Status of the bioliq-process

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„Synthetic Biofuels
Techniques, Potentials, Perpsectives“

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Motivation

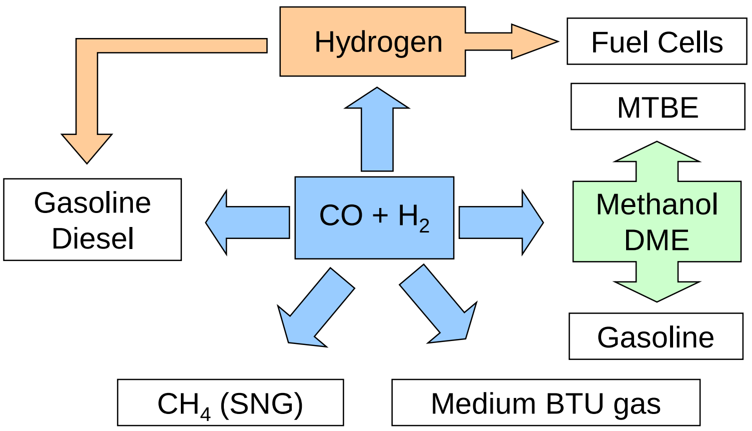
Biomass is the only renewable carbon source!

Biomass should be used favourably for organic chemicals and fuel production instead of electrical power and heat generation!

Syngas and its main constituent, Hydrogen, are key intermediates for synthetic chemistry!

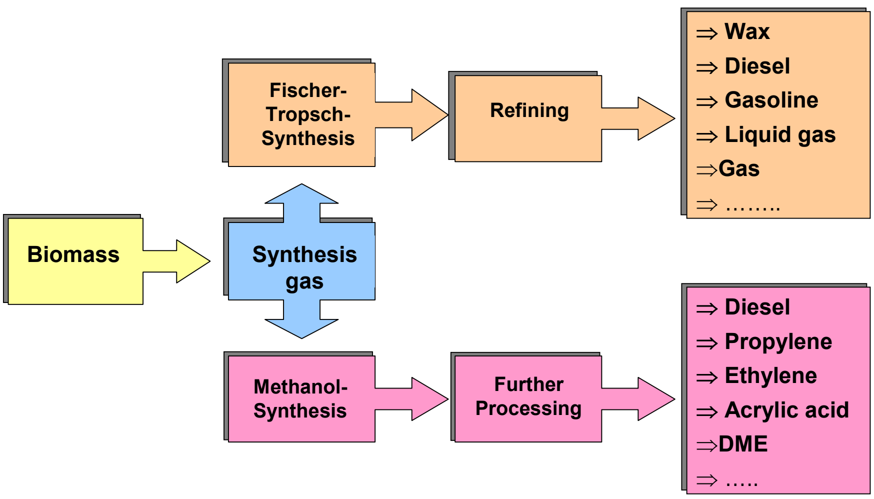
Synthetic fuels are most promising products!

Fuel options of syngas and hydrogen



I. Wender, Fuel Proc. Techn. 48 (1996) 189

Production paths to synthetic fuels



Thermochemical gas formation from biomass

Dry Biomass →

CO, H_2 →

Fischer-Tropsch

Methanol

DME .....

$C_6H_{12}O_6 \rightarrow 6\ CO + 6\ H_2$

$6\ CO + 6\ H_2O \rightarrow 6\ CO_2 + 6\ H_2$

Wet Biomass →

H_2, CH_4 →

Fuell cells

Gas engines

......

$C_6H_{12}O_6 + 6\ H_2O \rightarrow 6\ CO_2 + 12\ H_2$

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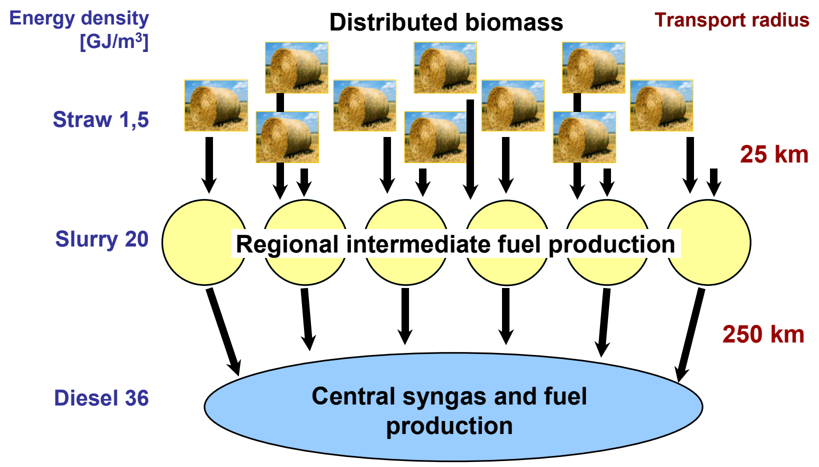
Hurdles in biomass utilization

- Usually low volumetric energy density
- Widely distributed occurrence
- Heterogeneous solid fuels
- High ash and salt contents
- Direct gasification is problematic (tar and methane formation)
- Unfavourable H_2:CO ratio after gasification
- Downstream syntheses require high pressures
  (Fischer-Tropsch ≈ 30 bar, Methanol, DME ≈ 80 bar)
- Use of catalysts sensitive to impurities

The slurry gasification concept



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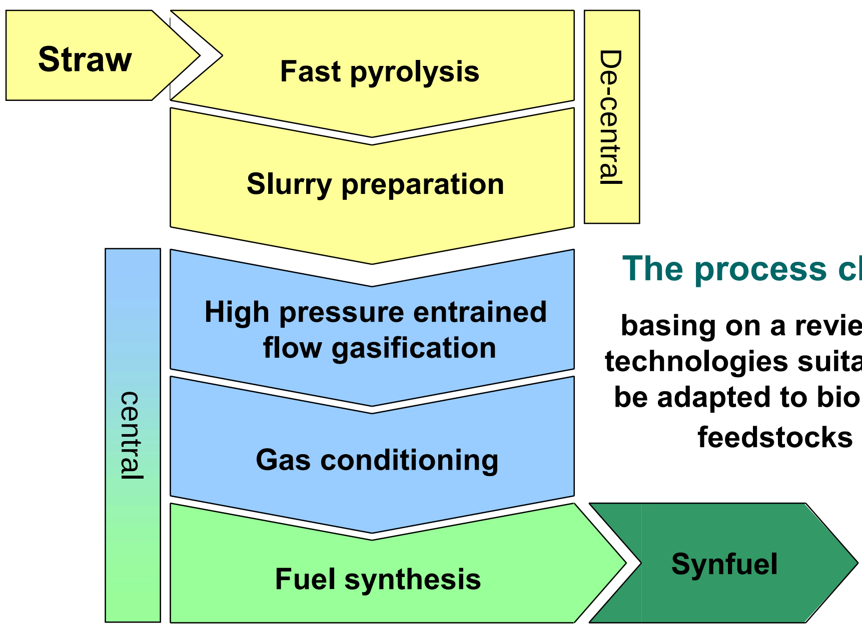
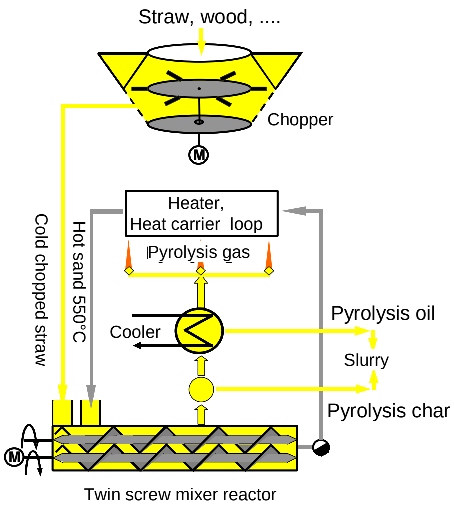


The process chain

basing on a review an technologies suitable to be adapted to biomass feedstocks

Fast pyrolysis using a twin screw mixer reactor

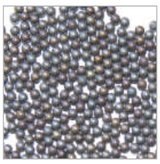
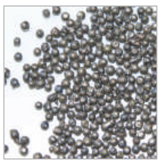
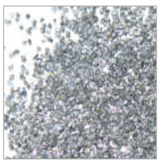
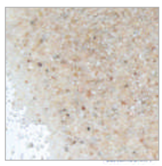


Variation of heat transfer carriers

- Optimisation of the heat transfer medium for:

- sperical particles → reduced abrasion of the medium
- higher heat capacity → low heat carrier / biomass ratio
- coarse-grained particles → better milling of the char and its separation from the heat carrier medium

		Steel		**SiC**		**SiO_2**	
$c_{p,WT}$ (at 600°C)	[kJ/(kg·K)]	0,6		1,2		1,25	
$(T_{aus}-T_{ein})_{WT}$	[K]	50	100	50	100	50	100
m_{WT}/m_{Bio} (wet)	[-]	50	25	25	12,5	24	12
m_{WT}/m_{Bio} (dry)	[-]	43	22	22	11	21	10

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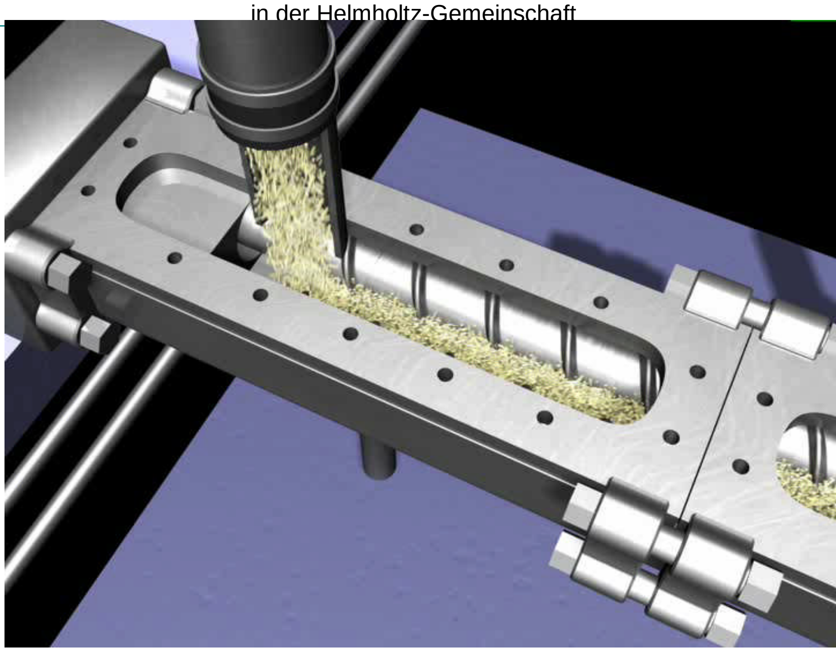

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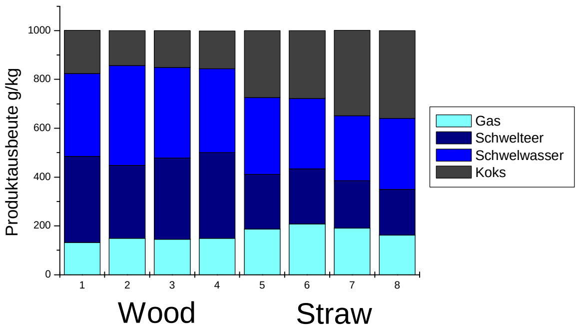
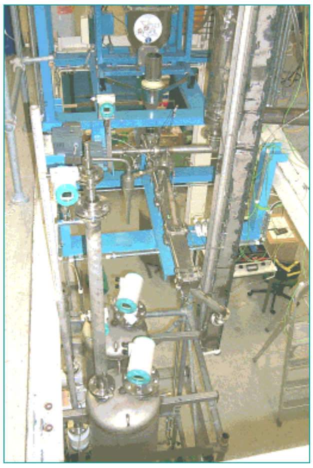
Representative results



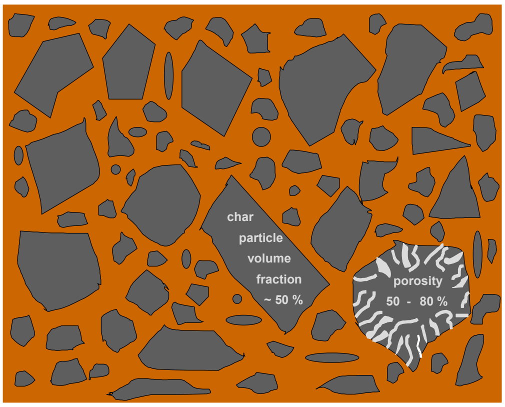
- Focus on more „difficult“ biomass like straw
- less condensates, more ash (solids)

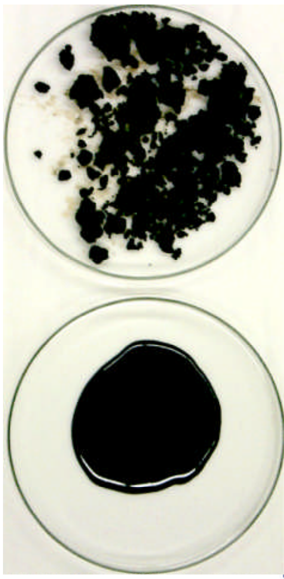


Lab scale plant (10 kg/h)

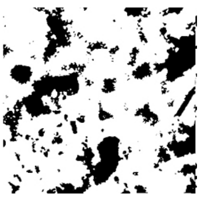
Slurry preparation

Highly porous char from straw,
soaked with 78 wt.% tar
Is liquefied by milling and heating

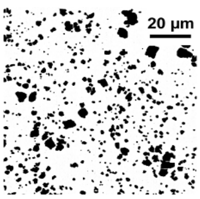




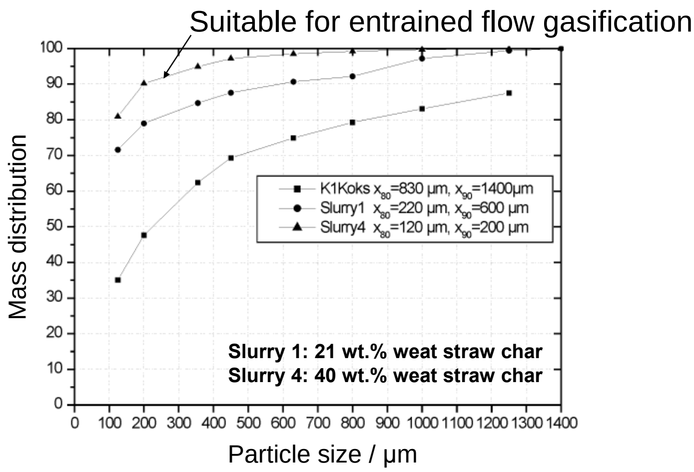
Influence of milling on slurry preparation



Original char particles suspended in alcohol



Char particles after colloidal milling



- Better milling with increasing viscosity and particle content

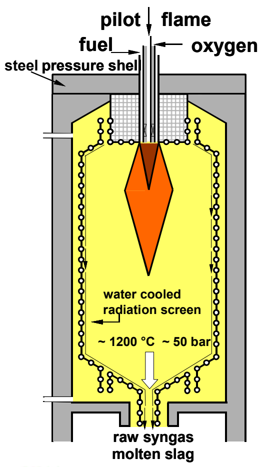
Continuous slurry preparation

Supply of pyrolysis oil (8 t) and char (4 t) at Future Energy

Continuously operated slurry mixer (1 t/h) at FZK

High pressure entrained flow (GSP) – gasifier

- Tar free synthesis gas
- Suitable for feeds rich of ash
- Gasification with pure O_2
- High pressures, 30 to 100 bar
- Temperatures around 1200°C
- Residence time of seconds, complete C-conversion
- 4 gasification campaigns with different feed materials, process parameters, 500 kg/h (2-3 MW_{th})



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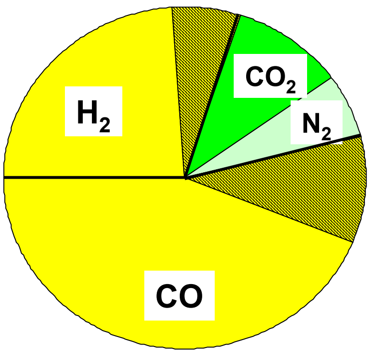
Results of slurry-gasification

Gas composition



- no tar, < 0.1 vol.% methane
- C-conversion ≥ 99 %
- operation without problems

Feeds:

Solids: 0 – 39 wt.%
Ash: 3 %
Heating value: 10 – 25 MJ/kg
Density: 1250 kg/m³

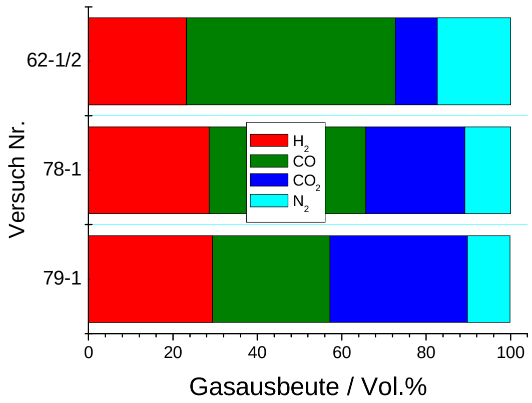
Operation conditions:

Throughput: 0.35 – 0.5 t/h
Pressure: 26 bar
Temperature: 1200 – 1600 °C
Feed-Temperature: 40, 80 °C

- Equilibrium:
  $(CO_2 \bullet H_2) / (CO \bullet H_2O) = K(T)$
- Slag melting point < 1200 °C

Experimental results of slurry gasification*

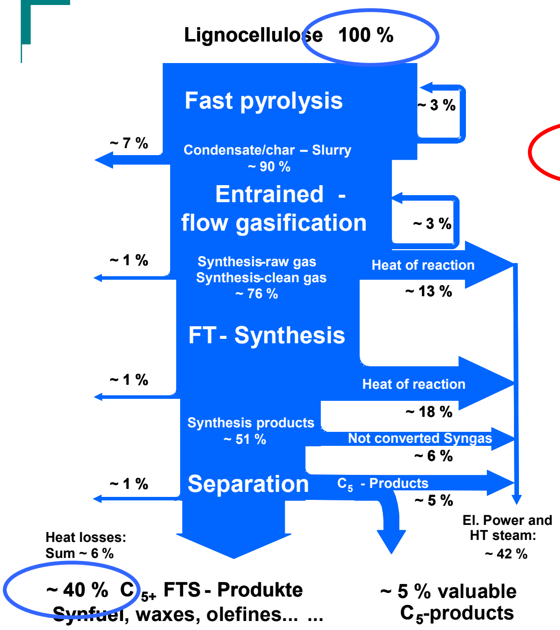
No tar, < 0,05 Vol.% methane, 0,5 t/h
1200 – 1300 °C, 24 MPa, 25 – 33 % char



H_20 %	Conv. %	HHV kJ/kg	η
5,8	95	24500	70
27,8	92	16860	57
50,6	90,5	13590	44

*** Gasification campaigns in Freiberg 2003 and 2005**

Energy- and mass balance



7.5 t Wood or Straw with 15 wt.% H_2O

5.4 t Condensate/char - slurry
plus ~ 1,8 t O_2

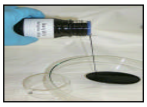
1.2 t FTS-raw products

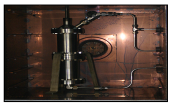
1 t Synthetic fuel

By-products:
Chemicals, Steam, Electricity

State of development

- Fundamental studies in lab scale equipment, parameter determination for various feed materials and conditions, selection of appropriate process technologies
- Demonstration of the principal technical feasibility in technical relevant plants, process variants in bench scale plants
- Construction and operation of a pilot plant proving practicability, allowing for scale-up and reliable cost estimates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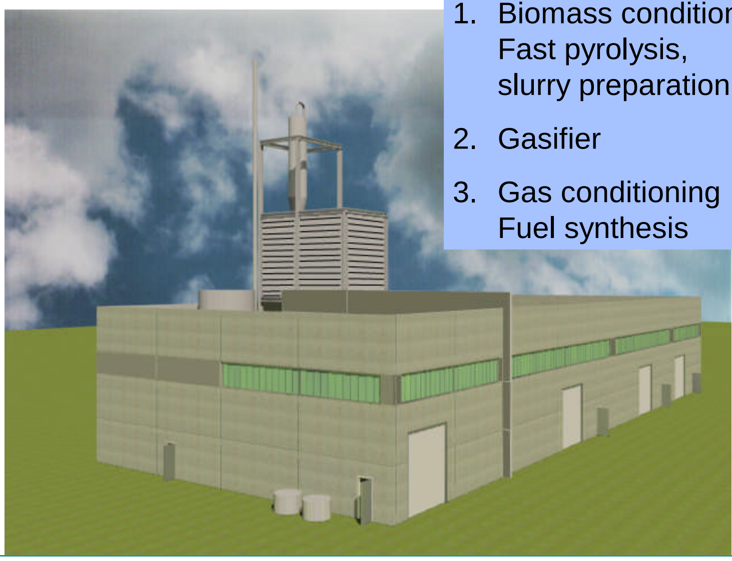
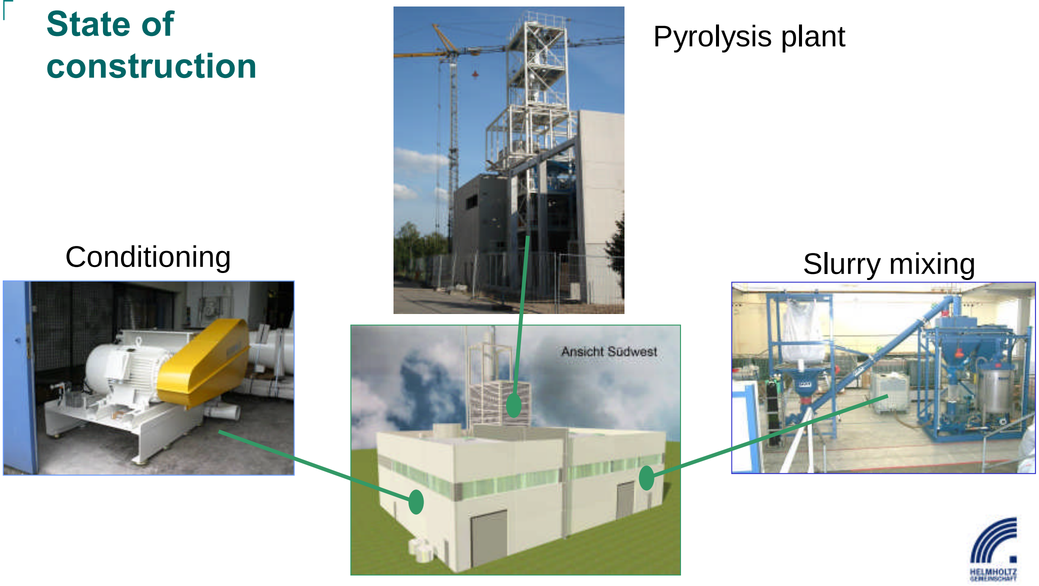
Pilot plant (500 kg/h)

Stepwise construction :

1. Biomass conditioning Fast pyrolysis, slurry preparation	2006
2. Gasifier	2007
3. Gas conditioning Fuel synthesis	2008



State of construction



Concluding remarks

- For syngas production from biomass to large extent, thermochemical processes adapted from fossil fuel treatment are well suited, operational practicability and economics have to be proved
- Biomass as the only carbon containing renewable energy preferentially should be used for the production of fuels and organic chemicals (consuming ca. 10 % of the primary energy). Heat and electrical power can be produced from other renewable energy sources
- Since C/H-ratio available from biomass is worse than that from fossil fuels, additional hydrogen should be produced from other renewable resources

Financing

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- EU-Commission
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