Methanol Synthesis from CO_2

RESEARCH | TECHNOLOGY | CATALYSTS

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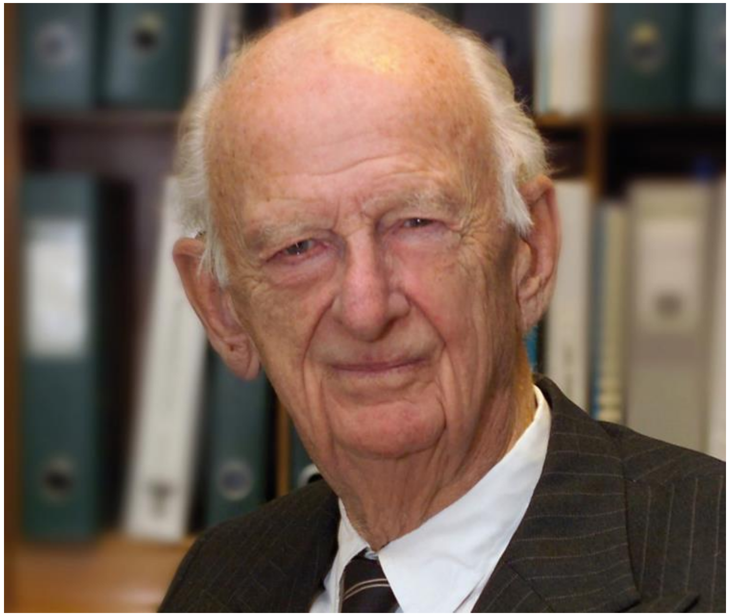
Columbia Unviersity, New York City – April 14, 2014

HALDOR TOPSØE

We have been committed to catalytic process technology for more than 70 years

- Founded in 1940 by Dr. Haldor Topsøe
- Revenue: 700 million Euros
- 2700 employees
- Headquarters in Denmark
- Catalyst manufacture in Denmark and the USA



Topsoe Fuel Cell A/S

- Founded in **2004** after more than 20 years of research and development
- Located in Lyngby, **Denmark** (north of Copenhagen)
- Employees 105
- Development, manufacturing and marketing of the **Solid-Oxide Fuel Cell** technology (SOFC technology)
- Subsidiary of **Haldor Topsøe A/S** (100%)

Topsoe Fuel Cell Employees

Headquarters in Lyngby, Denmark

Supported by funding under the
LIFE Programme
of the European Union

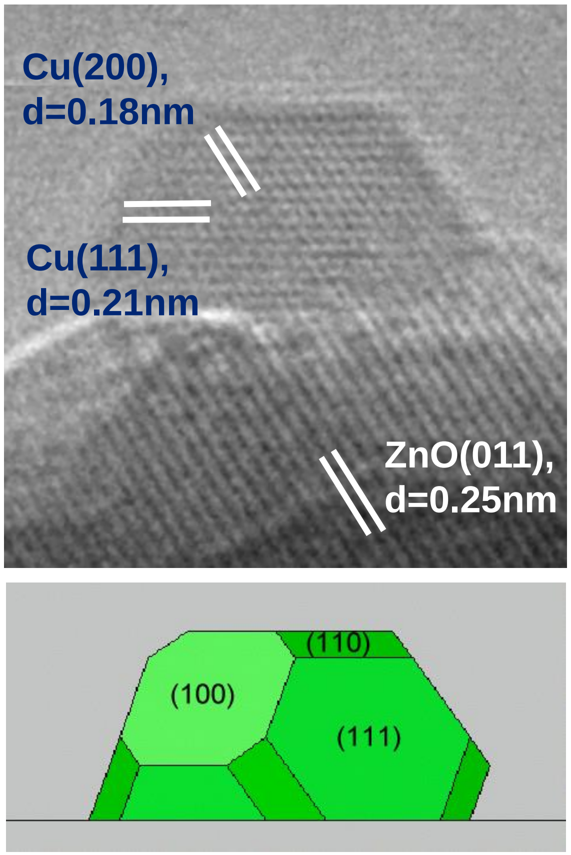
Methanol synthesis

- $CO + 2H_2 = CH_3OH + 91$ kJ/mol
- $CO_2 + 3H_2 = CH_3OH + H_2O + 41$ kJ/mol

$$M = \frac{H_2 - CO_2}{CO + CO_2} = 2$$

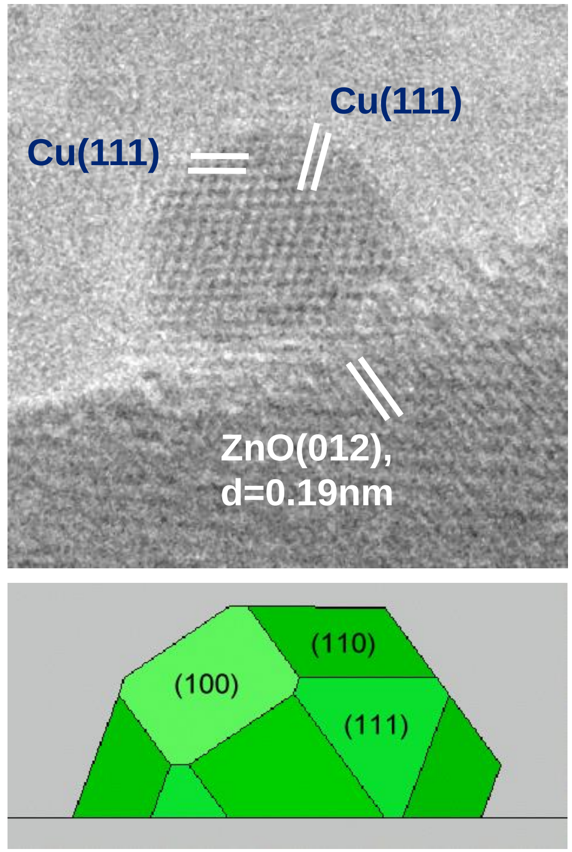
The Active Site of Syngas Catalyst

H_2



1.5mbar, 220ºC

H_2/H_2O

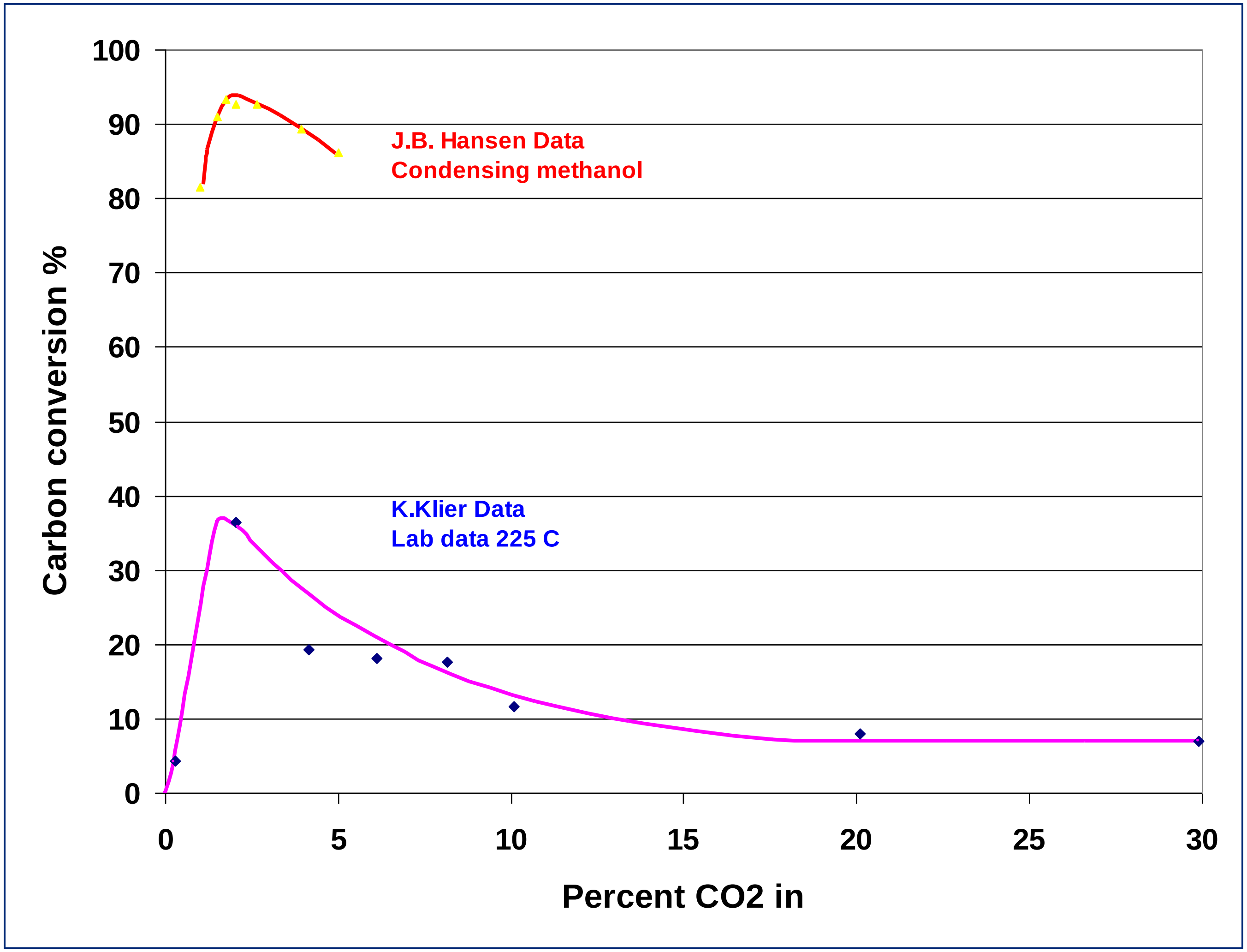


1.5mbar, H_2/H_2O=3/1, 220ºC

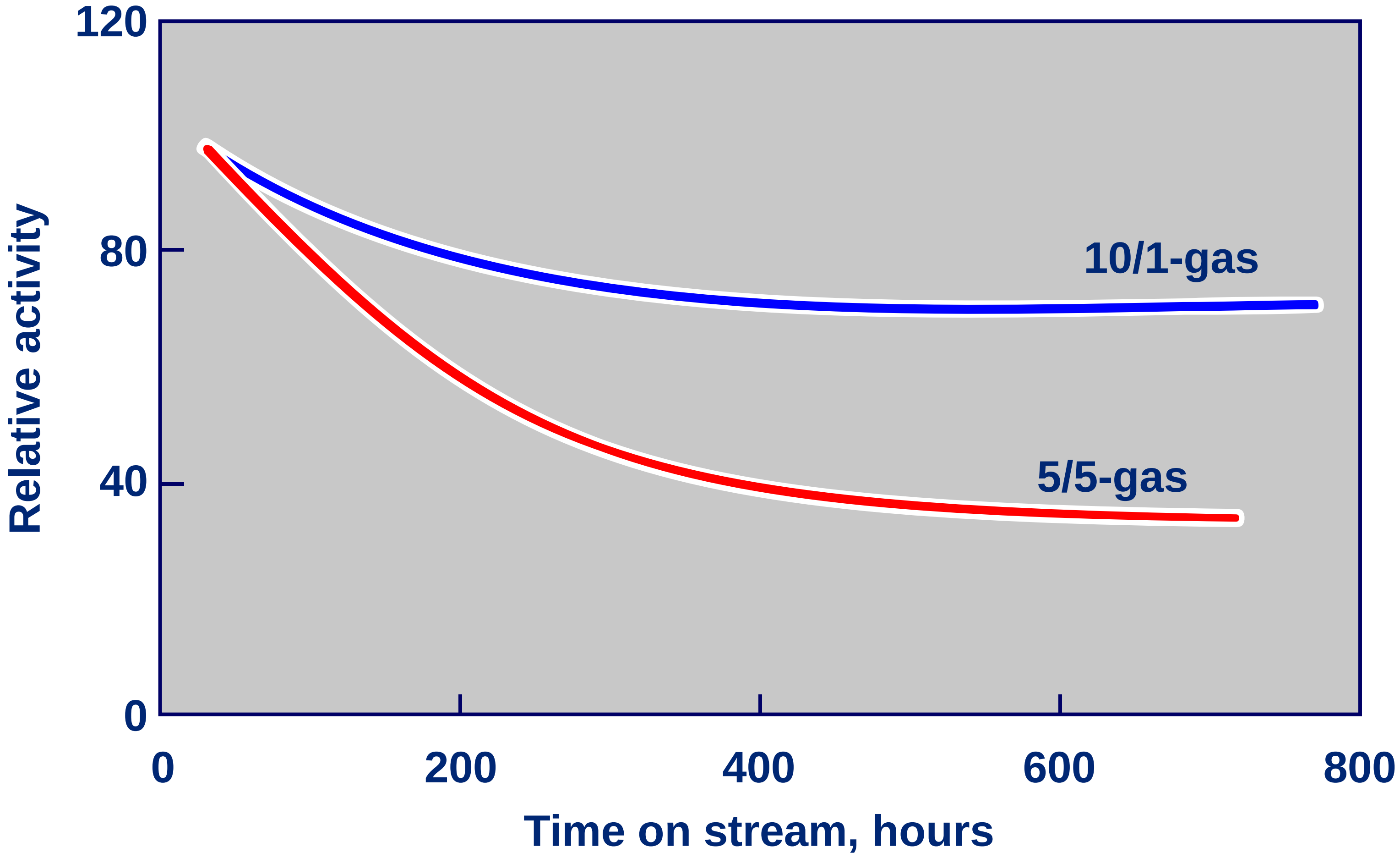
Cu is metallic when catalyzing:
- WGS
- MeOH synthesis
- MeOH reforming

Catalyst dynamic:
- Number of active sites depends on conditions

Conversion of methanol as function of CO_2 content in stoichiometric gas



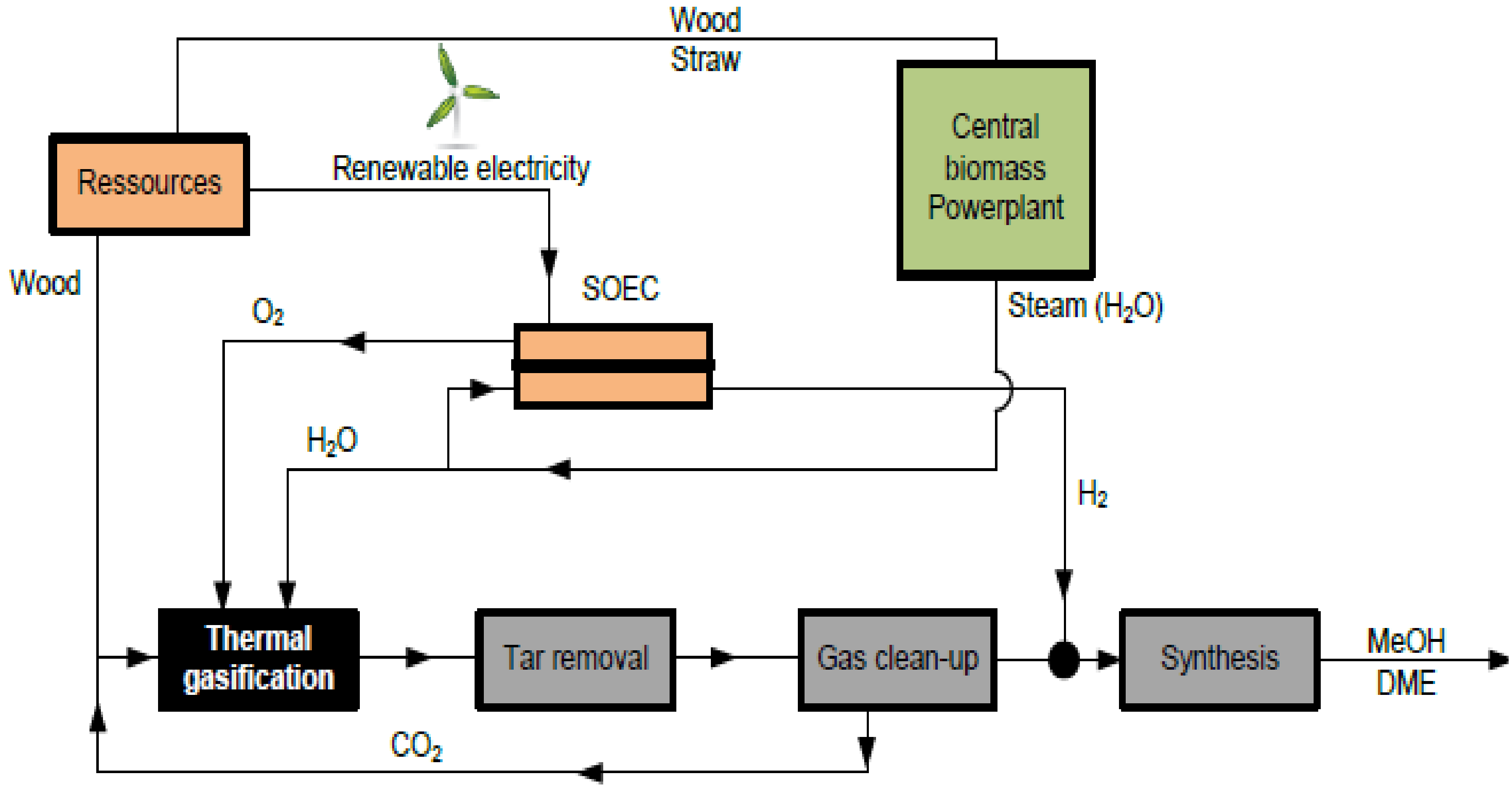
Ageing of methanol catalyst in Normal and Dry Syngas



Reformers for Methanol Plant utilising CO_2

$$\tfrac{3}{4}CH_4 + \tfrac{1}{2}H_2O + \tfrac{1}{4}CO_2 = CH_3OH$$

GreenSynFuel Project



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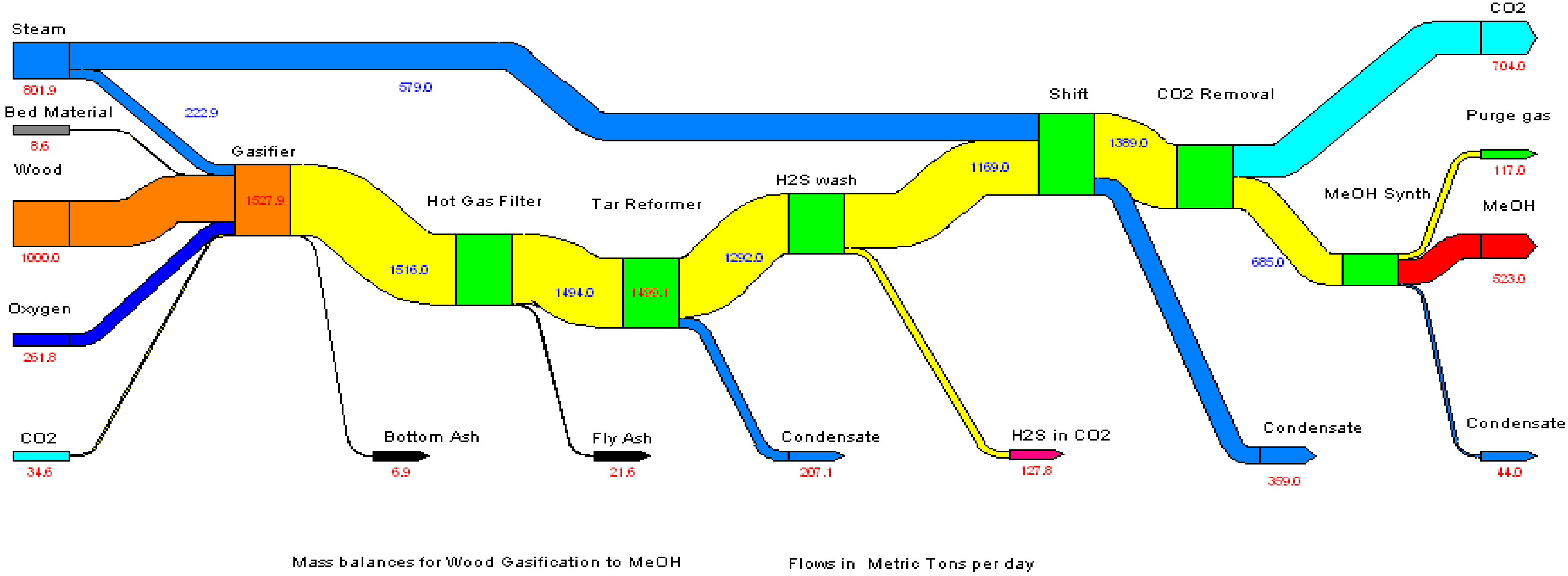
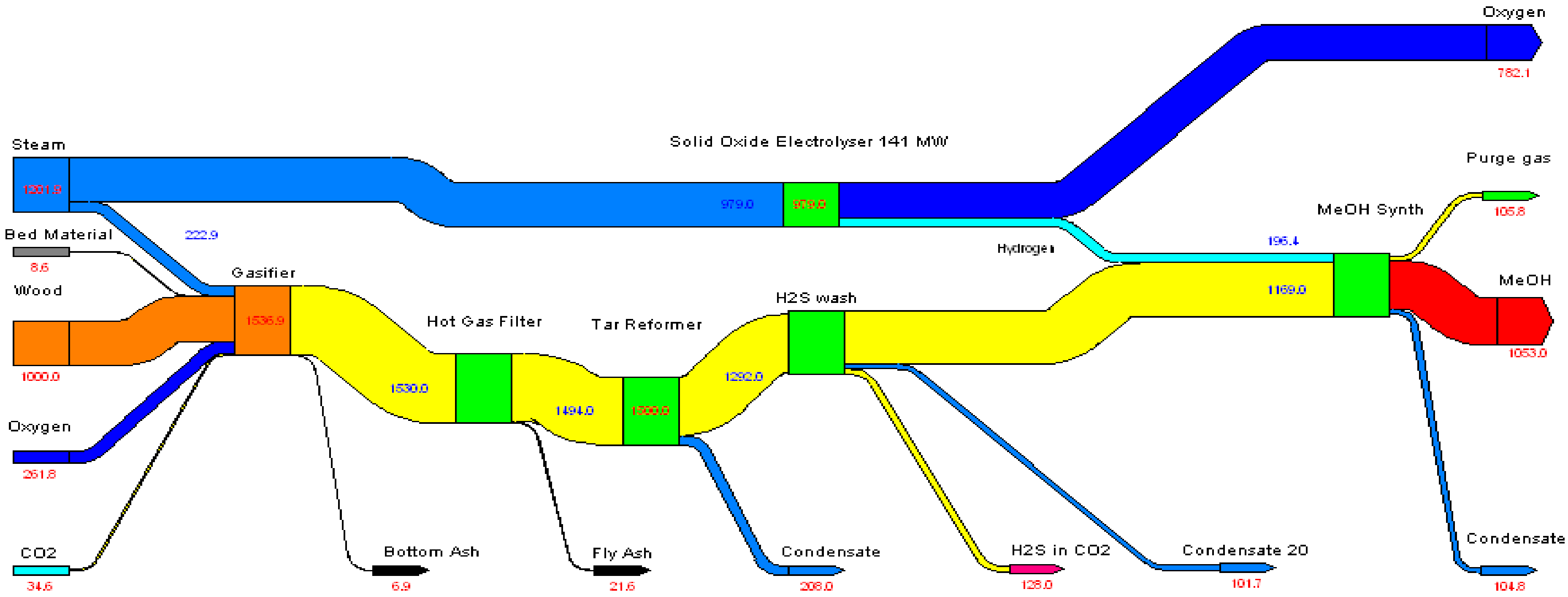
Mass Flows in Wood to MeOH



Mass Flows in Wood + SOEC to MeOH



Mass balances for combined Wood Gasification and SOEC to MeOH

Flows in Metric Tons per day

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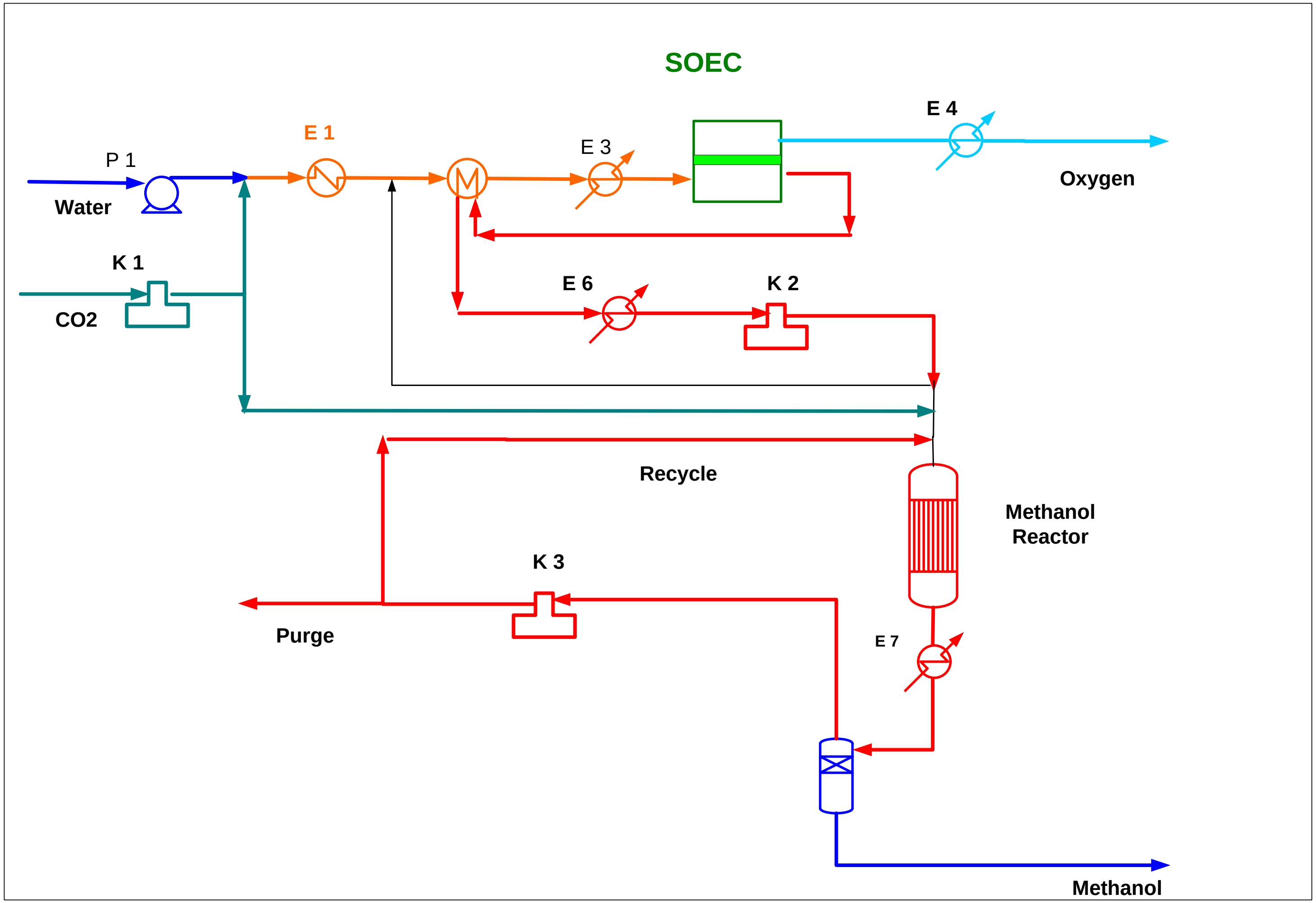
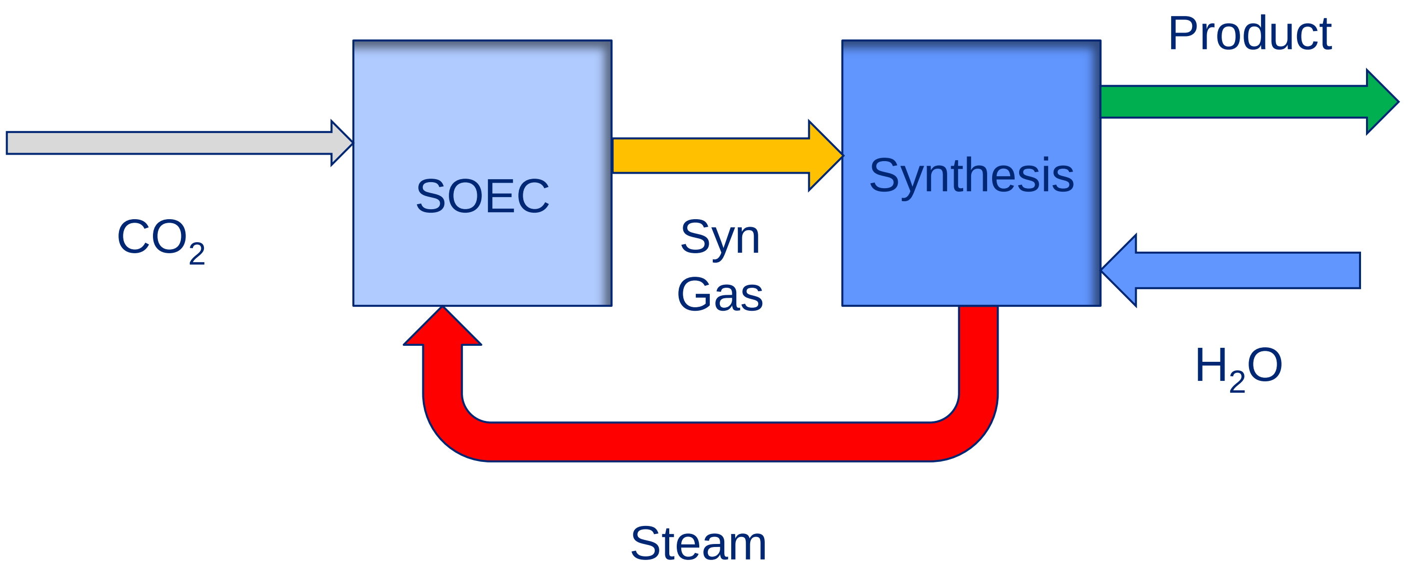
Effciencies: Stand alone wood gasifier and gasifier plus SOEC

LHV Efficiency %	Wood Gasifier alone	Wood gasifier Plus SOEC
Methanol	**59.2**	**70.8**
District Heat	22.6	10.8
Total	81.8	81.6

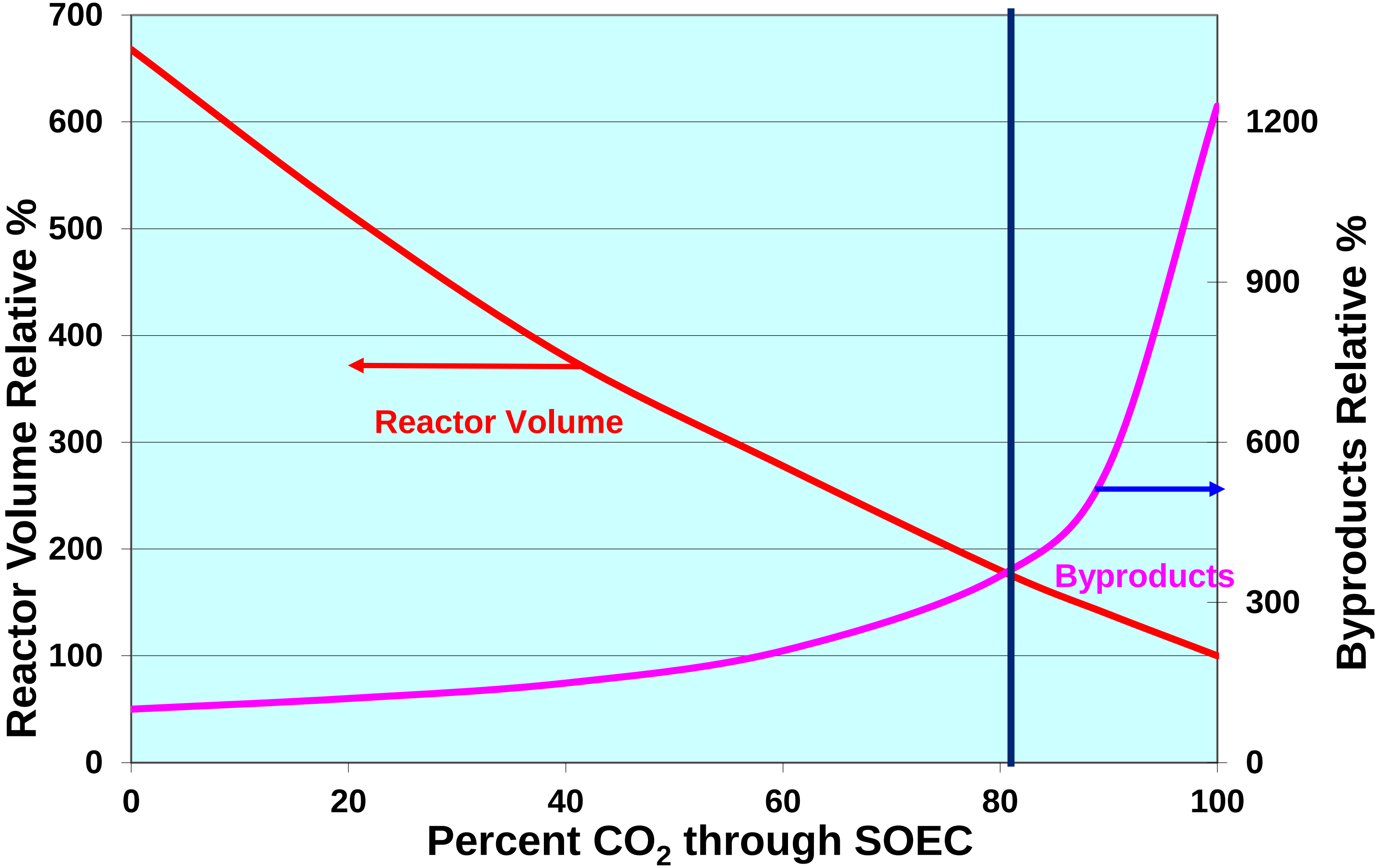
Methanol from CO_2 and Steam



Synergy between SOEC and fuel synthesis



Reactor volume and byproducts as function of CO_2 converted in SOEC



Results of ”to pressurize SOEC stacks or not”

SOEC Pressure		***Syngas Comp %***	***CO2 Comp***	***LHV Efficiency %***
Atmospheric		6.8	0.1	75.8
@50 bar		0.0	1.9	79.5
Max. theoretical				***83-88***

Conclusions

- Very efficient methanol plants based on power, steam and CO_2 is possible via SOEC
- Co-electrolysis offers the opportunity to reduce methanol synthesis catalyst volumes by a factor around 5
- Pressurising the SOEC stacks can eliminate synthesis gas compressor and increase efficiency
- Coupling SOEC with biomass gasification can double the biomass potential by converting excess carbon.