Methanol Production Technology: Todays and future Renewable Solutions

RESEARCH | TECHNOLOGY | CATALYSTS

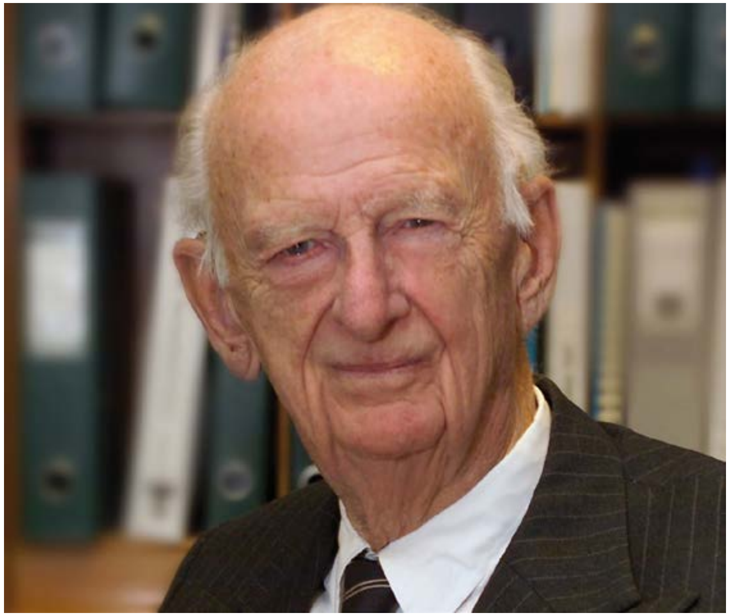
John Bøgild Hansen - Haldor Topsøe

Methanol Workshop, Lund University – March 17, 2015

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
- 2800 employees
- Headquarters in Denmark
- Catalyst manufacture in Denmark and the USA



Topsøe's position in methanol industry

Accumulated capacity, MTPD: [illegible]

Number of plants: [illegible]

Number of catalyst charges: [illegible]

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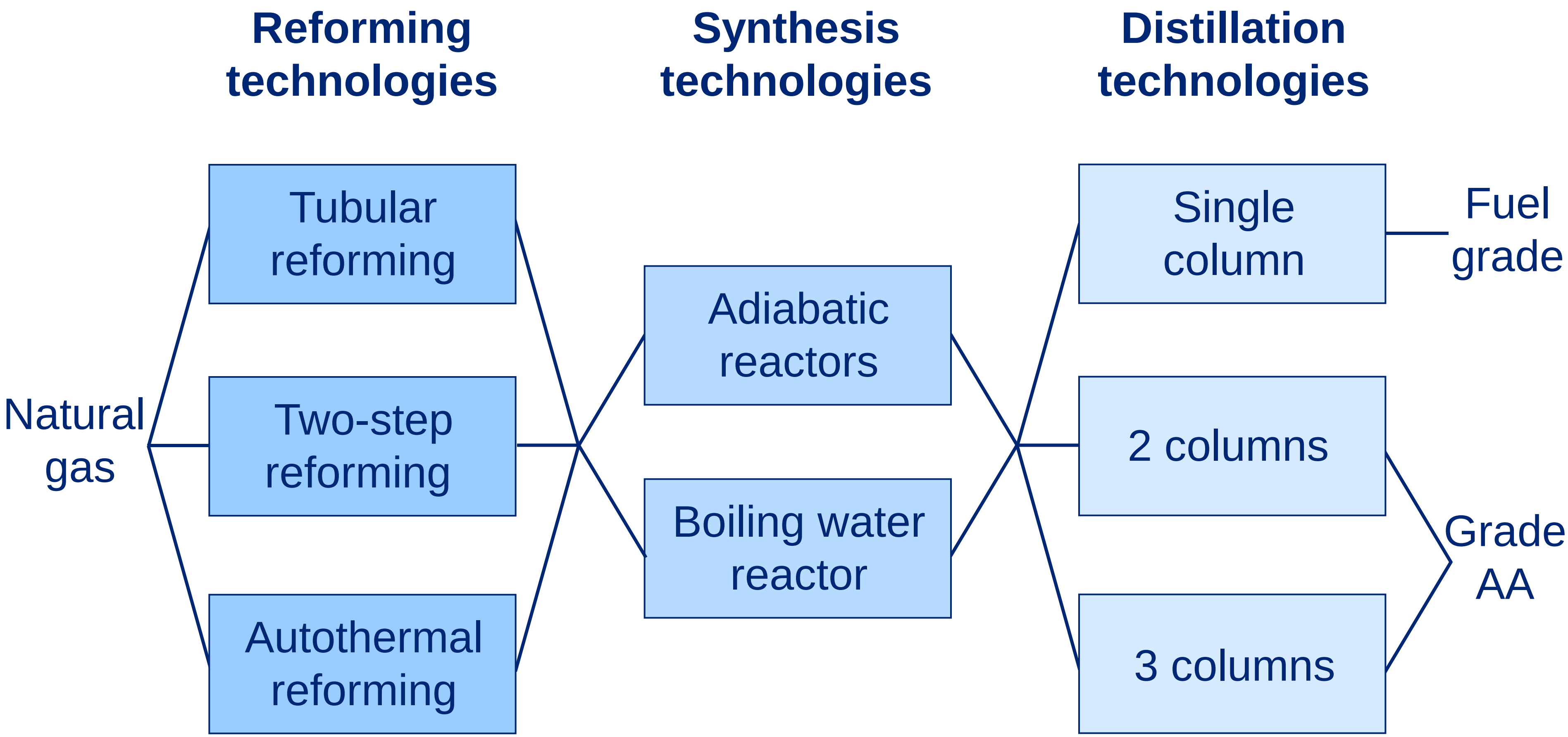
Methanol synthesis

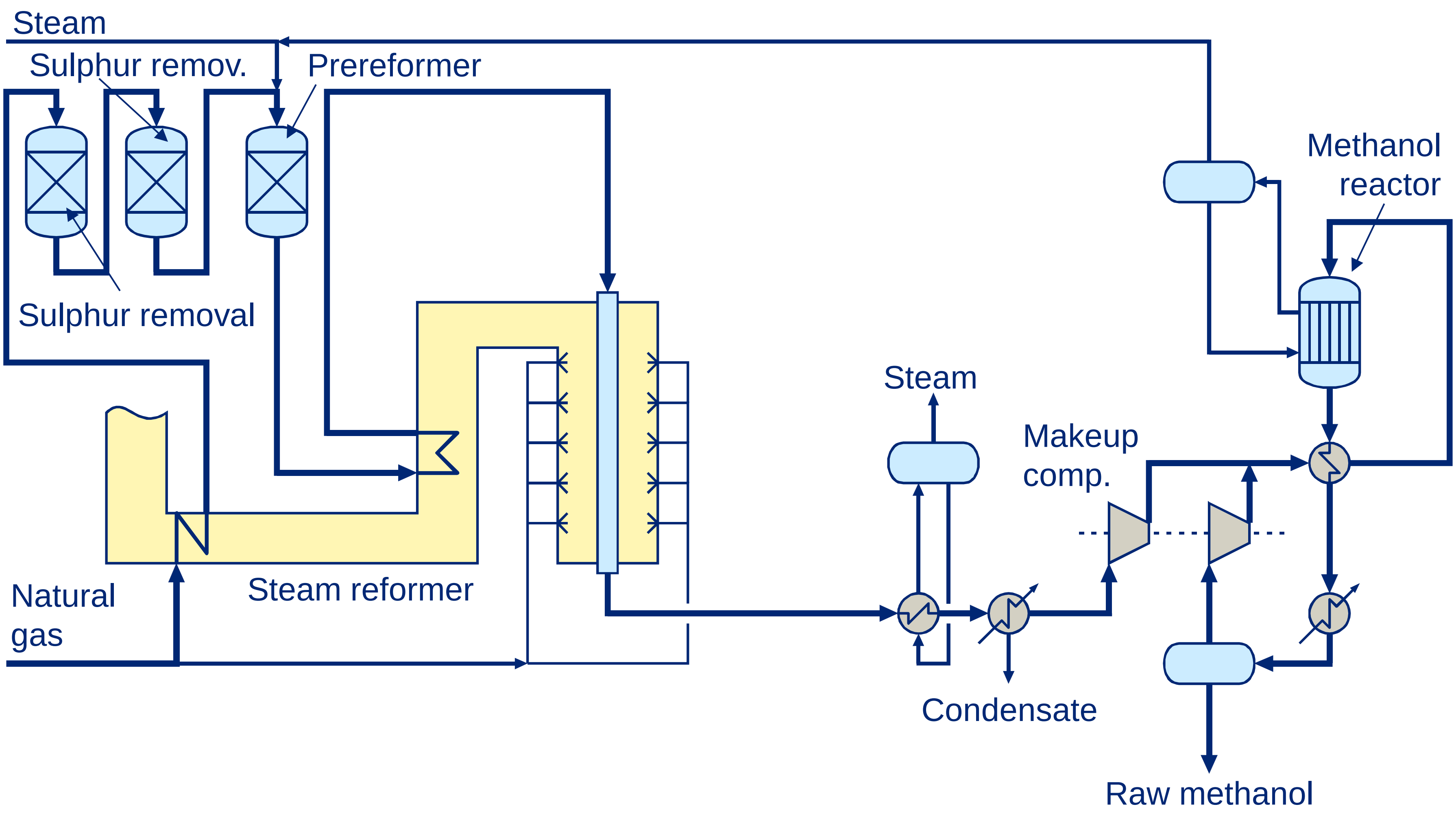
- $CO + 2H_2 = CH_3OH + 91$ kJ/mol
- $CO_2 + 3H_2 = CH_3OH + H_2O + 41$ kJ/mol

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

Topsøe technologies for shale gas based methanol plants



Methanol production by one-step reforming



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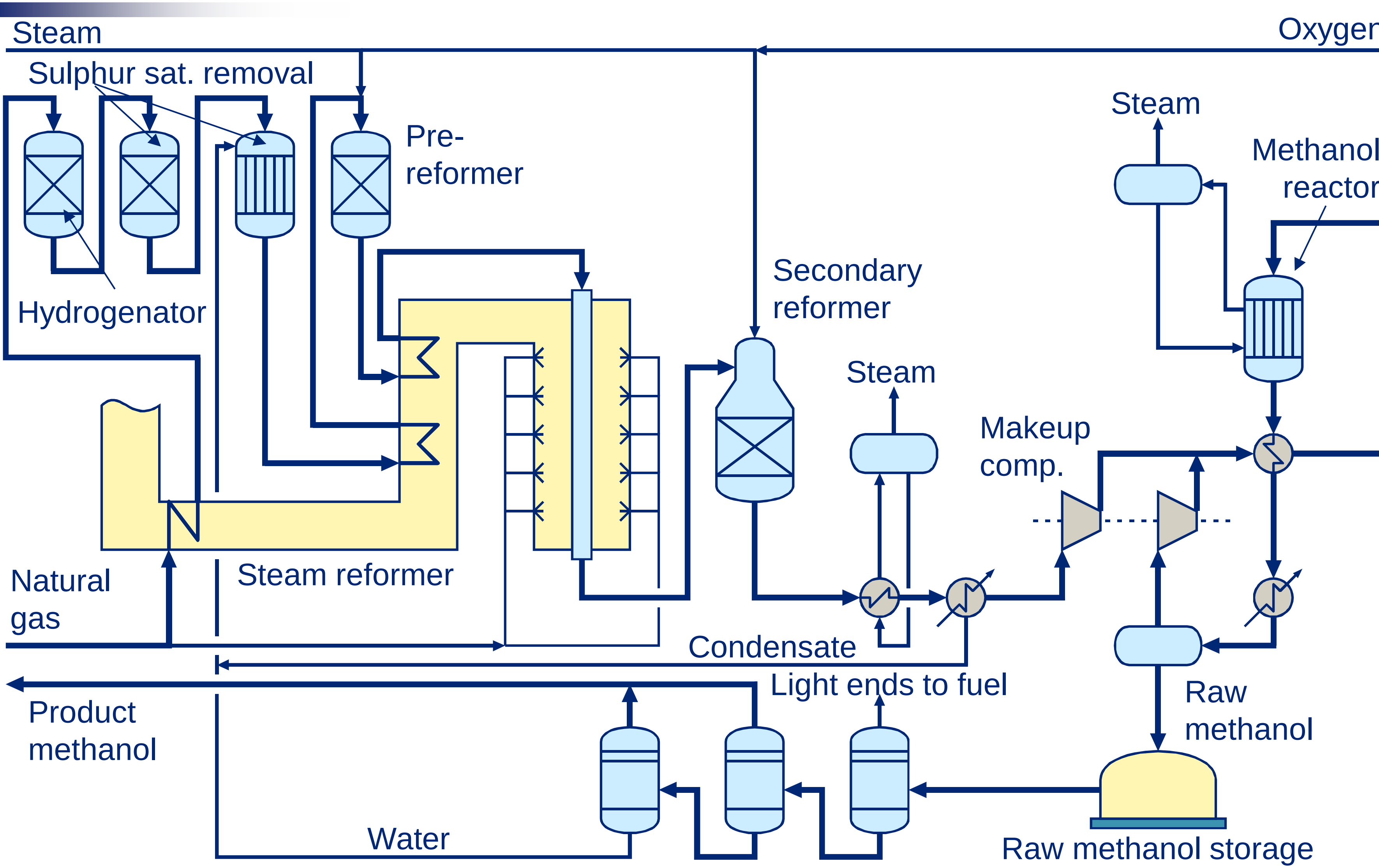
Methanol production by two-step reforming



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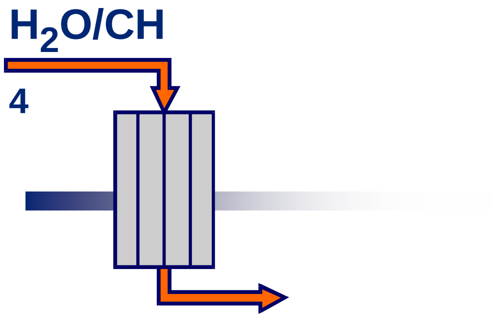
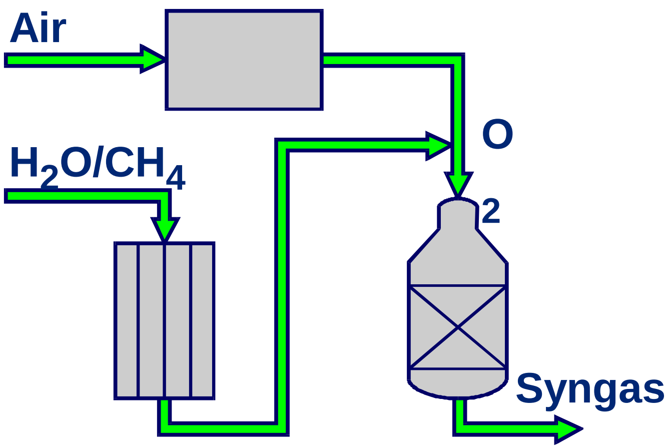
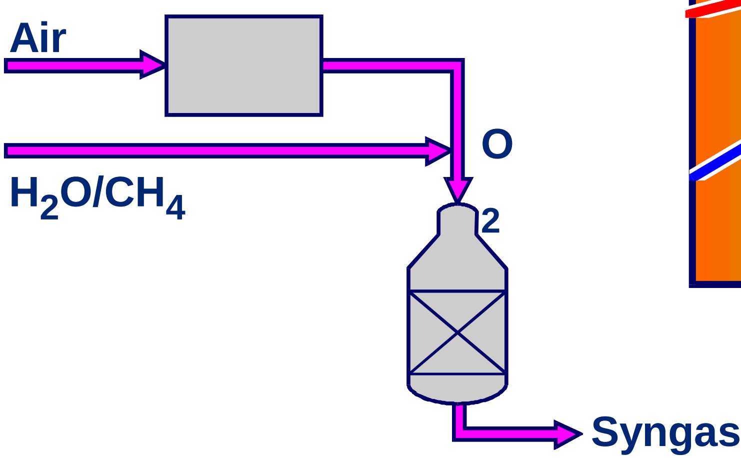
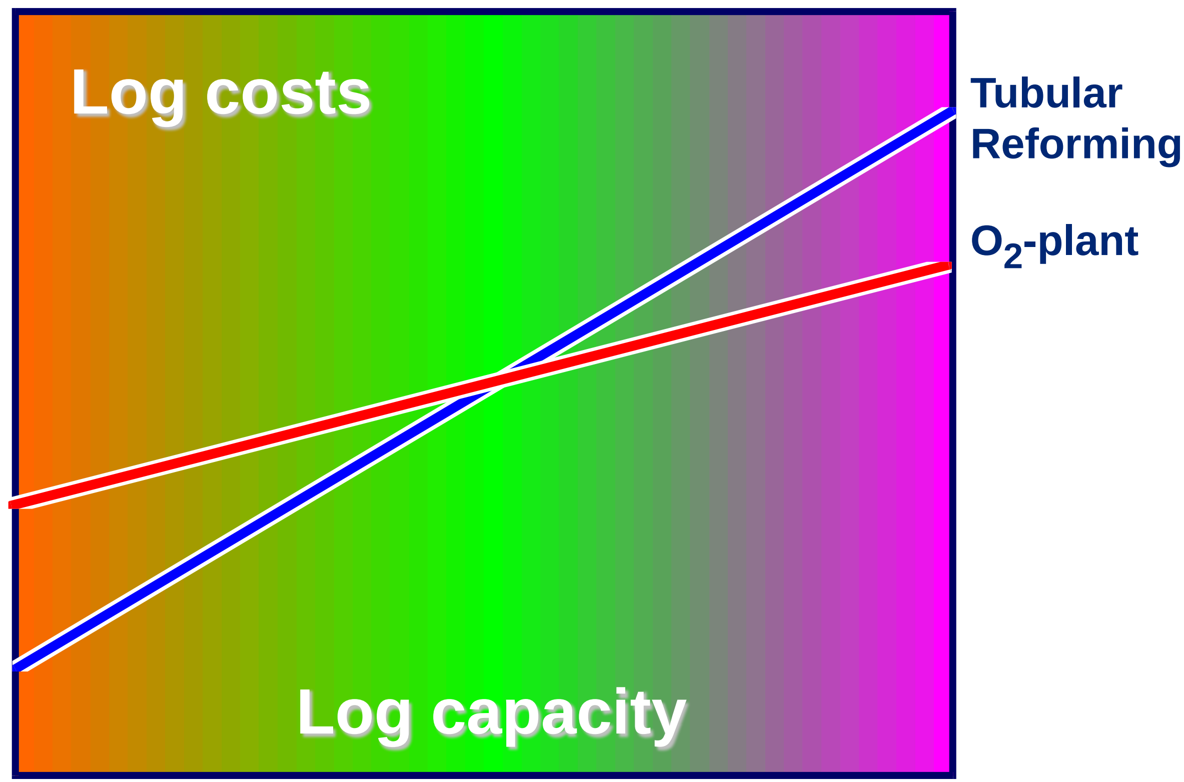
Economy of scale





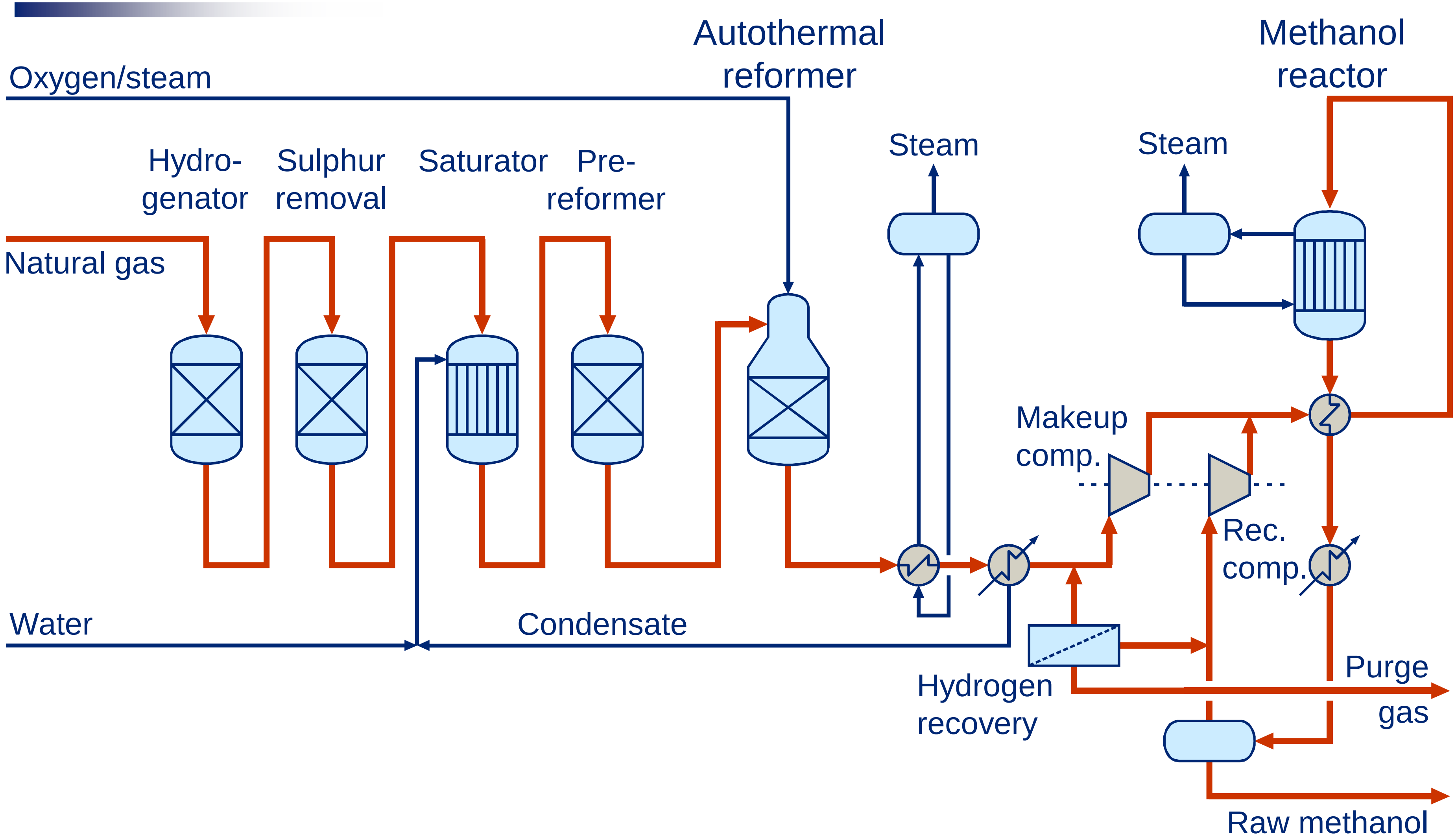




Tubular reformer for methanol plant based on two-step reforming

Topsøe boiling water cooled methanol reactors at Bandar Imam, Iran

Methanol production by ATR



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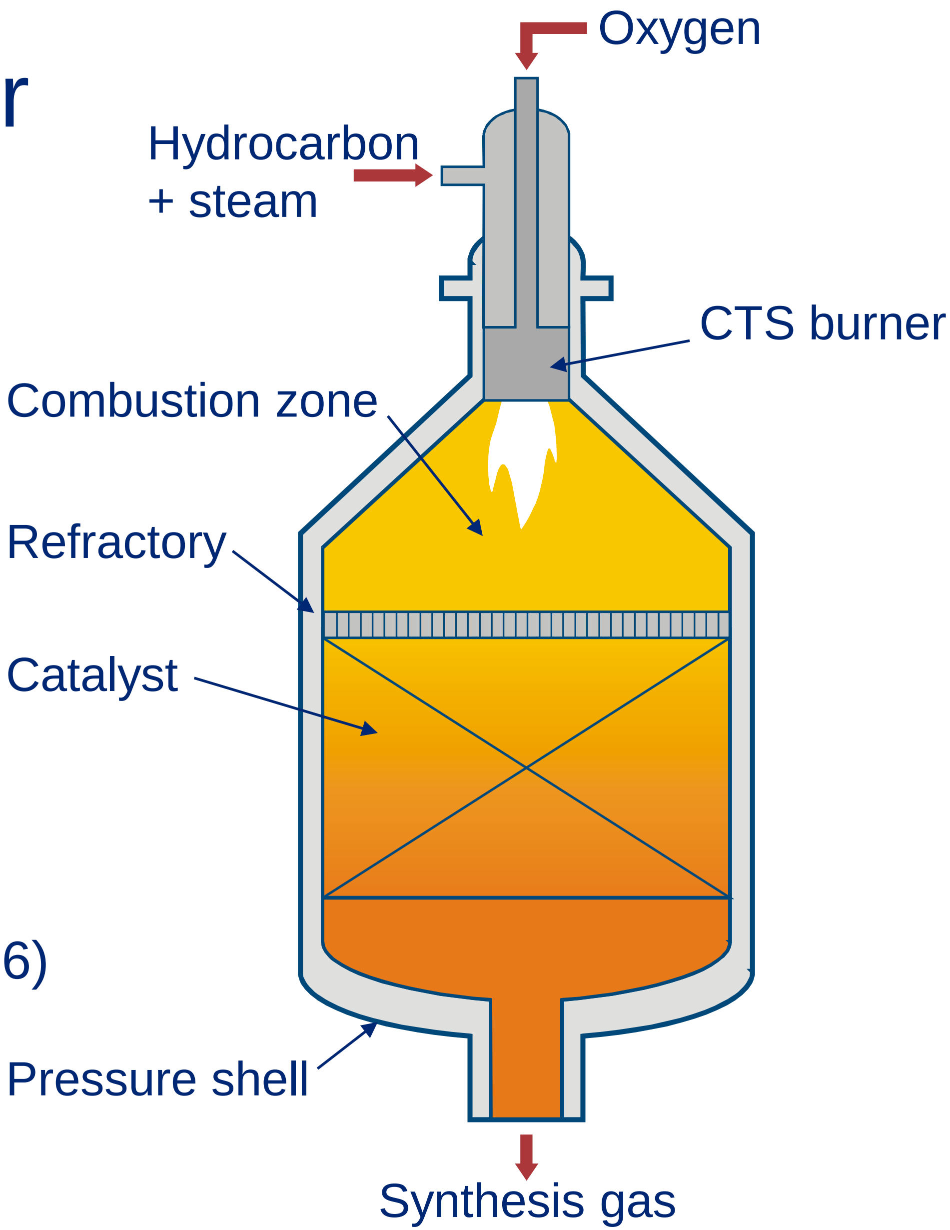
Topsøe ATR reactor

- Large single line capacity
- Economic of scale
- Soot-free process
- In industrial operation
- Low steam to carbon (S/C < 0.6)



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Projects using ATR for synthesis gas generation

- Oryx, Qatar (GTL)
  34,000 BPD
- Escravos, Nigeria (GTL)
  34,000 BPD
- Viva, Nigeria (methanol)
  10,000 MTPD
- Sasolburg, South Africa (syngas)
  2 x 215,000 Nm3/h

Industrial benefits

Industrial experience

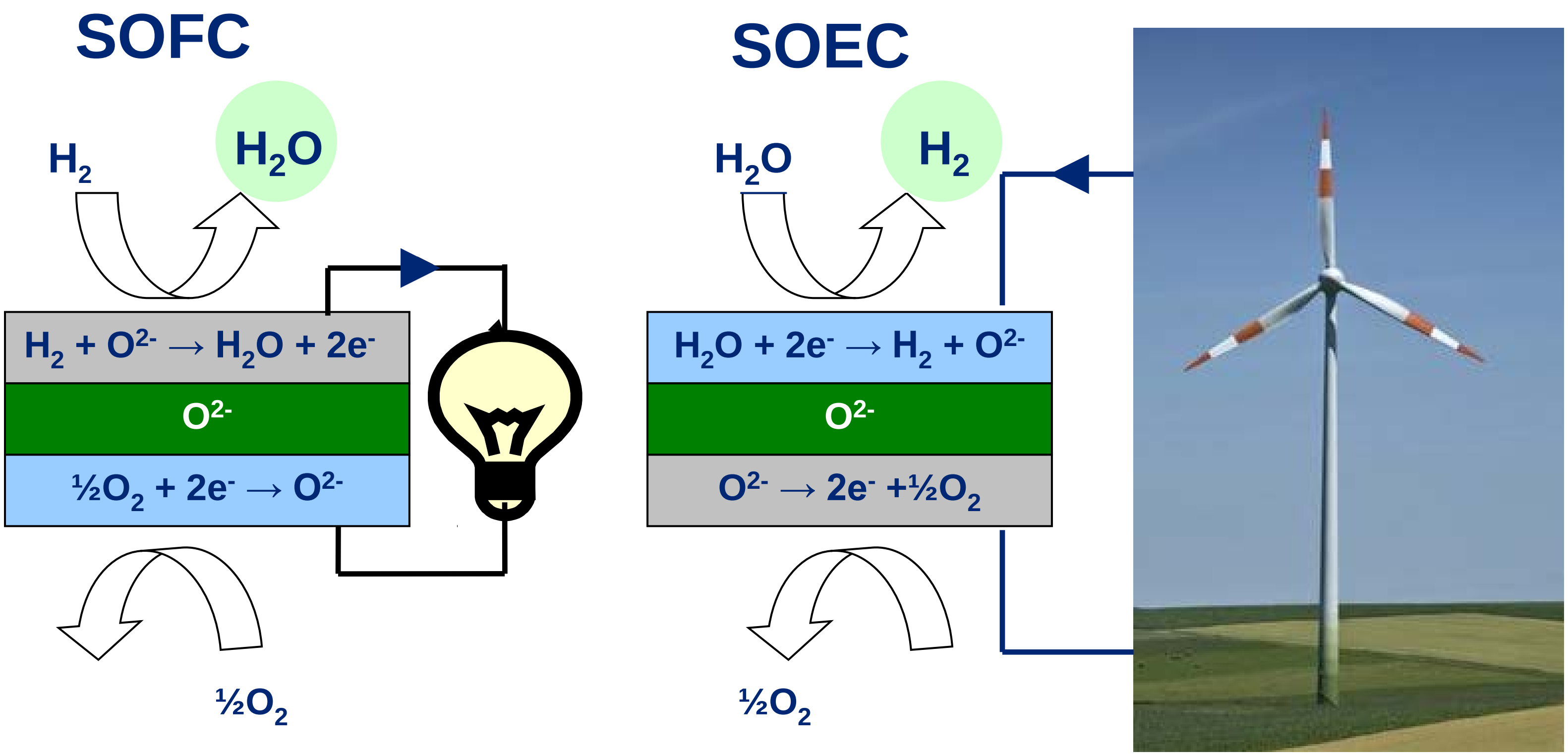
Statoil, Norway, 2500 MTPD
28.8 GJ/MT => 69 % effeiciency

- Increased loop efficiency
  - Production gain
  - Inc
  - Lo
- Longe
  - Le
  - Inc

Reformers for Methanol Plant utilising CO_2

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

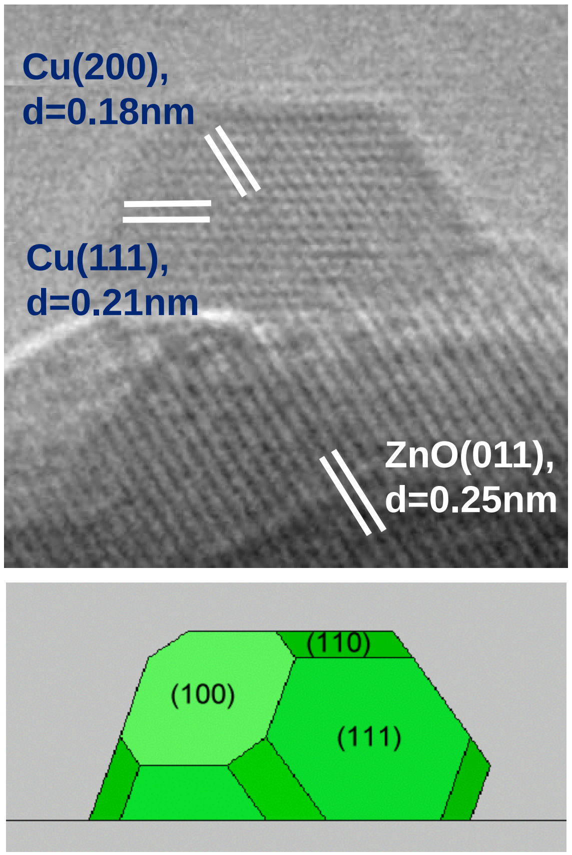
Fuel Cell and Electrolyser



$$H_2 + CO + O_2 \underset{\text{SOEC}}{\overset{\text{SOFC}}{\rightleftarrows}} H_2O + CO_2 + \text{electric energy } (\Delta G) + \text{heat } (T\Delta S)$$

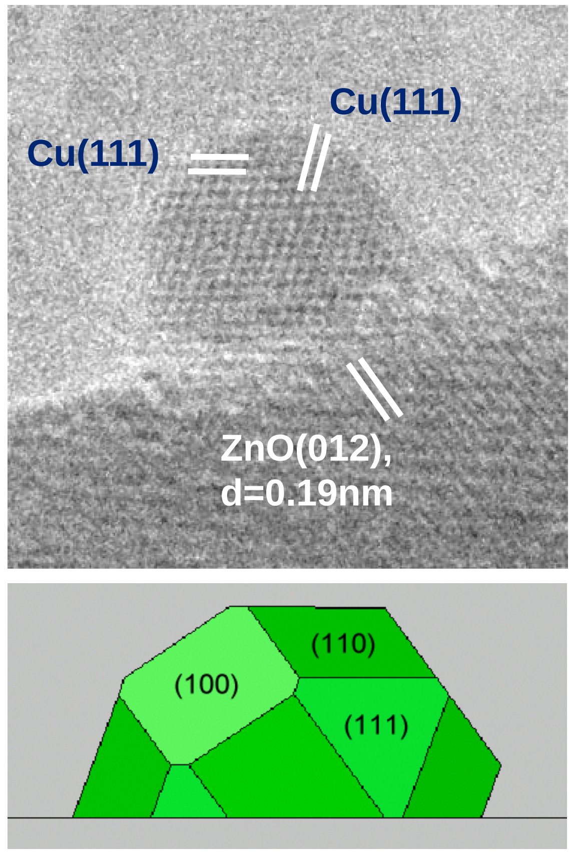
The Active Site of Syngas Catalyst

H_2



1.5mbar, 220°C

H_2/H_2O

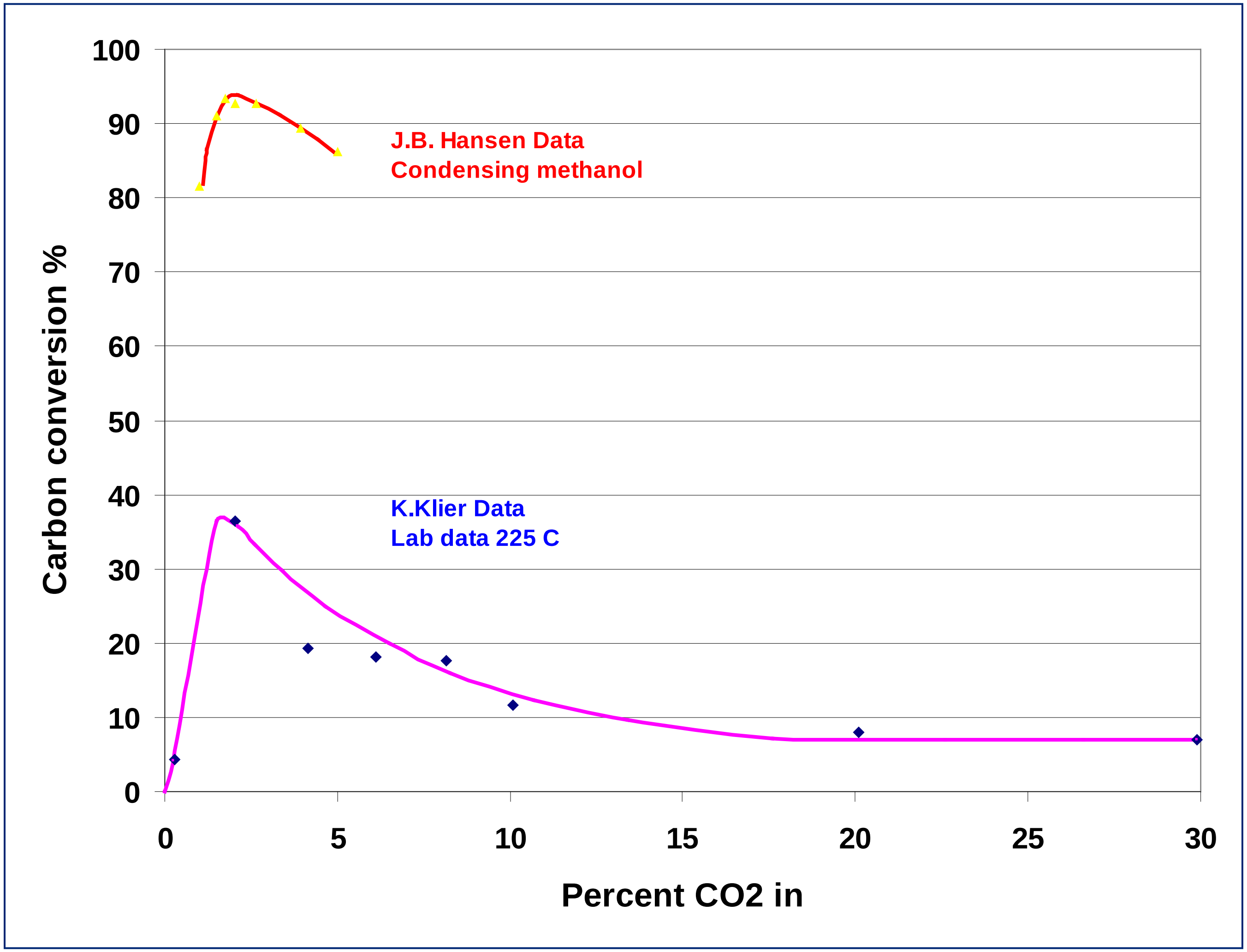


1.5mbar, H_2/H_2O=3/1, 220°C

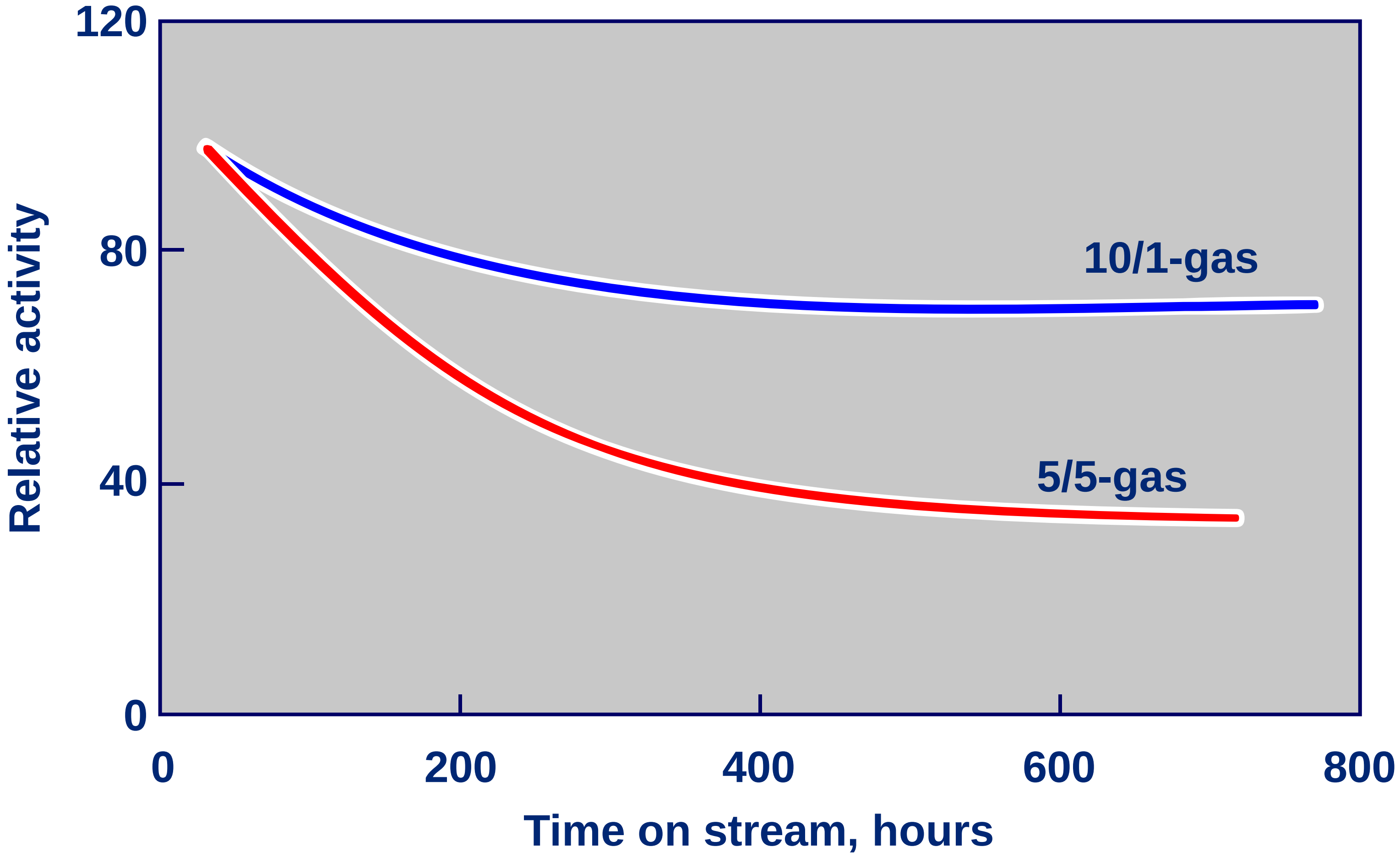
Cu is metallic when catalyzing:
- **WGS**
- **MeOH synthesis**
- **MeOH reforming**

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



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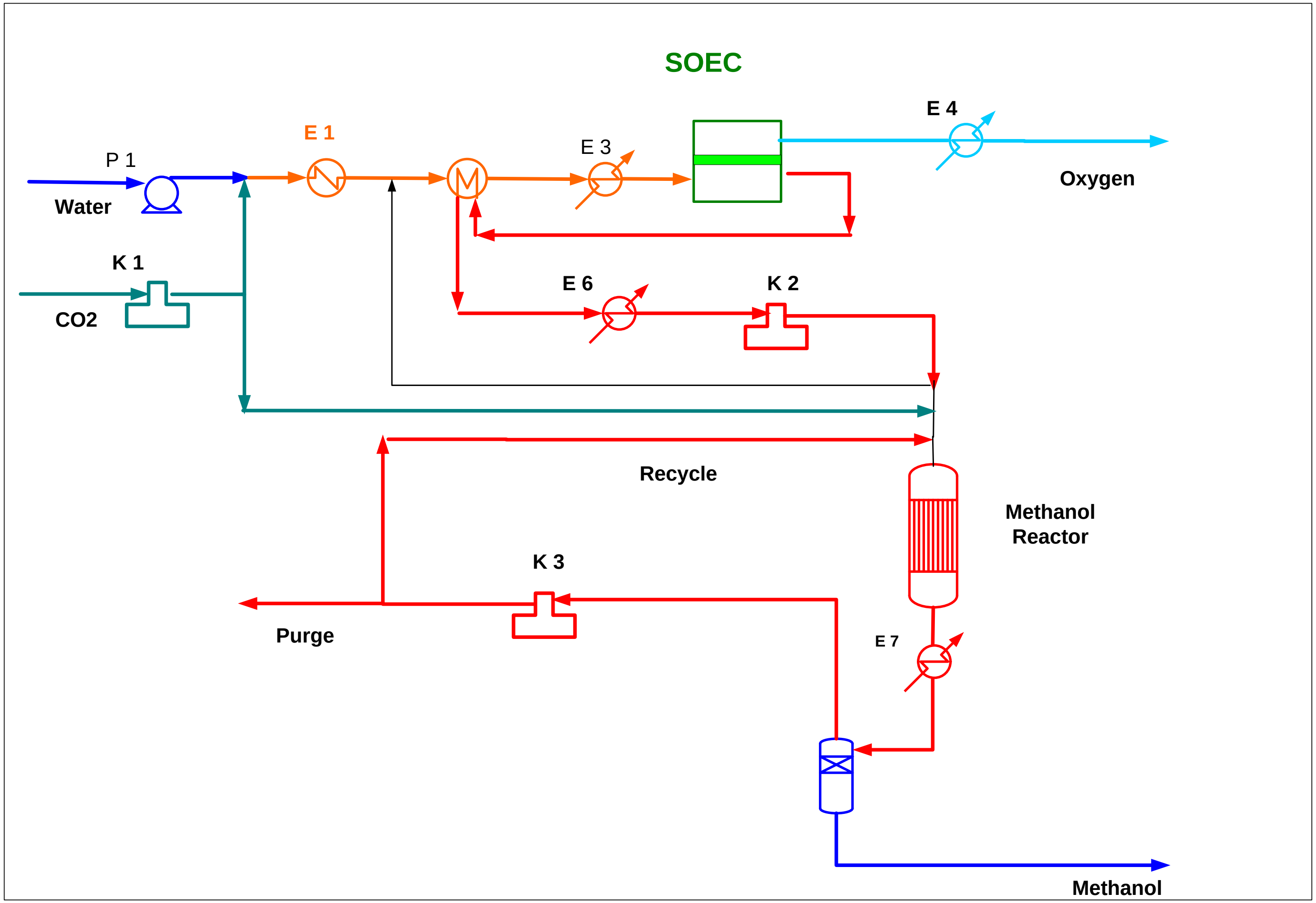
Methanol from CO_2 and Steam



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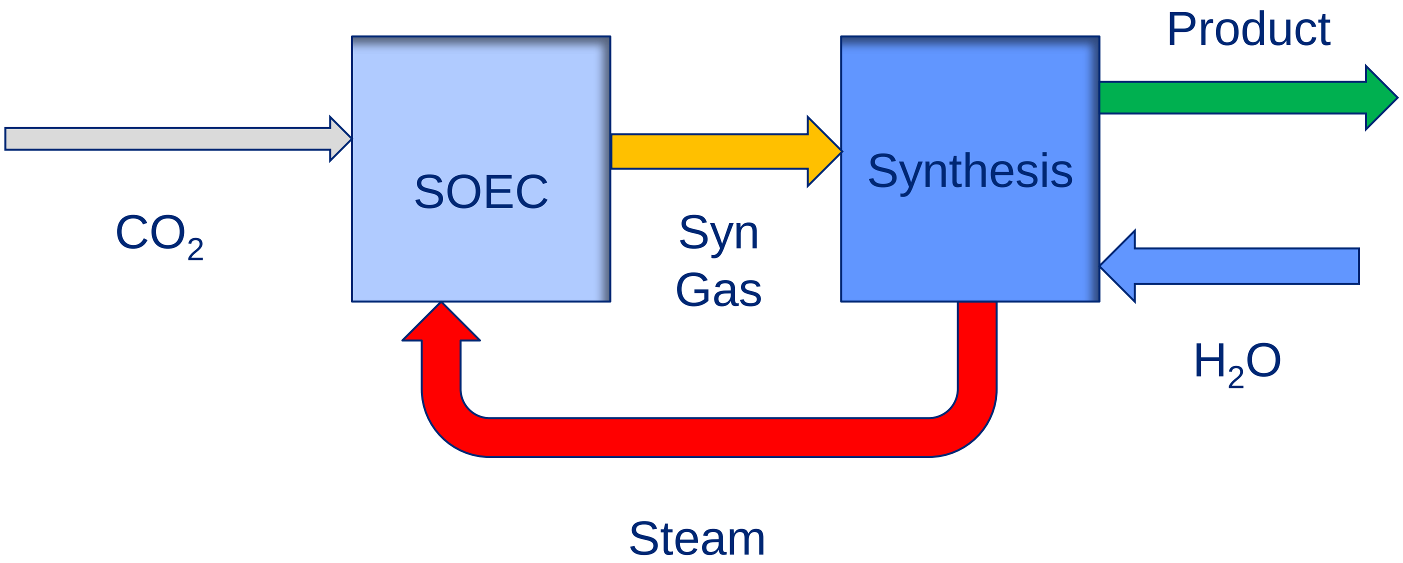
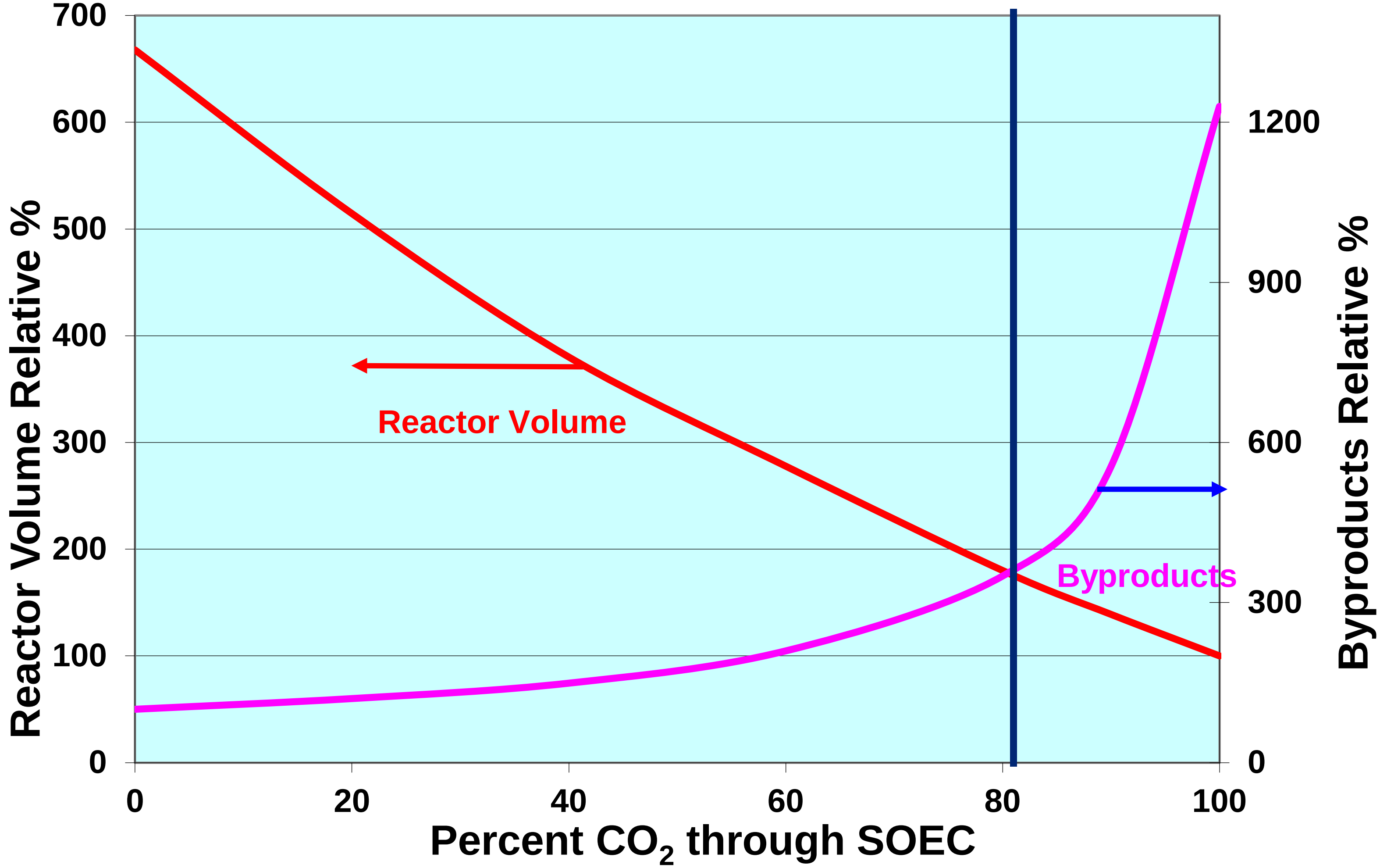
Synergy between SOEC and fuel synthesis

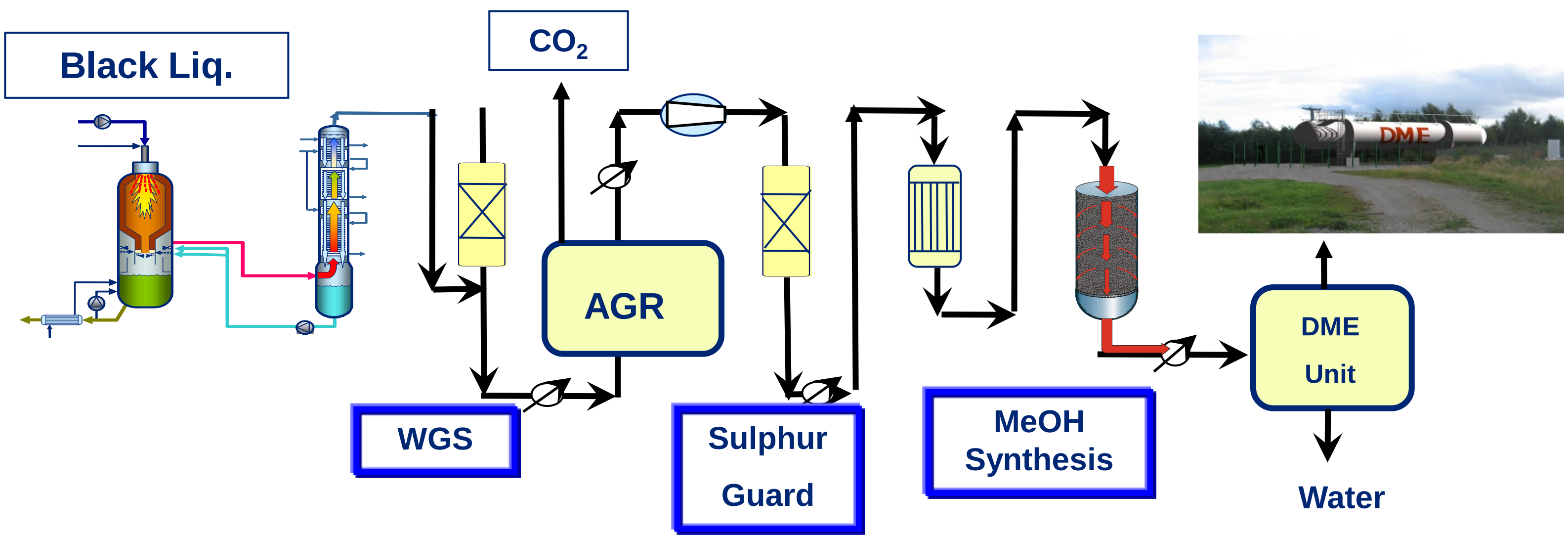


Reactor volume and byproducts as function of CO_2 converted in SOEC

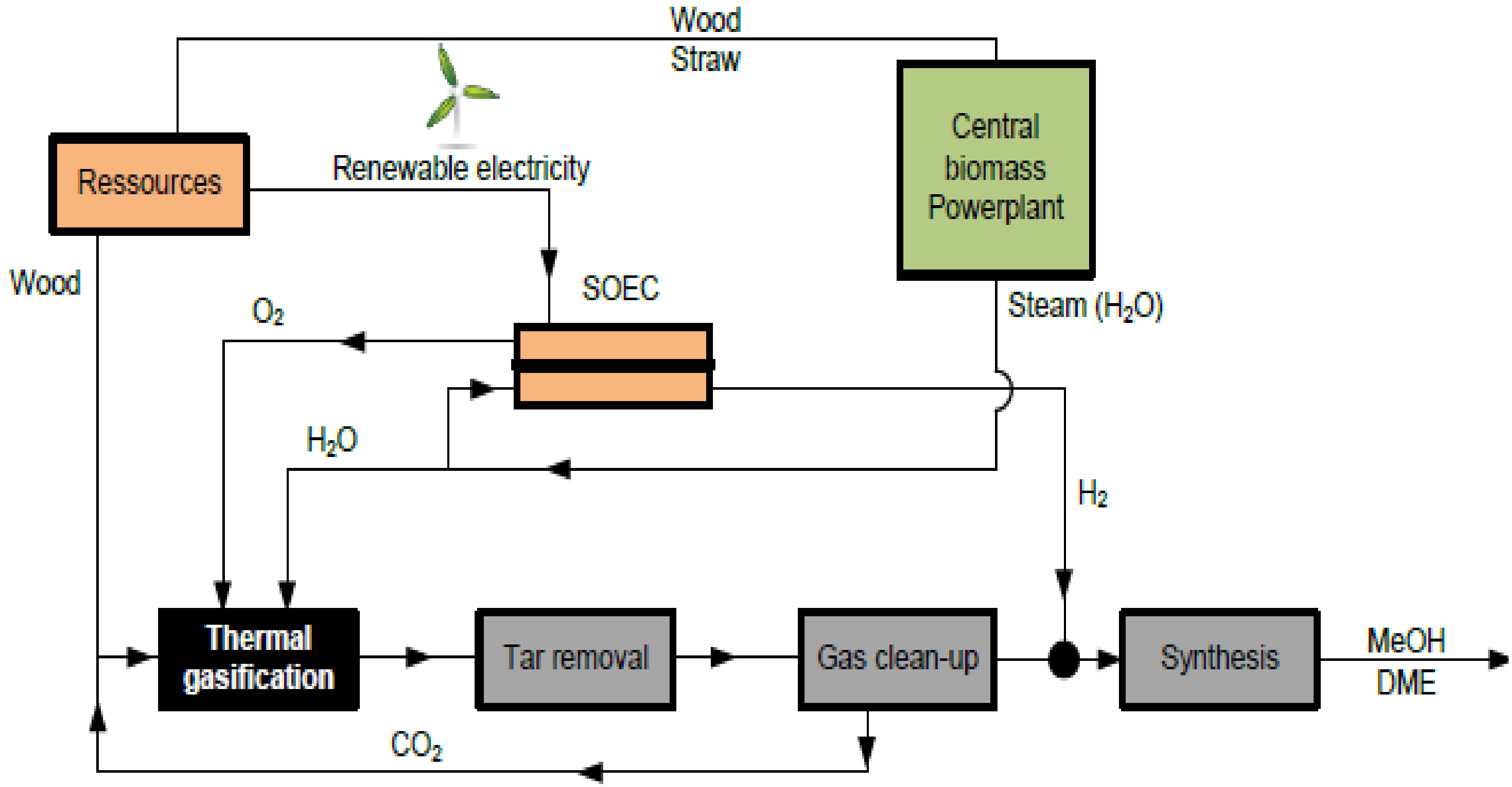


Methanol from sustainable sources

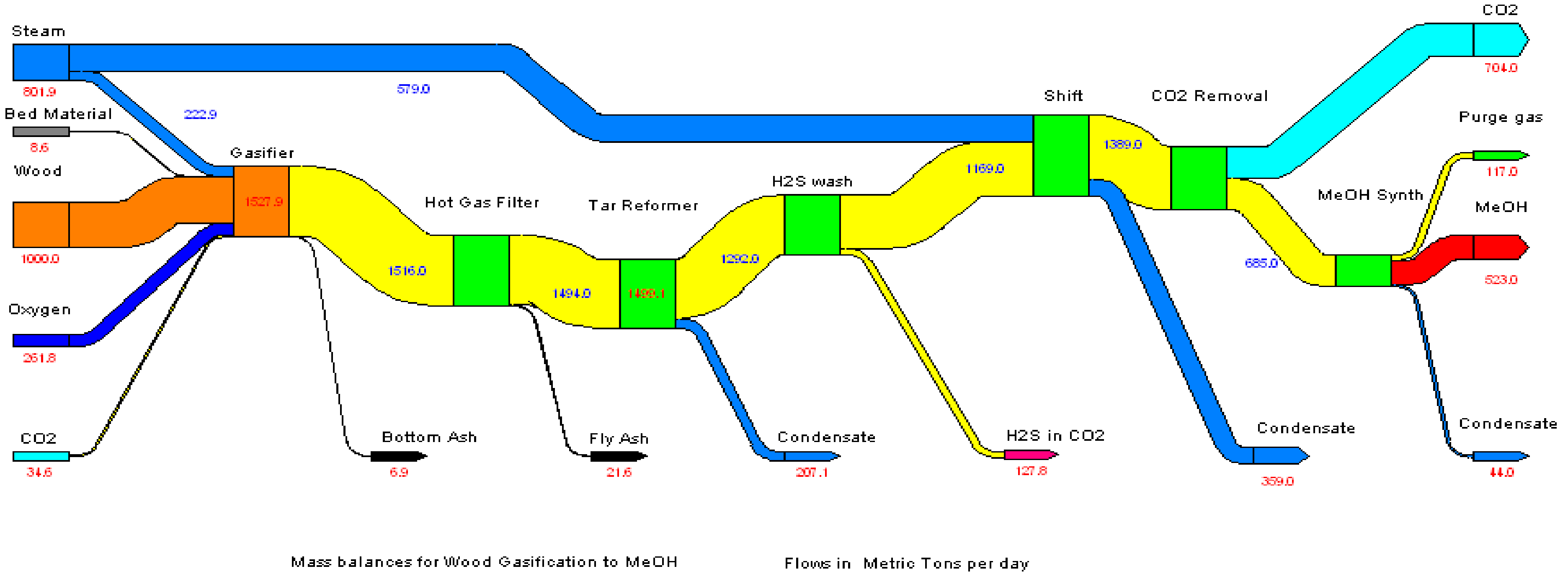
BioDME Black Liqour to Green DME Demo



GreenSynFuel Project



Mass Flows in Wood to MeOH



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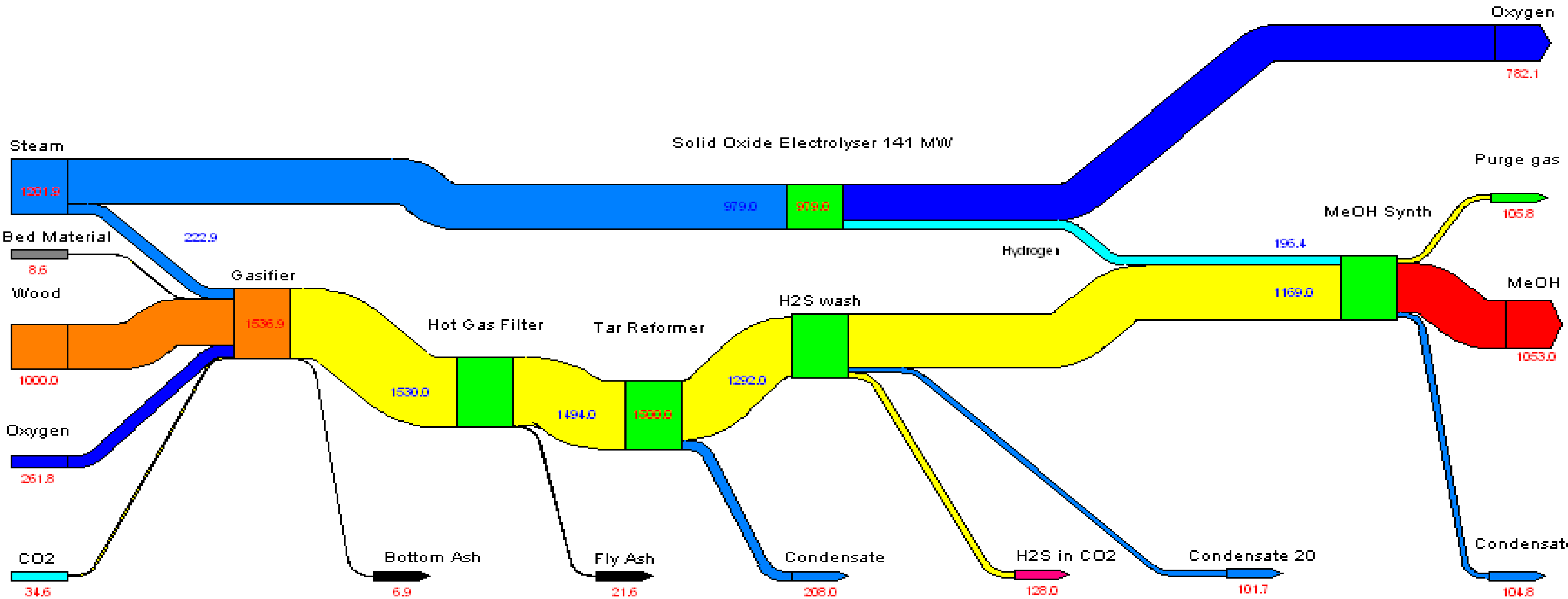
Mass Flows in Wood + SOEC to MeOH



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

The CO_2 Electrofuel Project

VOLVO

e.on

CHEMREC

Energy to Succeed

Nýsköpunarmiðstöð Íslands

Olíudreifing

SORPA

Flokkum og skilum

WÄRTSILÄ

Ea Energy Analyses

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DTU

Is CO_2 electrofuels a viable and competitive technology for the Nordic countries?