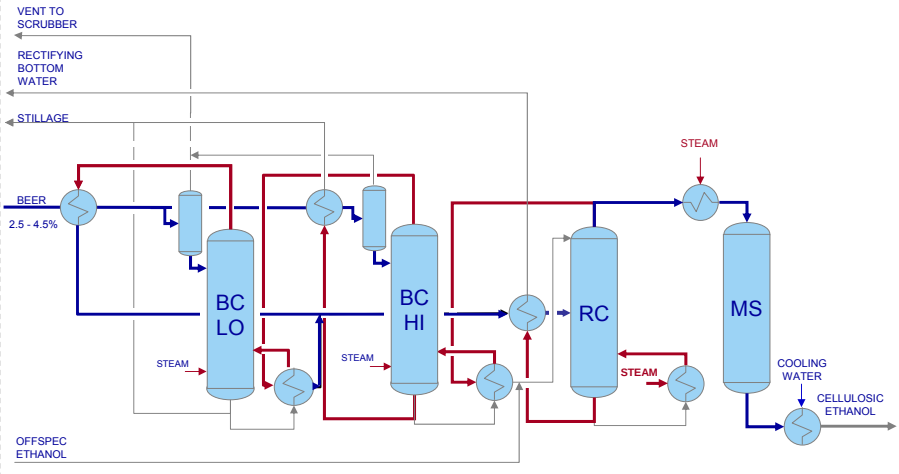
- Bioliq Technology under Development with FZ Karlsruhe

Bio-ethanol

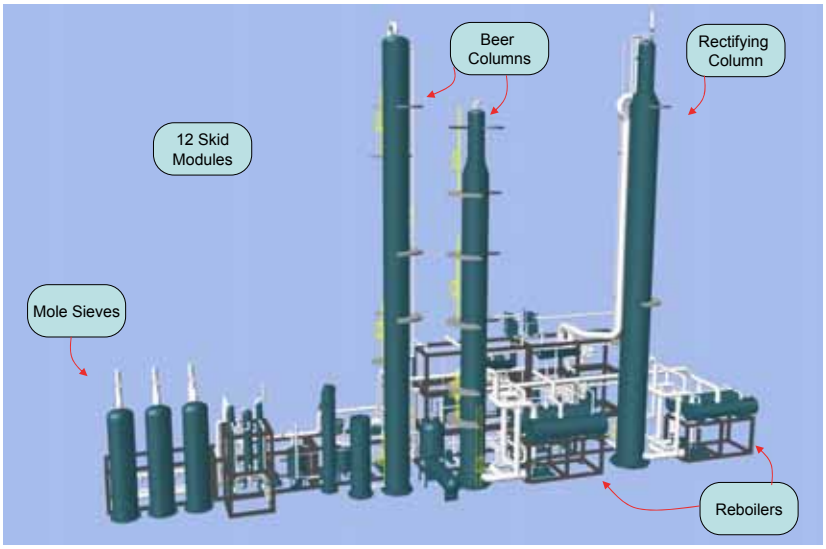
Lignocellulosic Ethanol



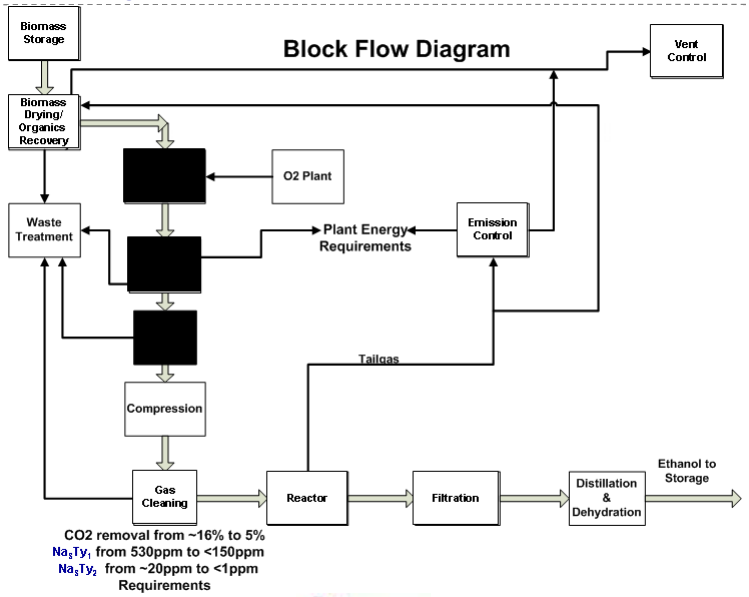
Process Overview–
DEAP – Dilute Ethyl Alcohol Purification



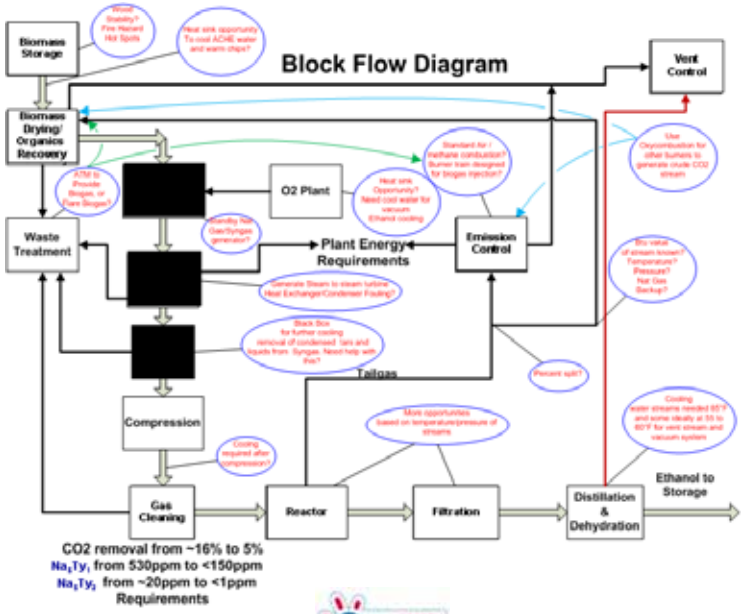
Model of a single train



Process Diagram



Process Heat Recovery and Optimization Schemes

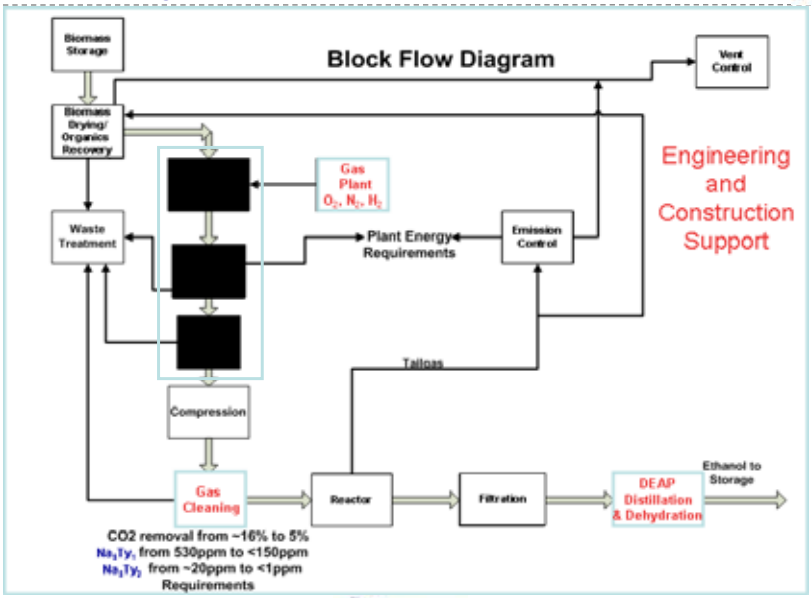


"Your Company" – Unit Operations

Biomass Storage / Biomass Drying/Organics Recovery

- Biomass pile hotspots , safety hazard, detrimental to processing / hazard mitigated?
- Possibility to warm the biomass and cool the ACHE cooling water
- Type of dryer?
- Partial gas recycle? (typically 15% energy savings)
- Moisture level feed 30 to 50% - output 10% to 12%?
- CO levels in dryer exhaust? Scrubber sufficient? RTO?
- Organics condensed out of drying vapors? Product or waste stream?
- Safety systems for dryer?

Process Diagram



End of Presentation

DISCUSSION