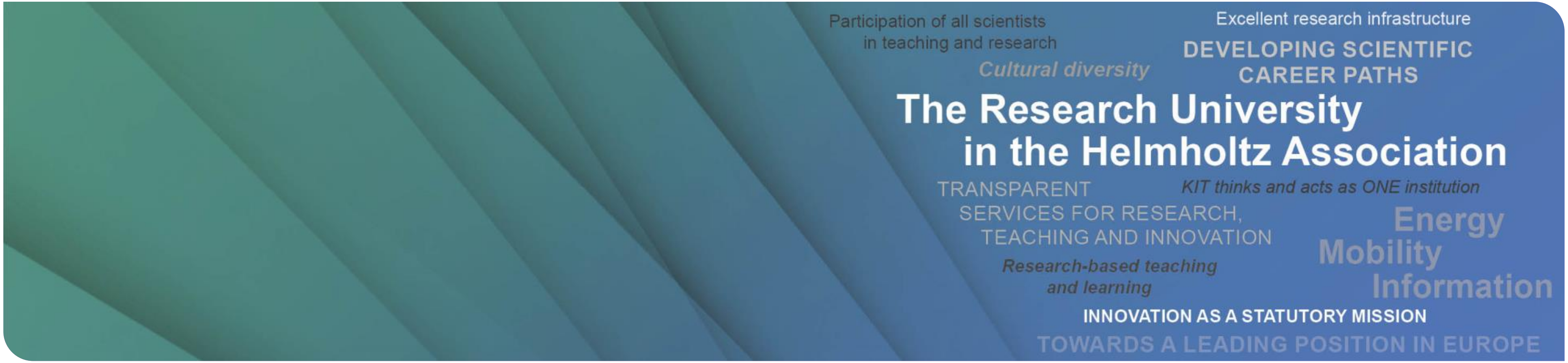
BtL and PtL, differences and similarities at technical level

Reinhard Rauch



KIT Figures and Facts

Karlsruhe Institute of Technology

59 Spinoffs and Startups

5 Campuses – **200** ha area

368 Professors and executive scientists

371 Trainess

24,381 Students

300 Buildings with a usable area of **478,000 m²**

3,100 Doctoral students

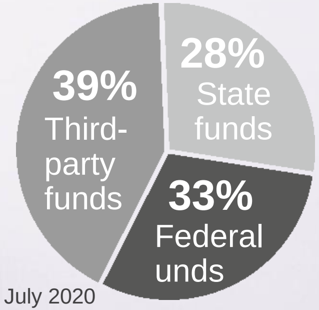
40 Patent applications

9,398 Employees

1,178 international scientists

KIT budget 2019

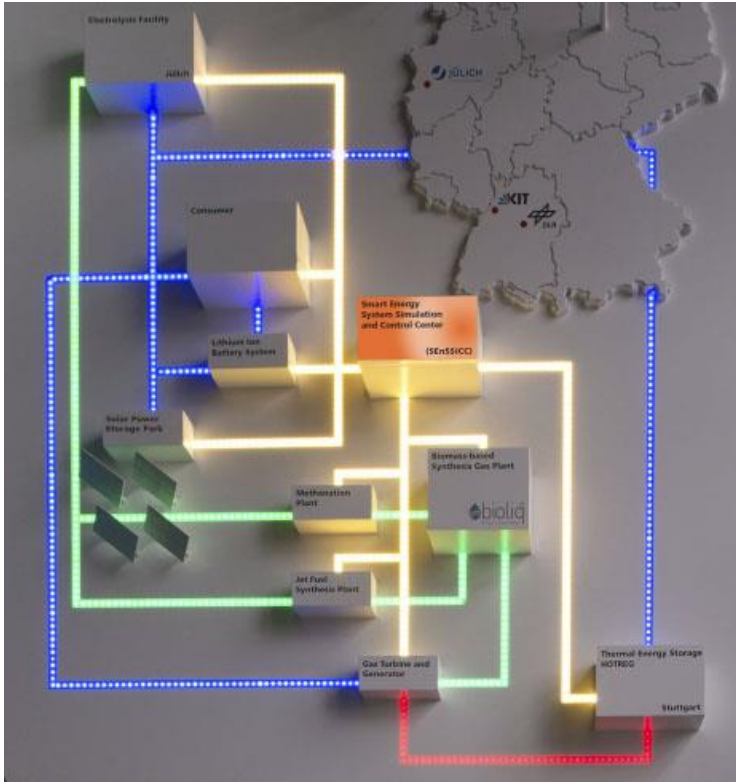
EUR 951 million



Status: July 2020

Biomass to Liquid (bioliq®)

EnergyLab 2.0



Types of renewable fuels

1st generation biofuels

TRL 9, but food versus fuel debate

- Biodiesel by transesterification of vegetable oils
- Ethanol from fermentation of sugar and starch
- Biodiesel by hydroprocessing of vegetable oils

2nd generation biofuels

TRL 5-7, direct and indirect land use change

- Synthetic fuels produced from synthesis gas (Fischer Tropsch Fuels, DME, etc.)
- Ethanol from lignocellulosic biomasses via fermentation
- Pyrolysis oil upgrading by hydroprocessing

3rd generation (bio) fuels

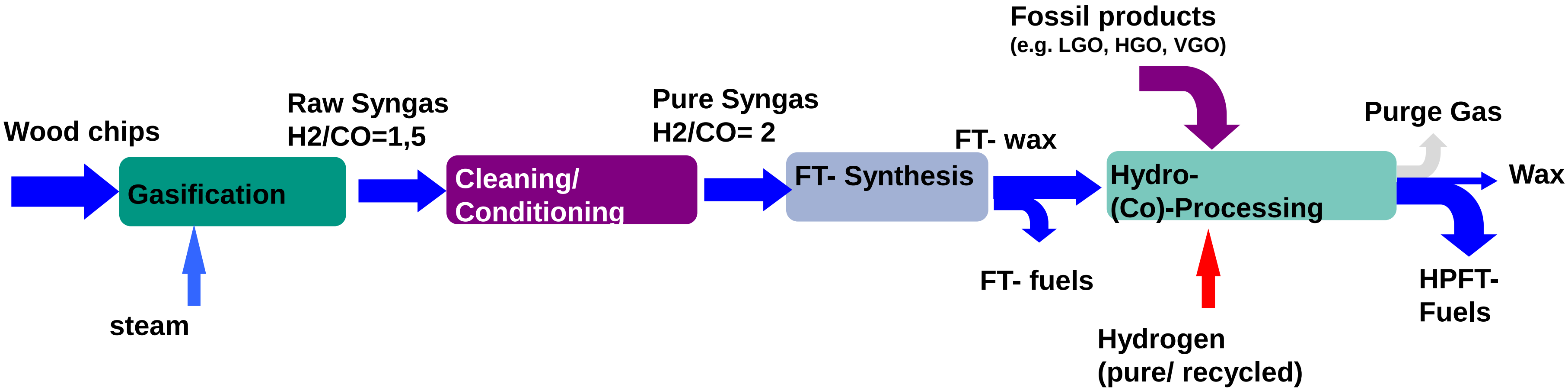
TRL 1-5, No more limitations !

- Algae, hydrogen… , Power to Liquids

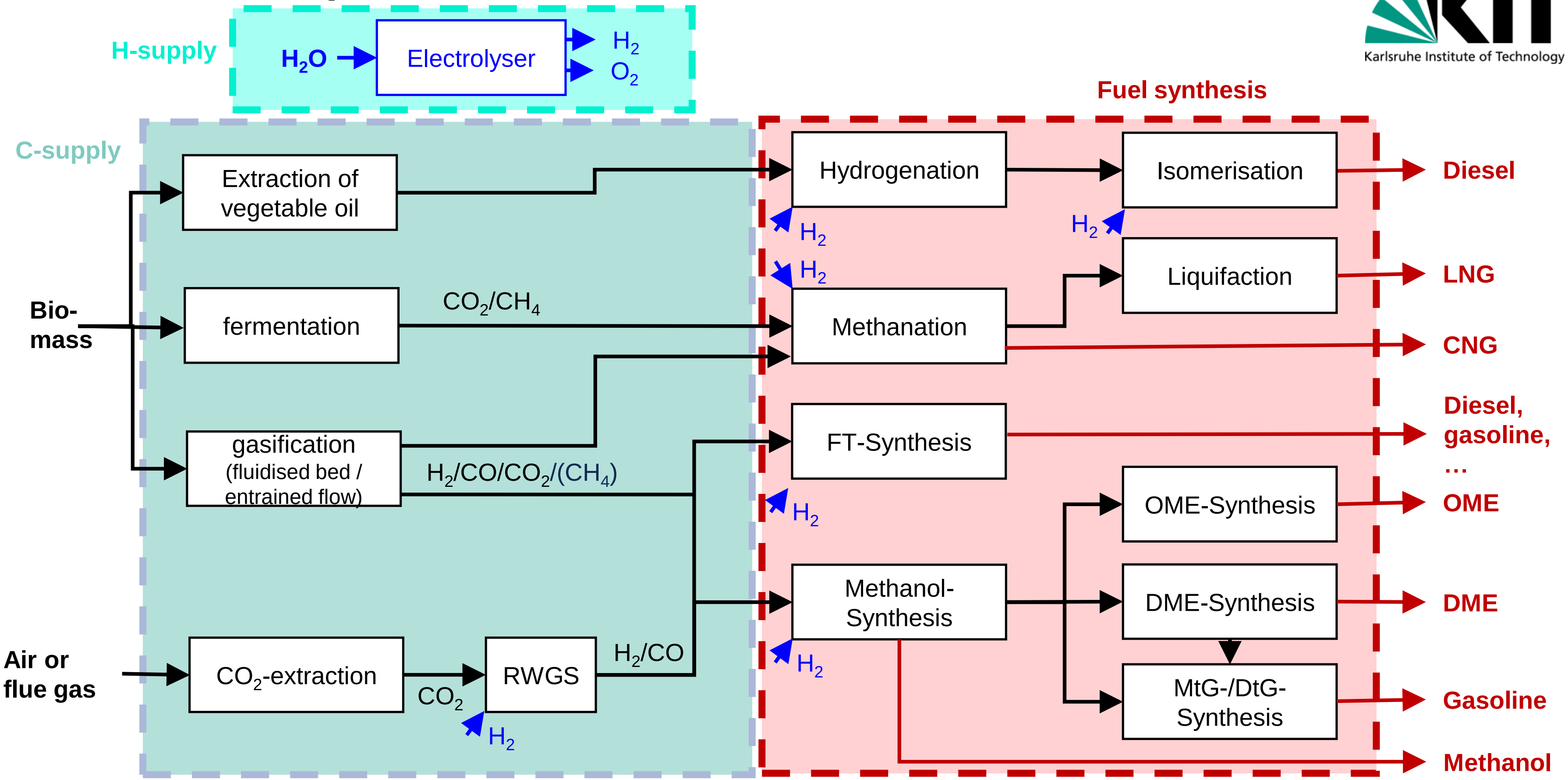
Biomass to Liquids (FT- Route)

Biomass (Cellulose, Hemicellulose Lignin)

hydrocarbons (i/n- paraffins)



Transportation fuels over PtX-Processes



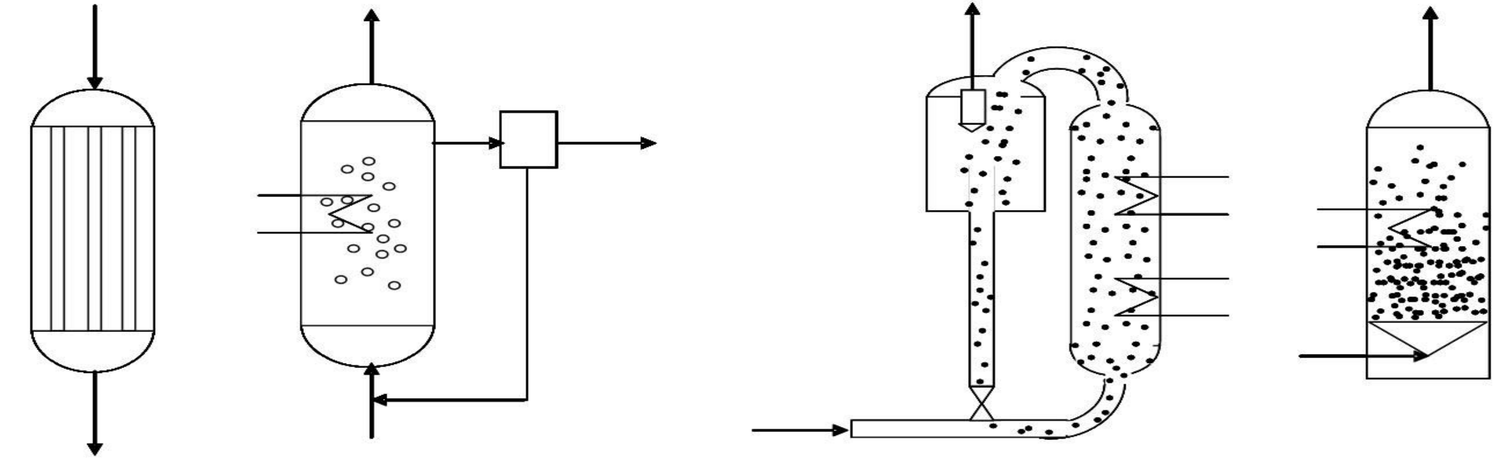
Fischer Tropsch Synthesis

$$CO + 2H_2 \Rightarrow -(CH_2)- + H_2O$$

Parameter	Low-temperature FT	High-temperature FT
Products	Waxes and/or diesel fuels	Gasoline, light olefins
Temperature [°C]	220 - 250	330 - 350
Pressure [bar]	25 - 60	25
$CO + H_2$ conversion [%]	60 - 93	85

Catalytical Reactors in FT-Synthesis

Low-T (180 – 260 °C) Gas-liquid-solid	High-T (300 – 350 °C) Gas-solid



Tube bundle fixed bed

Bubble column

Circulating fluidised bed

Bubble forming fluidised bed

source: Schaub and Edzang 2011

Methanol synthesis

$CO + 2H_2 \leftrightarrow CH_3OH$

$CO_2 + 3H_2 \leftrightarrow CH_3OH + H_2O$

$CO + H_2O \leftrightarrow CO_2 + H_2$

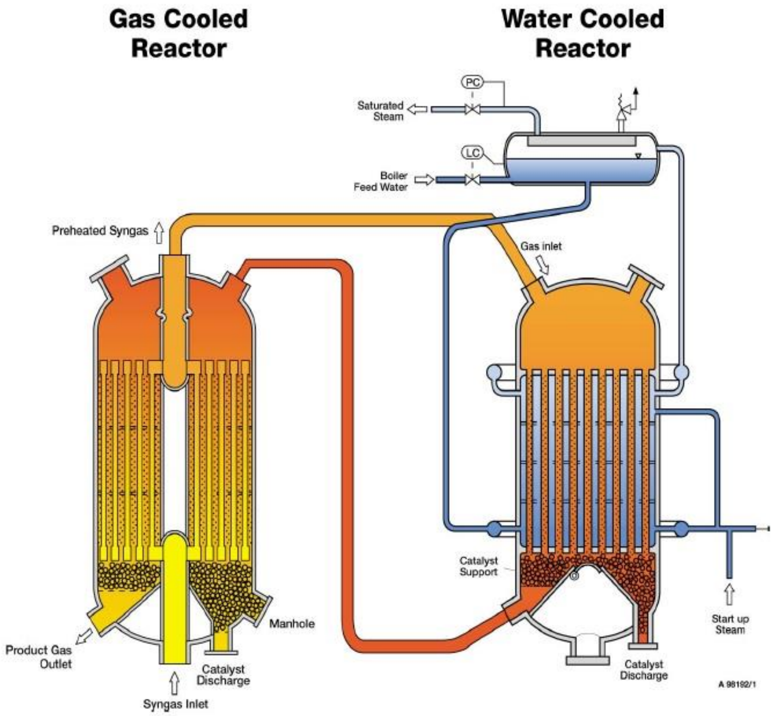
$$SN = \frac{(H_2 - CO_2)}{(CO + CO_2)} = 2 \text{ to } 2{,}1$$

Inerts like N_2, Ar, CH_4 as low as possible

Today low pressure prefered:

- 50 - 100 bar
- 230 - 270 °C
- $Cu/ZnO/Al_2O_3$ or $Cu/ZnO/Cr_2O_3$

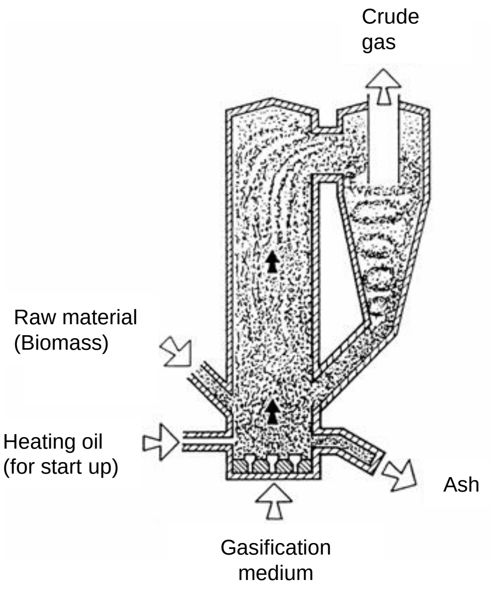
Reactors for Methanol synthesis



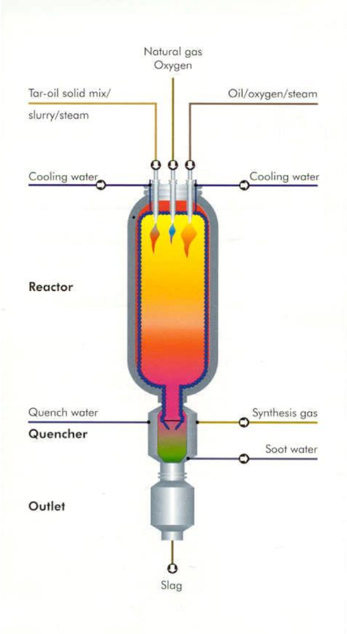
http://www.linde-engineering.com/de/process_plants/hydrogen_and_synthesis_gas_plants/gas_generation/isothermal_reactor/index.html

Wurzel, T., 2006, Lurgi MegaMethanol Technology, DGMK Conference „Synthesis Gas Chemistry“, October, 4. – 6., 2006.

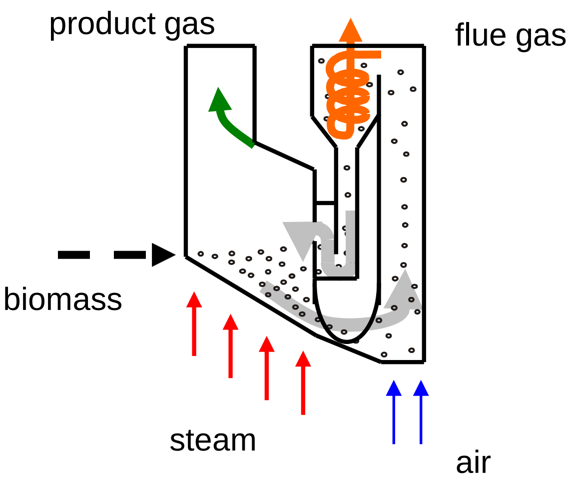
Reactors for Syngas Production from Biomass



Fluidised Bed ($Steam/O_2$)



Entrained Flow (O_2)



Dual Fluidised Bed (Steam / CO_2)

Integration of RWGS into gasifier? $H_2 + CO_2 \longleftrightarrow CO + H_2O$

Comparison PTL BTL – GTL - crude oil

	Plant capacity				
	feedstock		product	Invest	efficiency[2]
	kt a^{-1}	GW [1)]	GW [1)]	Mio €/$GW_{Pr.}$	%
Power to Liquids [6)] (PtL)	-	0.1	0.04	~5000	40
Biomasse – FTS [3)] (BTL)	1000	0.65	0.3	1500-3000	45
Natural gas – FTS (GTL)	3100	5.5	3.3	400-750 [4)]	60
Crude oil-refinery (Referenz)	15000	21.8	19.6	350-500 [5)]	90

[1)] as upper heating value H_S
[2)] Definition over H_S in product and feedstock
[3)] [Deutsche Energie-Agentur GmbH (Dena), Biomass to Liquid – BtL.
Realisation study (Summary), final report, 2006]

[4)] Equivalent 25000 – 50000 US $ b^{-1}
[5)] Using German standards
[6)] Typical demoprojects discussed in Germany

Conclusion

- There are many similarities between PtL and BtL, the synthesis step is almost the same, main difference are:
  - Gas composition
  - Operation mode, as BtL is steady state and PtL is fluctuating
- All reactors from BtL can be also used in PtL, some has advantages for flexible operation, like slurry reactors
- Advanced control concepts, like model based control are very interesting
- Economy of scale is one major hurdle for BtL and PtL compared to fossil technologies
- Hybrid systems, where BtL and PtL are combined could offer some advantages for locations in Europe, like winddiesel (www.winddiesel.at)

Questions ?

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