Conversion of Renewable Synthesis Gas

Reinhard Rauch

IEA Bioenergy Task 33 workshop „Valuable (by-)products of gasification" on 19th October 2022

KIT: Figures and Facts 2021

37 Spinoffs and Startups

5 Campuses – **200** ha area

367 Trainess

385 Professors and executive scientists

22,225 Students

300 Buildings with a usable area of **492,000 m²**

3,100 Doctoral students

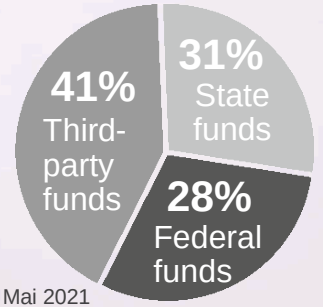
51 Patent applications

9,783 Employees

1,405 international scientists

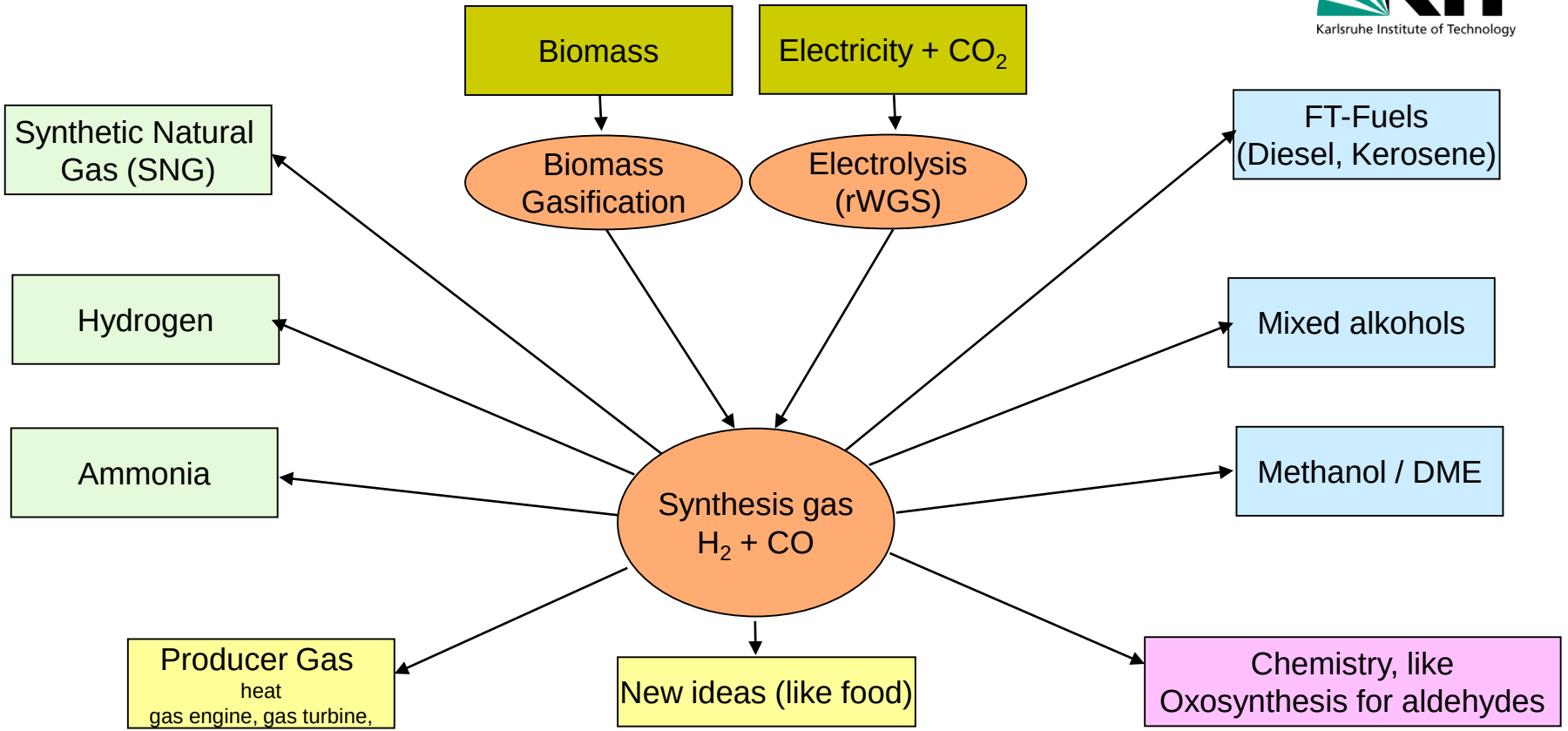
KIT budget 2021

EUR 1090,7 million



Status: Mai 2021

Synthesis Gas Conversion



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

Methanol synthesis

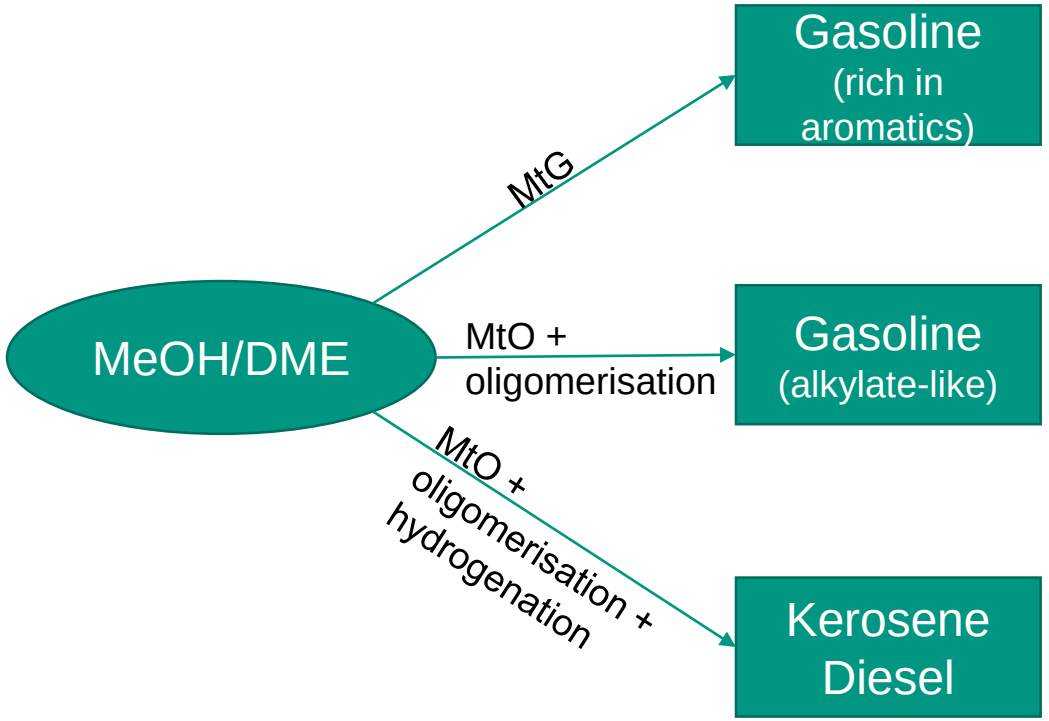
$CO + 2H_2 \leftrightarrow CH_3OH$

$CO_2 + 3H_2 \leftrightarrow CH_3OH + H_2O$

$CO + H_2O \leftrightarrow CO_2 + H_2$

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

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 $Cu/ZnO/Cr_2O_3$

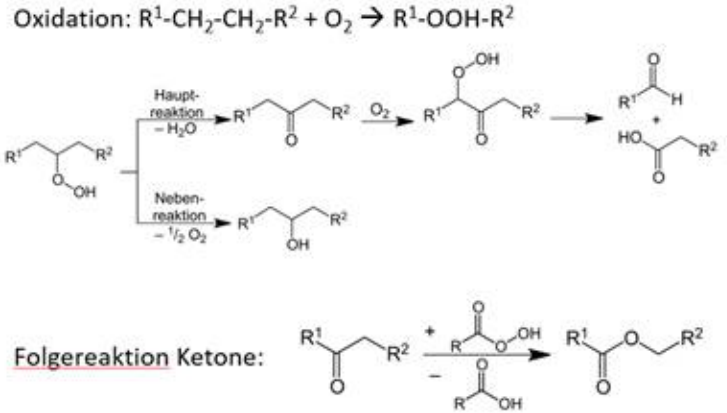
Products from Synthesis Gas (e.g. Sasol)

- Acetate
- Acrylate monomers
- Alkyl benzene
- Alkyl phenol
- C6+ alcohols
- Explosives
- Fertilisers
- Glycol ethers
- Hydrocarbon blends (white spirits)
- Inorganics
- Ketones
- Lacquer thiners
- Light alcohols
- Mining chemicals
- Phenolics or cresylic acids
- Polymers
- Wax
- Argon
- Xenon
- Bitumen
- Fuel oils
- Lubricants

Food and Feed: oils and fats from FT

- Developed in 1935 in Germany by Arthur Imhausen to produce synthetic soap and/or butter from coal
- Production capacity for butter was about 600 t/month
- After WW II the production was stopped and the FT plants were dismantled

- Principle is oxidation of paraffin's
- Byproducts are CO_2, organic acids, peroxides, aldehydes, alcohols
- By combination with glycerin synthetic fats can be produced



Source:
- https://de.wikipedia.org/wiki/Paraffinoxidation
- de Klerk – Continuous-Mode Thermal Oxidation of Fischer-Tropsch Waxes, Ind. Chem. Res. 2003, 42, 25, 6545-6548

Comparison

synthesis	Educts	Ratios	Selectivity	Conversion per pass	Status
MeOH	CO, CO_2, H_2	$SN = \frac{(H_2 - CO_2)}{(CO + CO_2)} \sim 2{,}1$	>99%	~40	Commercial (fossil)
FT	CO, (CO_2), H_2	H_2:CO > 2:1 (Co) H_2:CO ~ 1-2 (Fe)	ASF-distribution	~60 (LT) ~85 (HT)	Commercial (fossil)
Mixed alcohols	CO, CO_2, H_2	H_2:CO ~ 1-2 (MoS)	CH_4 as by product	~10-30	R&D
hydrogen	CO, H_2	-	-	>90	Commercial (fossil)

Nice to have, or a must?

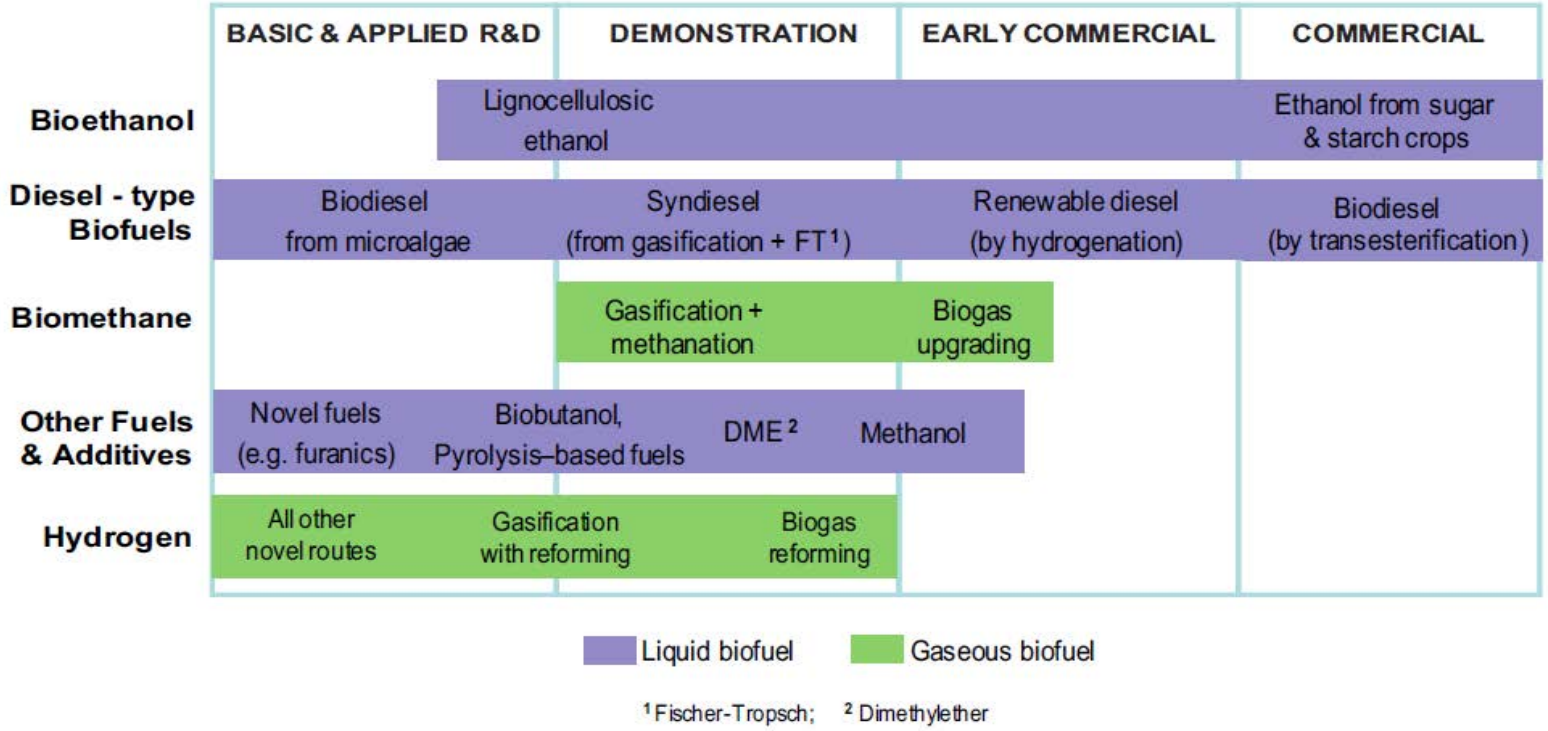
Comparison of combustion of

fossil heating oil

and

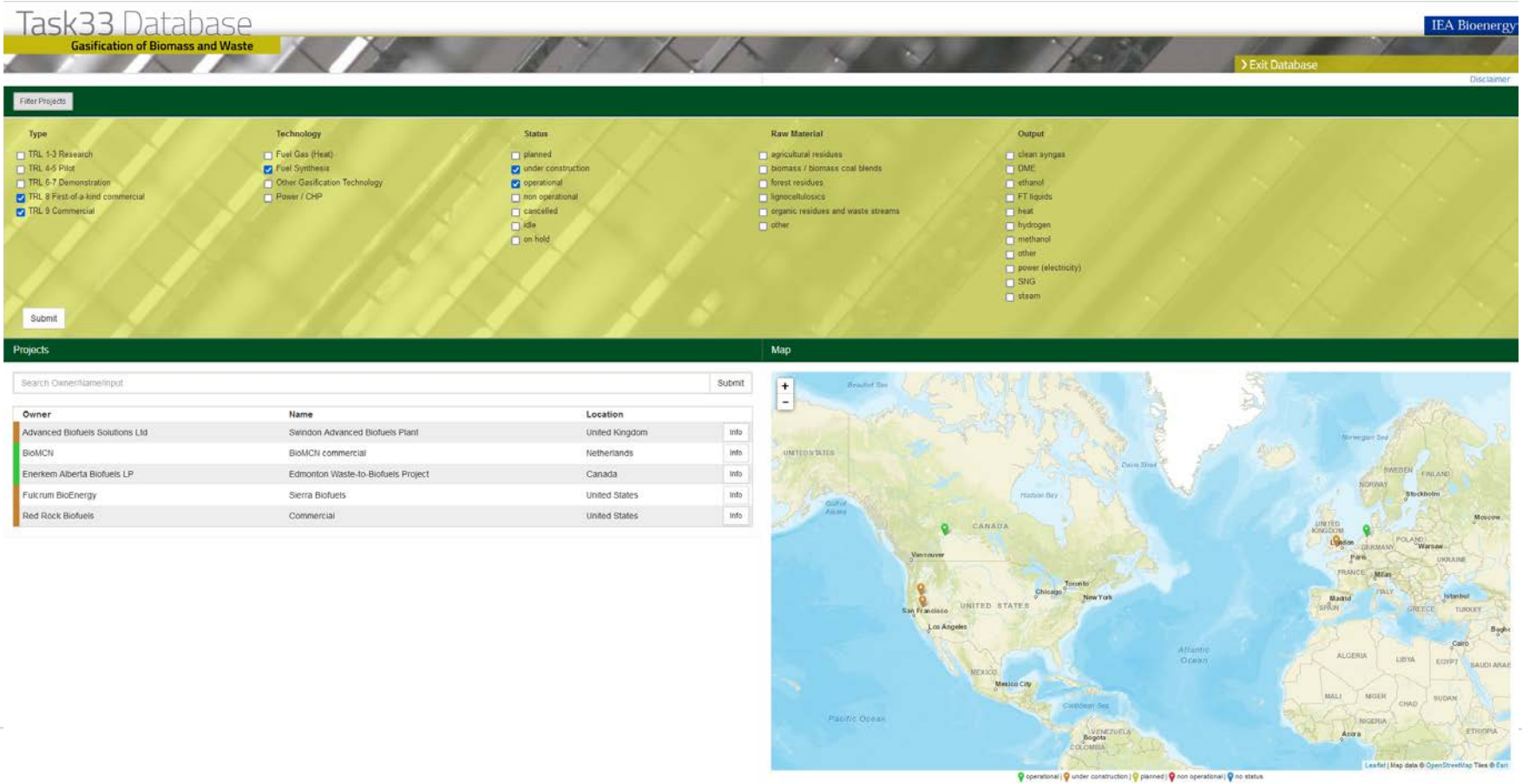
Fischer Tropsch diesel

Development Status

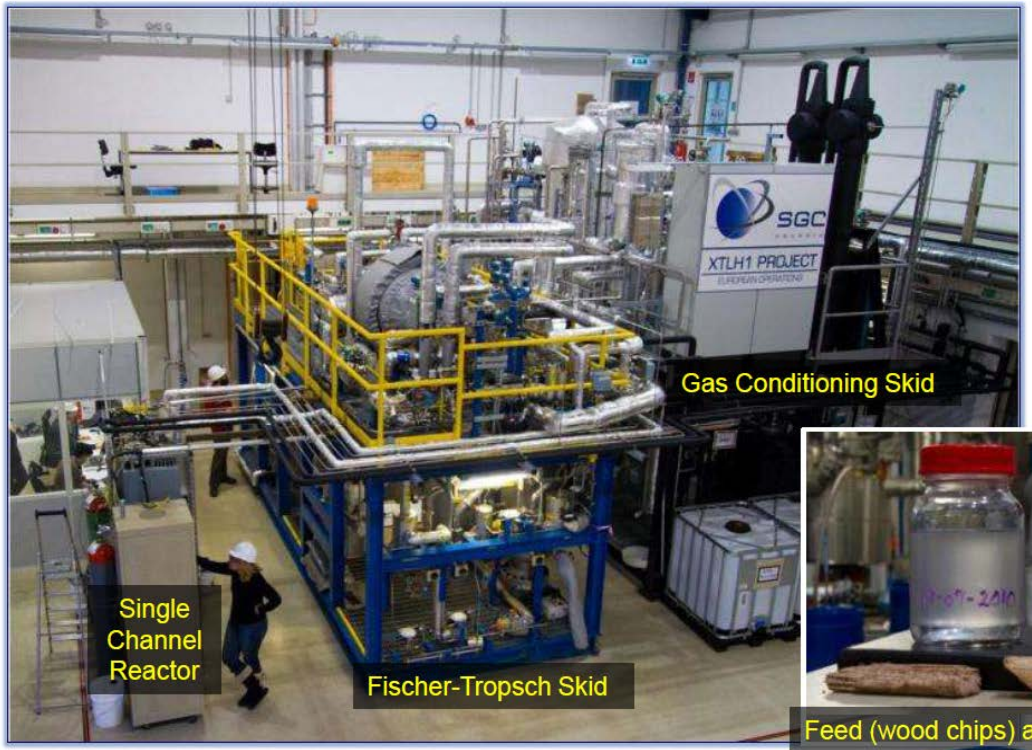


E4tech. 2009. Internal Analysis, www.e4tech.com

Ongoing Projects



2010: SGC Energia Finished Successfully their 1 bpd Demo



Feed (wood chips) and FT Product

OXFORD CATALYSTS
FUELLING A CLEANER WORLD

VELOCYS

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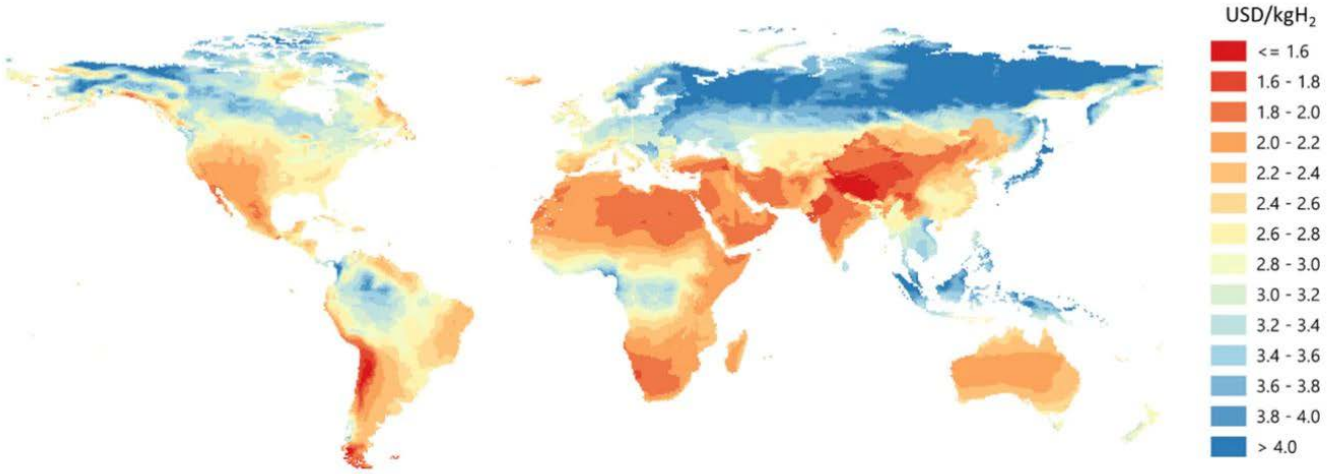
Outlook to the future of hydrogen production

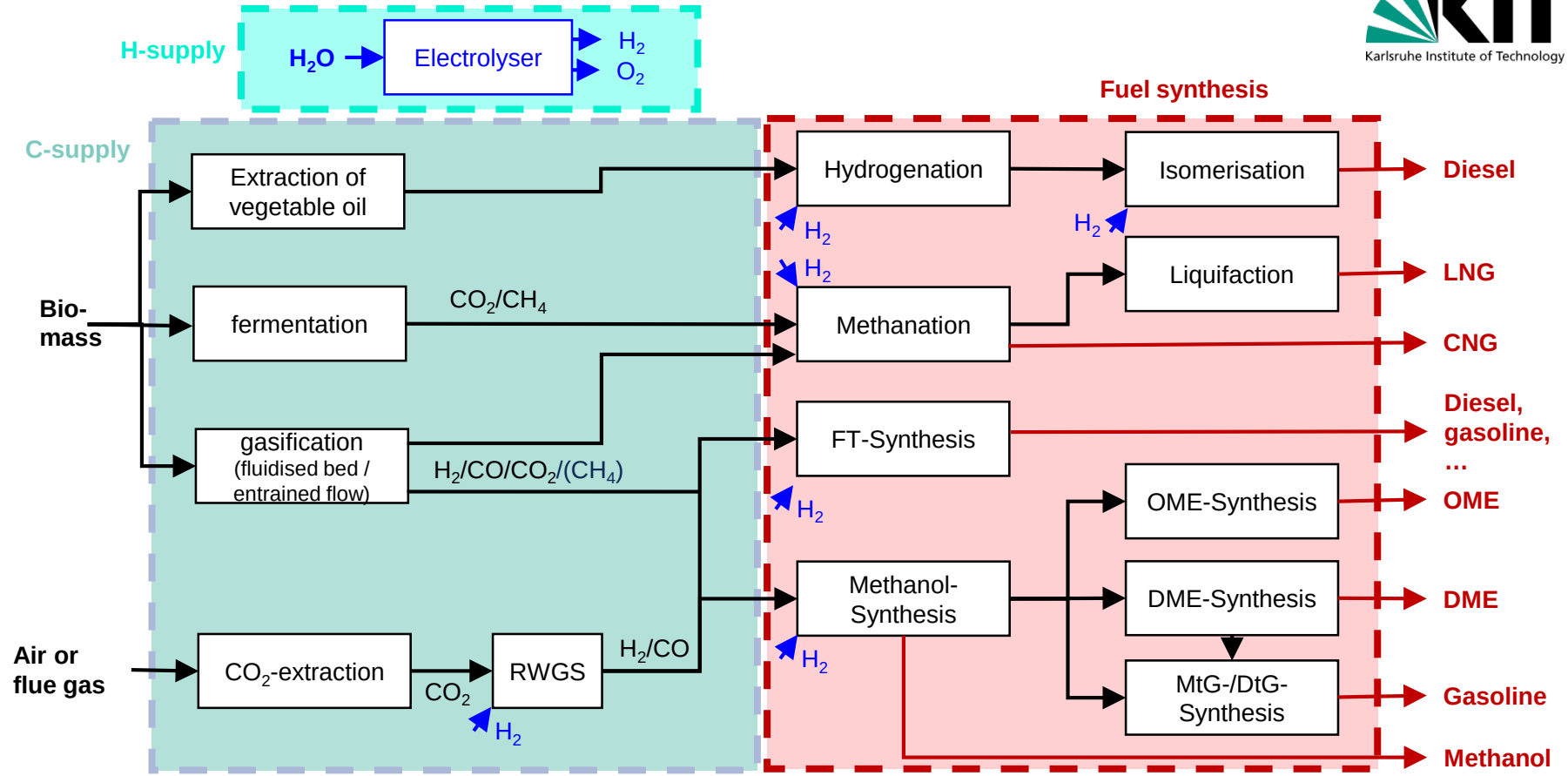
Hydrogen costs from hybrid solar PV and onshore wind systems in the long term



For comparison: H_2 from natural gas had costs of 1-3USD/kgH_2 before the Ukraine crisis

Source: https://www.iea.org/reports/the-future-of-hydrogen (14/01/2022)

Transportation fuels over PtX-Processes



Conclusion

- Synthesis gas conversion for fossil syngas is commercial, for BtL the progress could be better
- Power to Liquids is developing
- 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
- 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 ?

Prof. Dr. Reinhard Rauch

Engler-Bunte-Institute, Fuel Technology
Karlsruhe Institute of Technology
Engler-Bunte-Ring 1, building. 40.51, Room305
D-76131 Karlsruhe

Tel.: +49 721 608-42960
Mobil: +49 174 9675356
Reinhard Rauch@kit edu
http://ceb.ebi.kit.edu