



Catalytic and electrochemical conversion of biomass resources

RESEARCH | TECHNOLOGY | CATALYSTS

[John Bøgild Hansen](#) - Haldor Topsøe

Berlin, October 27, 2015

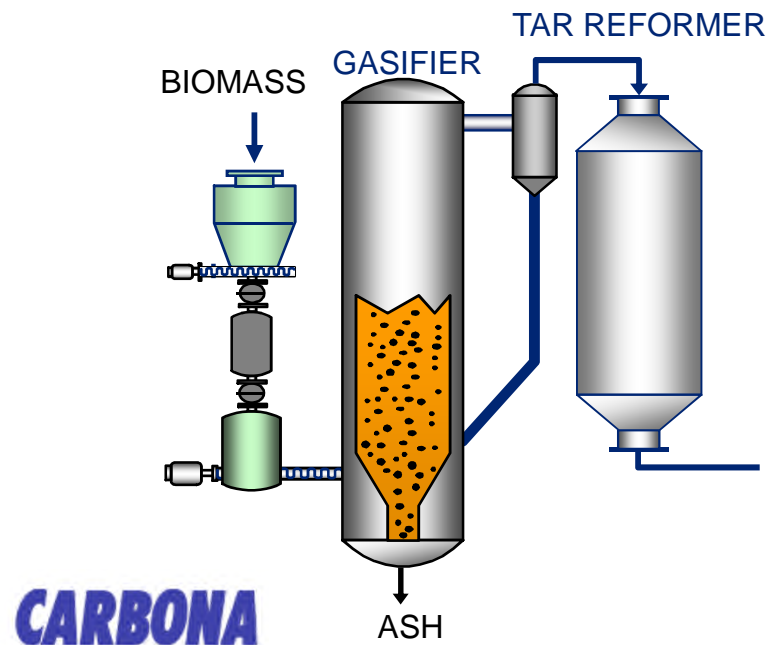
We have been committed to catalytic process technology for more than 70 years

- Founded in 1940 by Dr. Haldor Topsøe
- Revenue: 700 million Euros
- 2600 employees
- Headquarters in Denmark
- Catalyst manufacture in Denmark and the USA

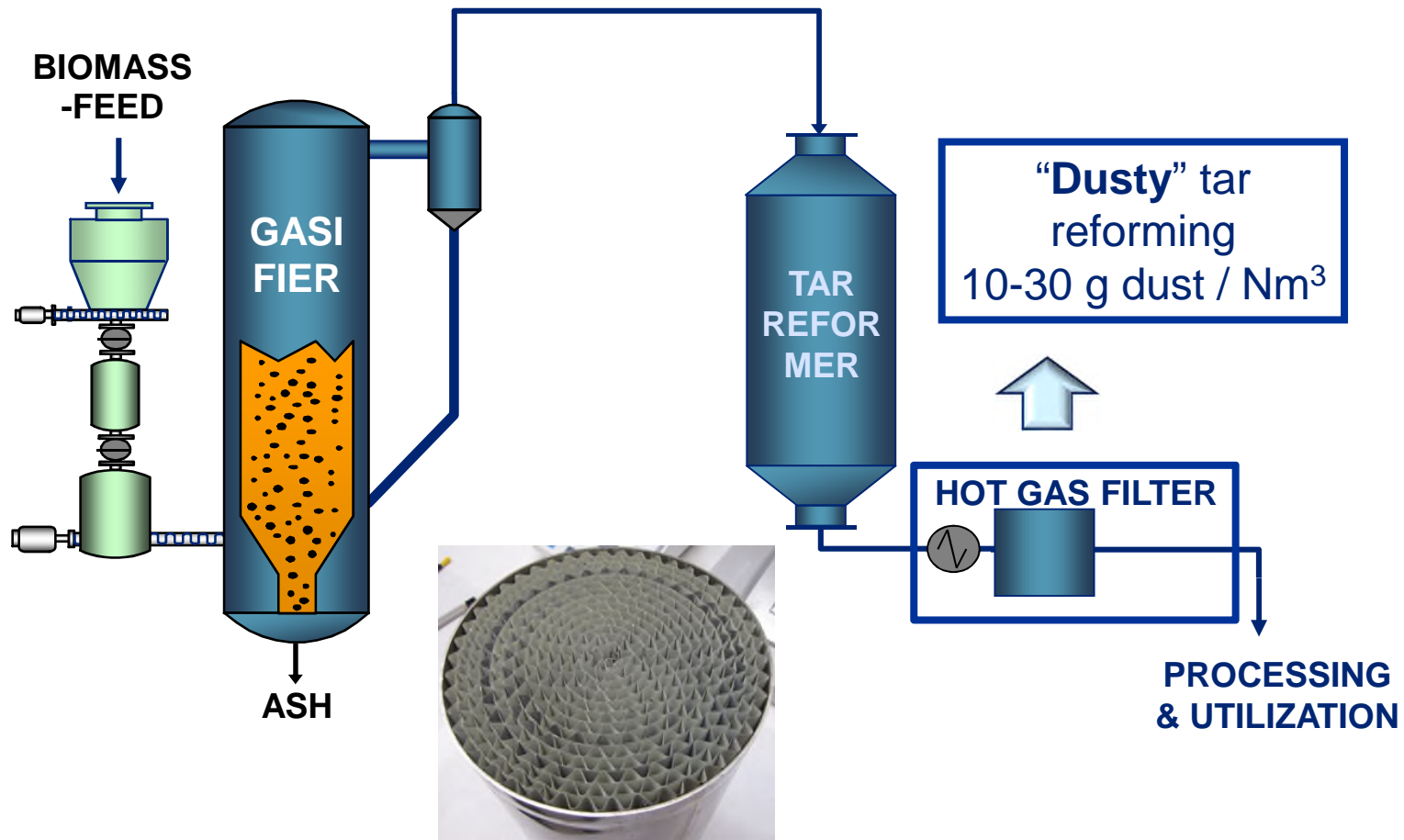


Tar reforming – Enabling technology for biomass gasification

- Gasification of biomass results in a syngas that contains tars and contaminants
 - 1000 -2500 ppm tar
 - 50 – 100 ppm S, particulates
 - 850-930°C, 1-30 bar g
 - Ammonia decomposition



“Dusty” tar reforming

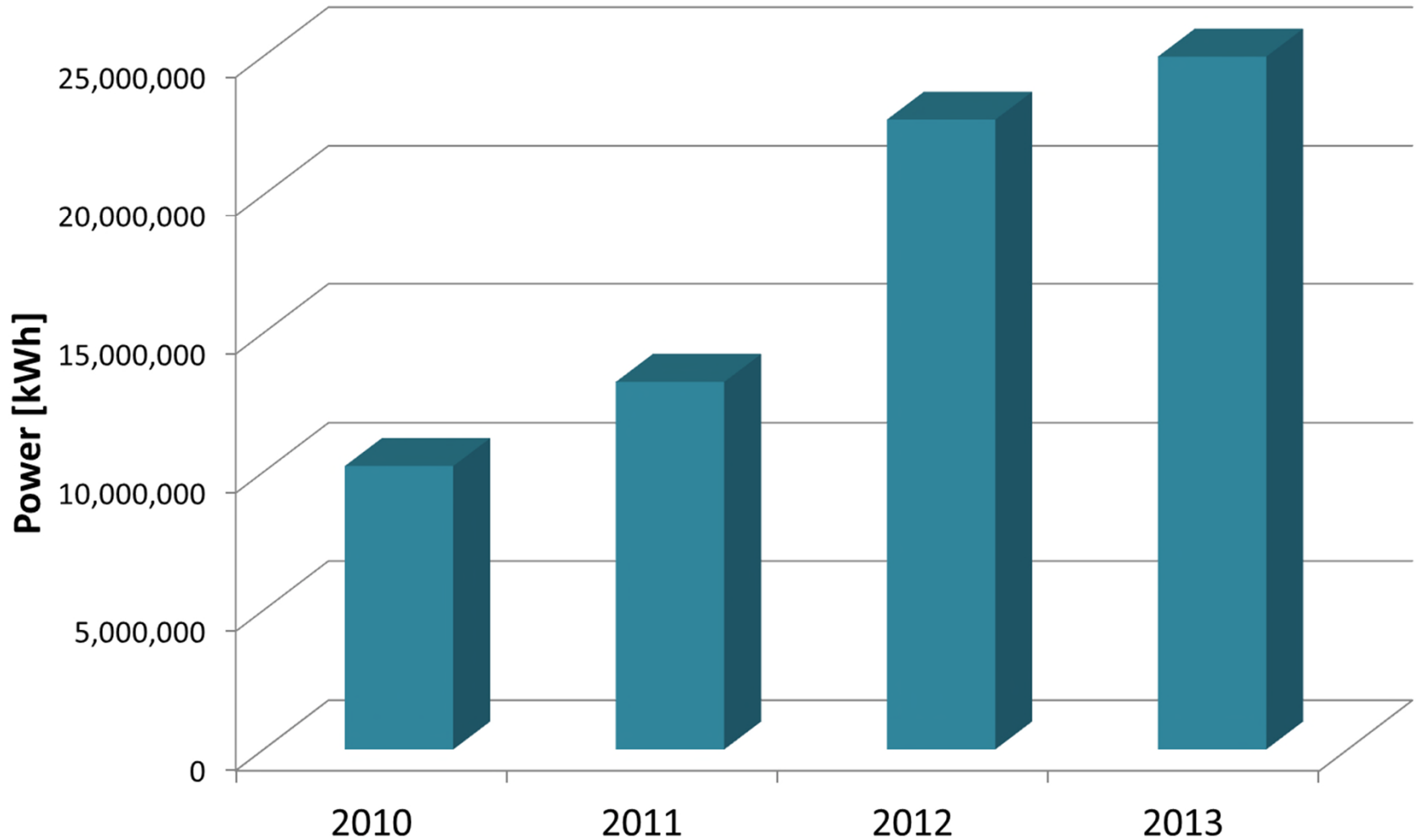


Skive Fjernvarme a.m.b.a. (Skive CHP)

| | |
|---------------------|---|
| Location | Skive, Denmark |
| Capacity | 21 MW_{th} , Max 28 MW _{th} |
| Operational year | 2009 |
| Fuel consumption | 100 TPD |
| Fuel | Biomass, wood pellets |
| Gasification techn. | Air blown, bubbling fluidized bed |
| Pressure range | 1 – 3 bar g |
| Power generation | Gas engines |

Skive Fjernvarme a.m.b.a. (Skive CHP)

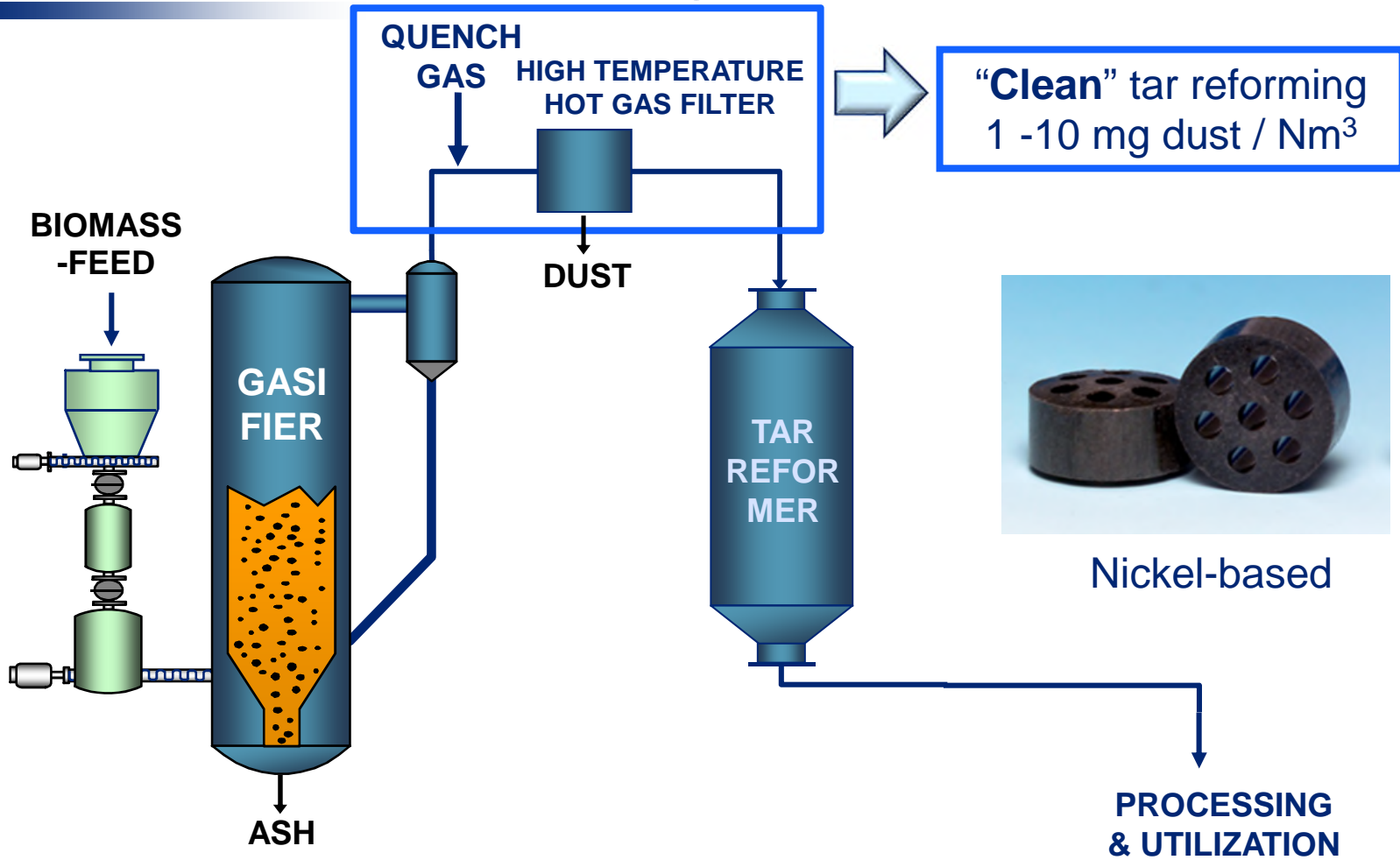
Power production for Skive CHP plant



Gas Technology Institute, Chicago

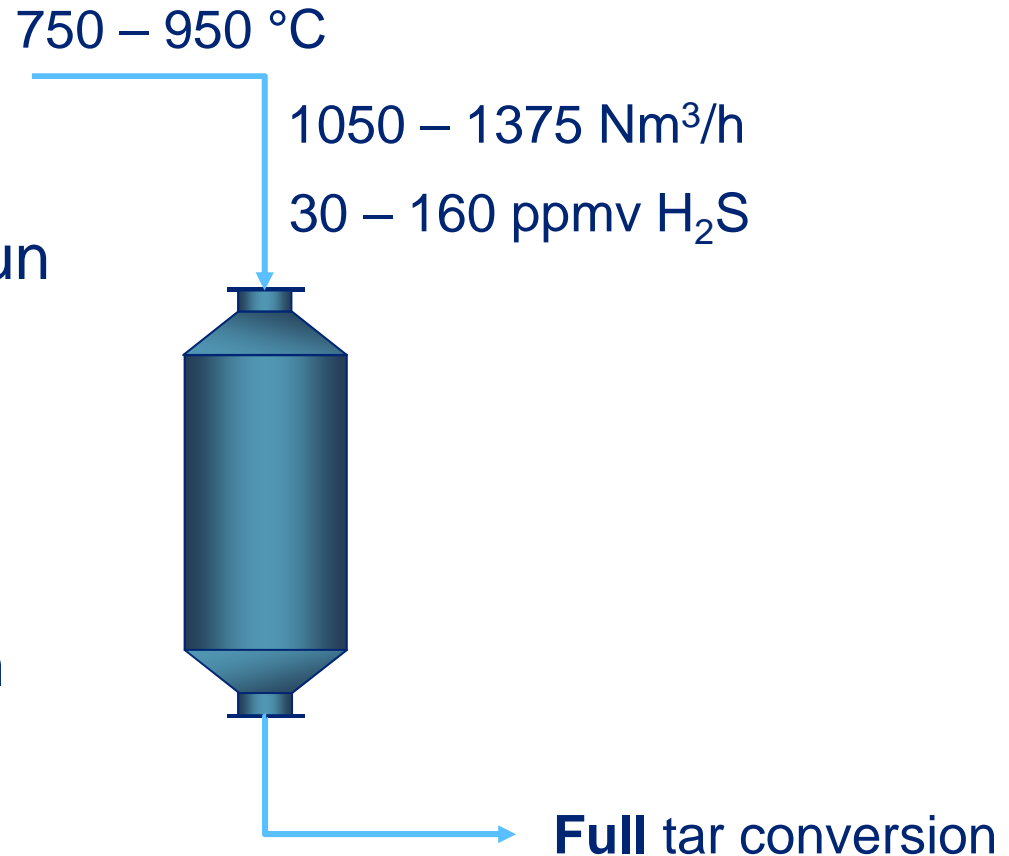
| | |
|---------------------|--------------------------------------|
| Location | Chicago, USA |
| Capacity | ~ 4 MW _{th} |
| Fuel consumption | 18 TPD |
| Fuel | Biomass, wood pellets |
| Gasification techn. | Oxygen blown, bubbling fluidized bed |
| Pressure range | 1-9 bar g |

“Clean” tar reforming



Gas Technology Institute, Chicago

- Tar reformer ~ 1150 run hrs
- No soot formation
- 15 min. lack of oxygen
 - **No deactivation!**



DME the versatile fuel

★ Aerosol Propellant
150.000 TPY

★ Energy
Production



★ Olefines



★ Gasoline

DME

★ Acetic Acid

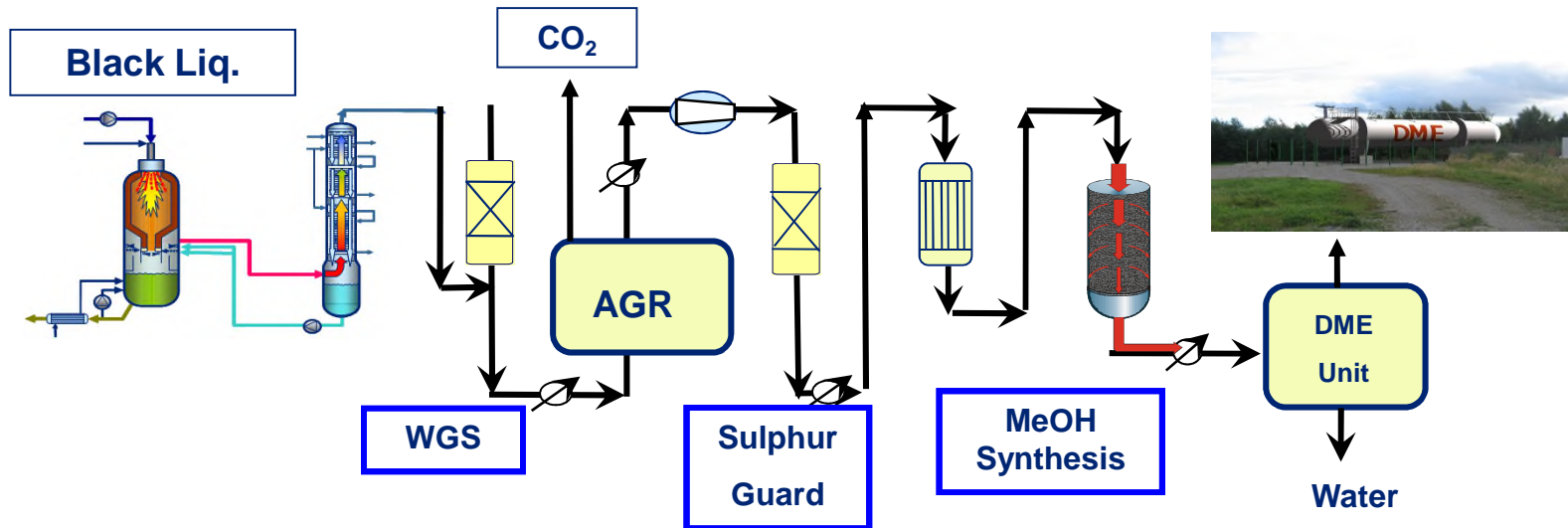
★ LPG Substitute
& Make-Up

★ Transportation Fuel
for Diesel & Fuel Cells



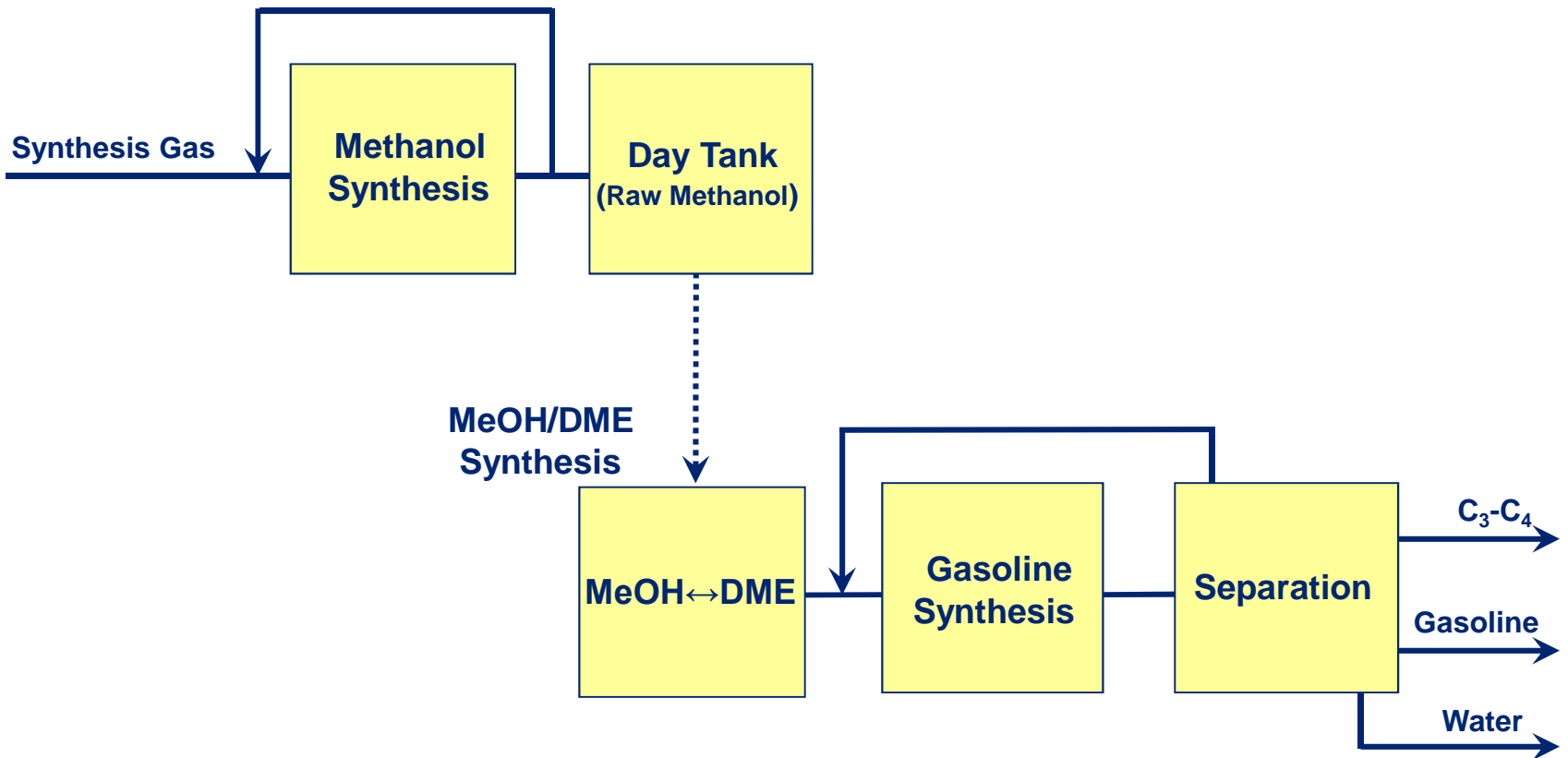
Methanol from sustainable sources

BioDME Black Liqour to Green DME Demo



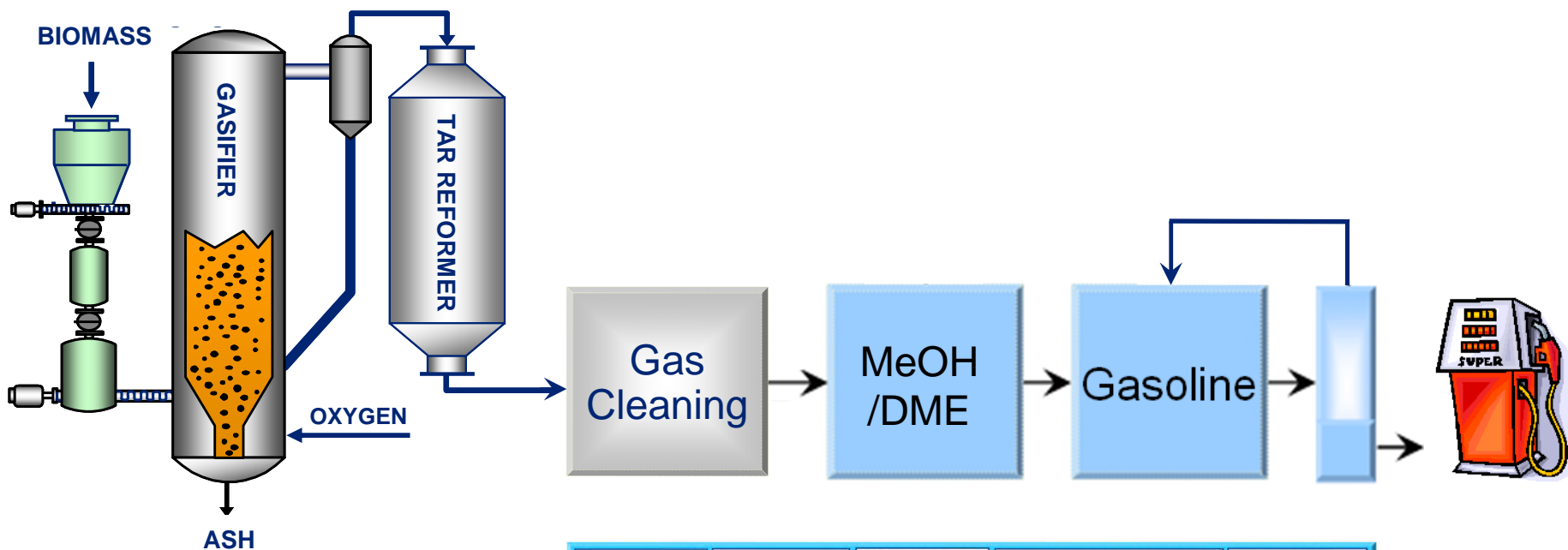
TMGAS

Topsoe Integrated Gasoline Synthesis

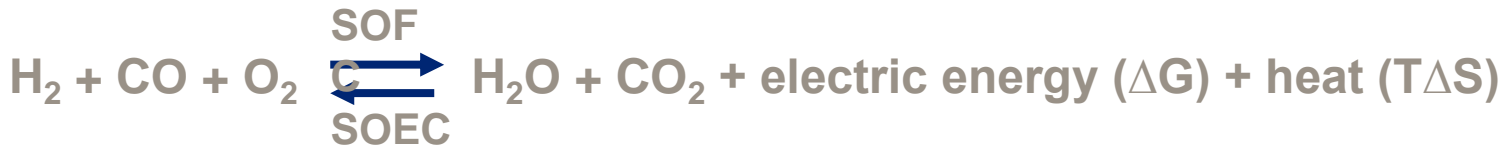
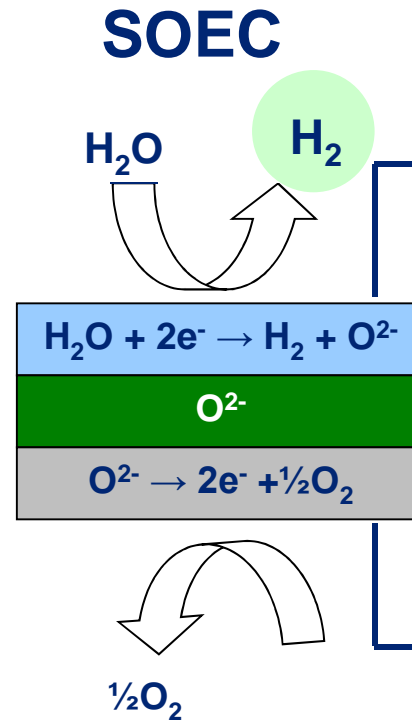
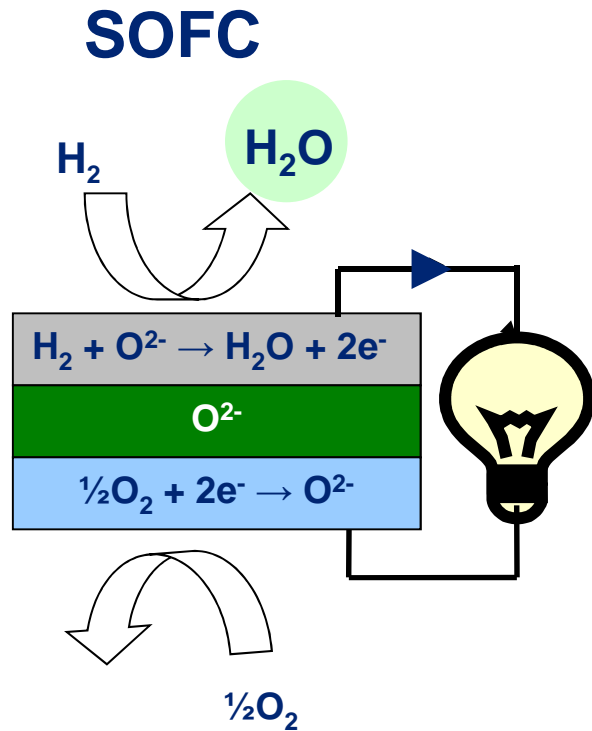


25 bbl/d Demonstration Plant

Green Gasoline from Wood Using Carbona Gasification and Topsoe TIGAS Processes

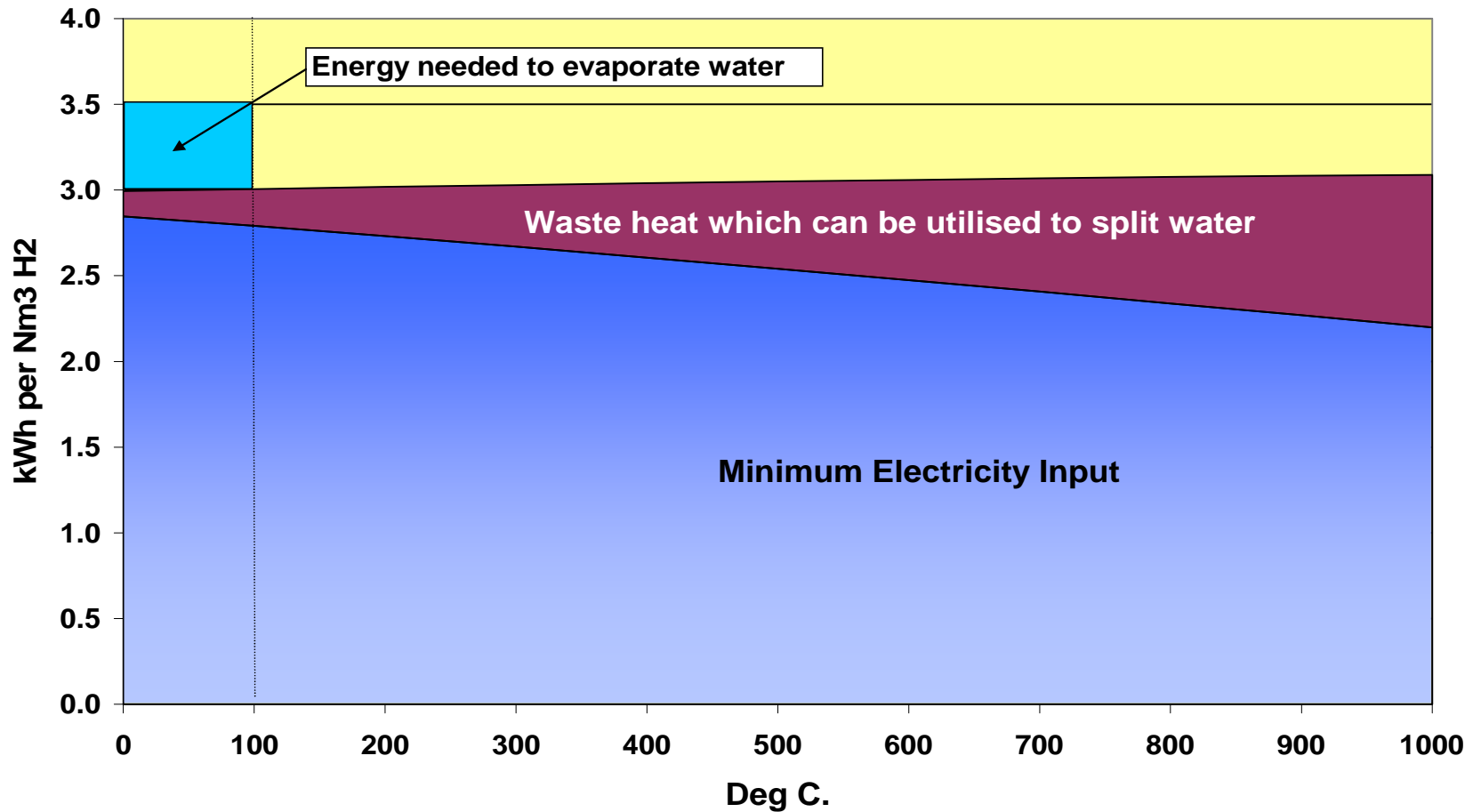


Fuel Cell and Electrolyser



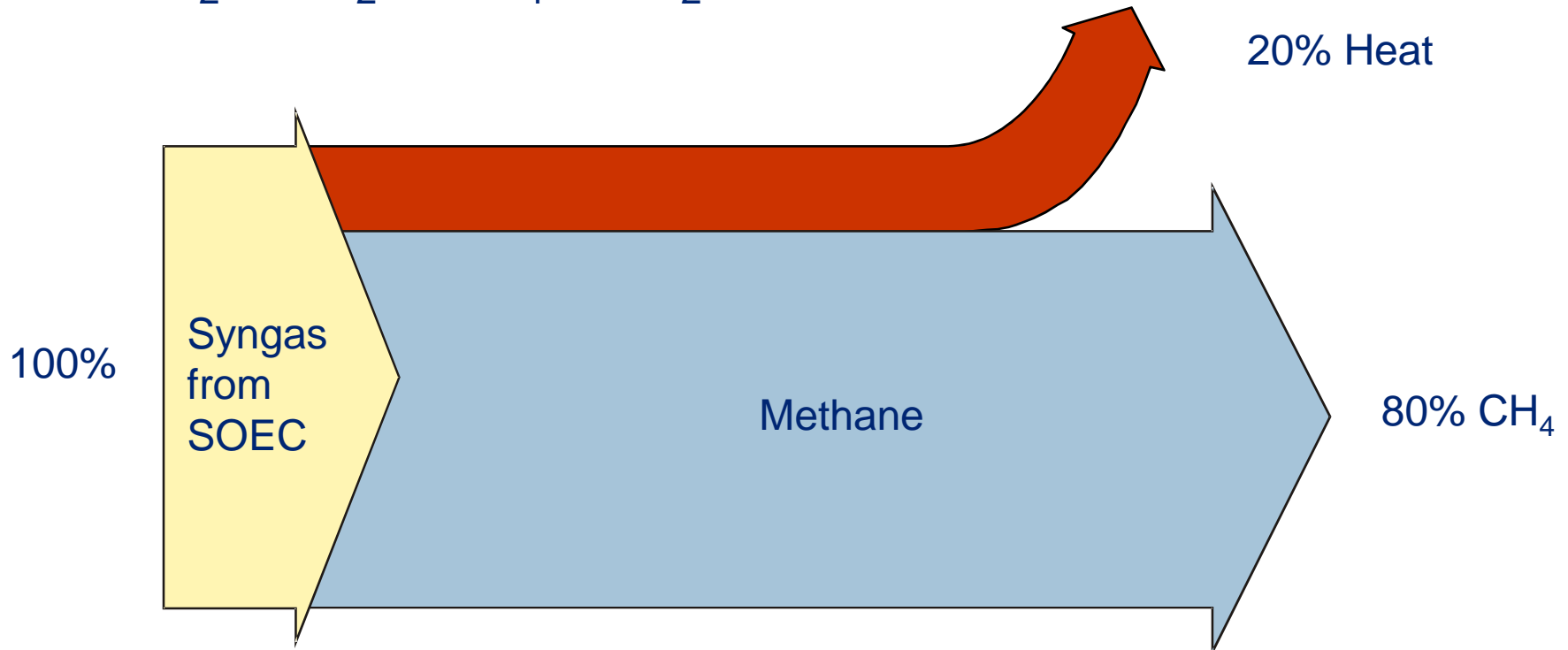
SOEC more efficient than present Electrolysers

Internal waste heat used to split water



Methanation essentials

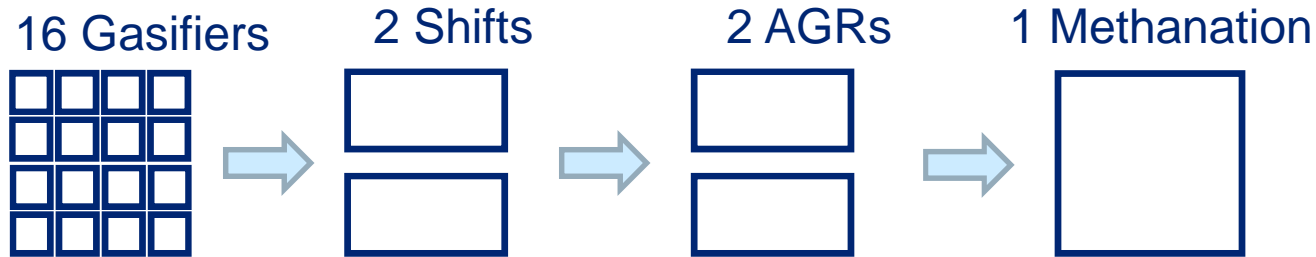
- $\text{CO} + 3\text{H}_2 = \text{CH}_4 + \text{H}_2\text{O}$
- $\text{CO}_2 + 4\text{H}_2 = \text{CH}_4 + 2\text{H}_2\text{O}$



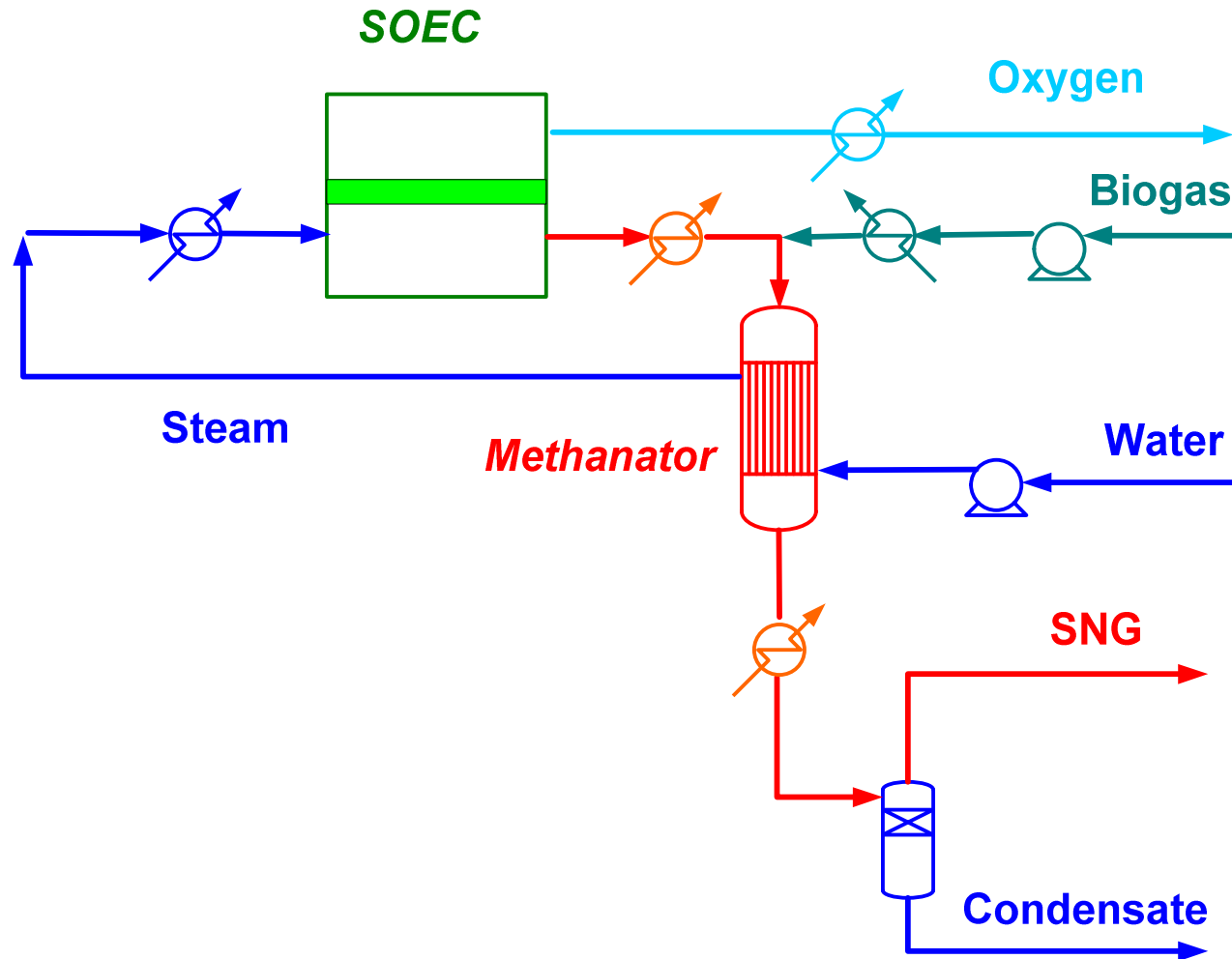
Heat recovery is the key to an efficient plant!

How to build the world largest SNG plant

- Qinghua plant is largest single line SNG (methanation) in world.

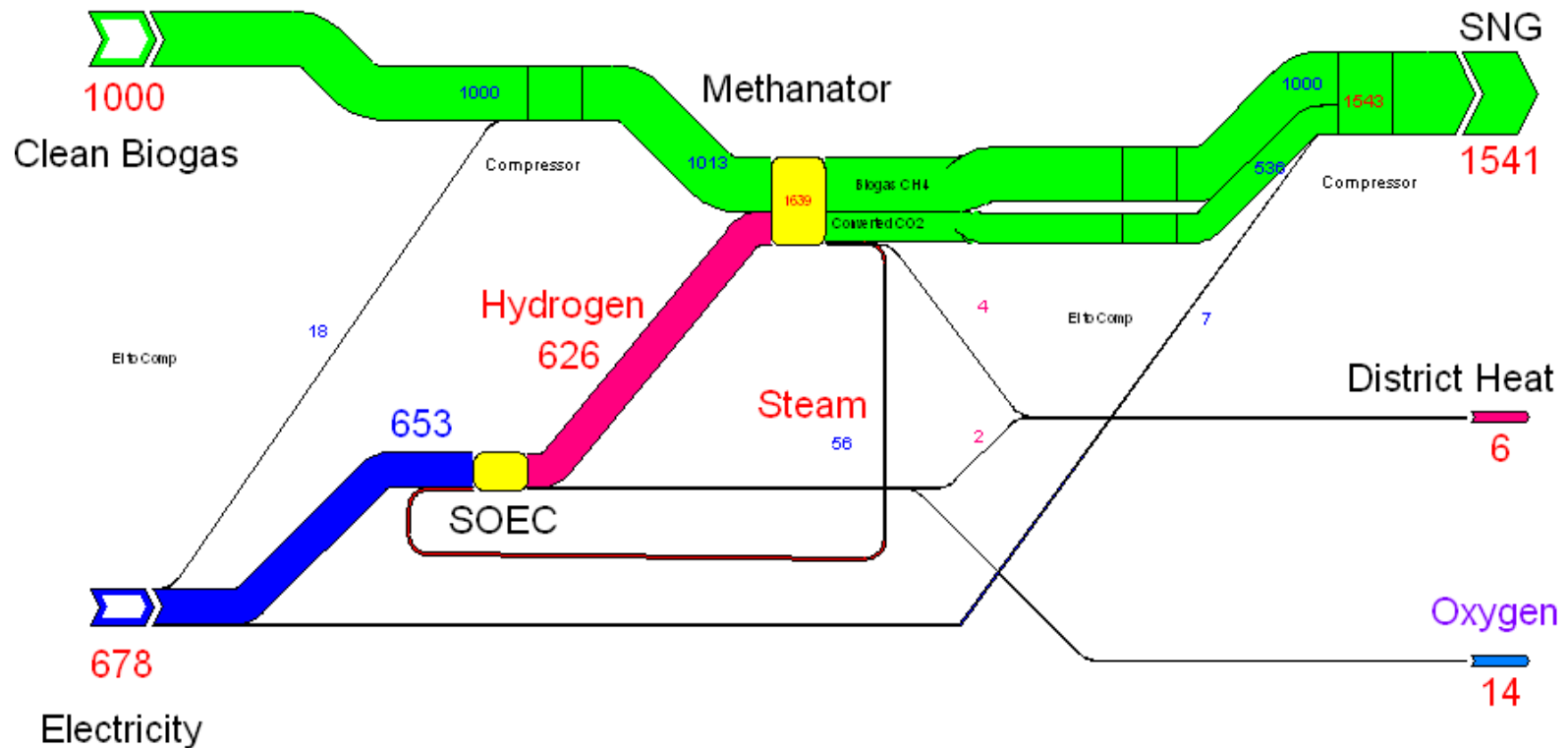


Biogas to SNG via SOEC and methanation of the CO₂ in the biogas

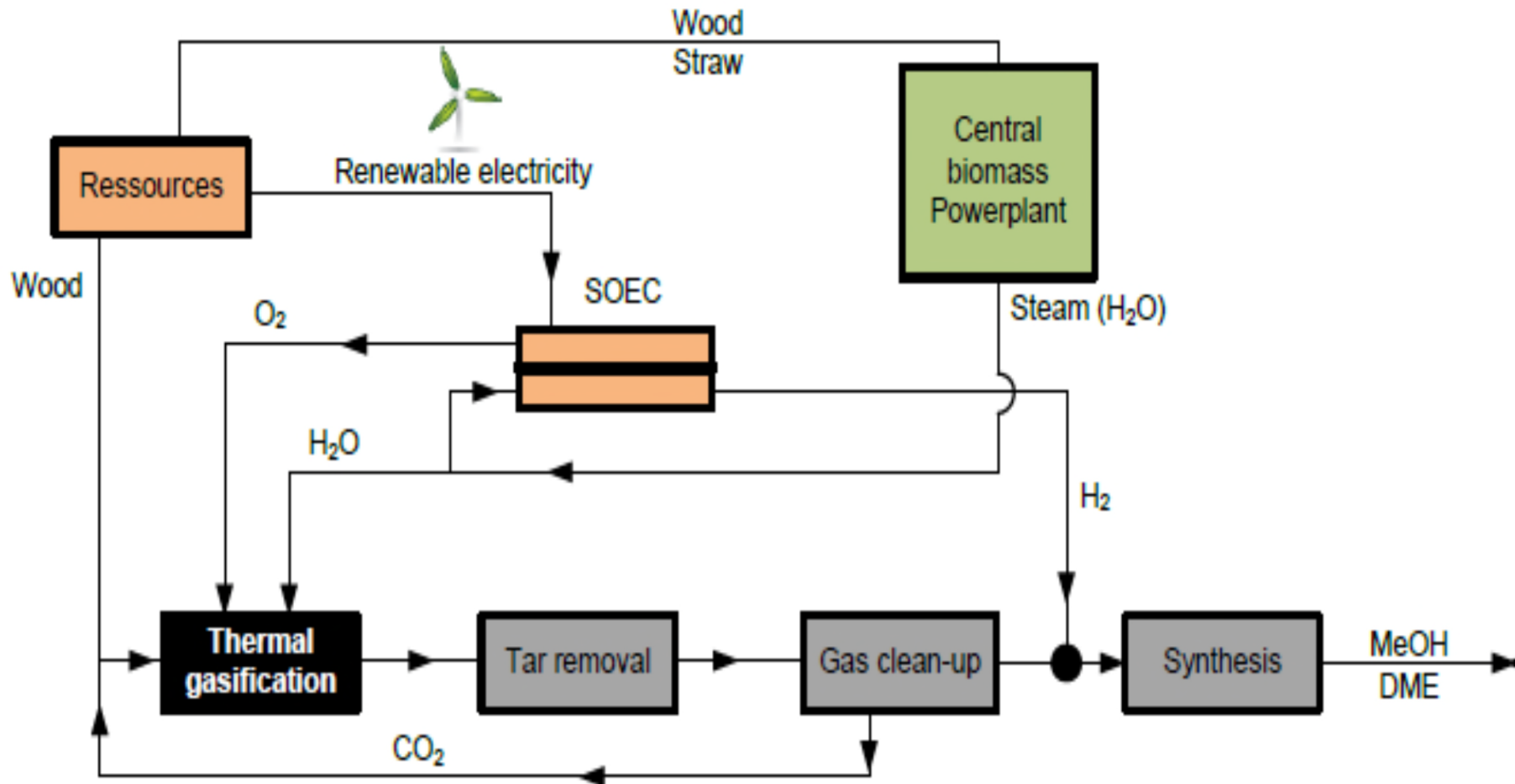


Exergy Flows in CO₂ case

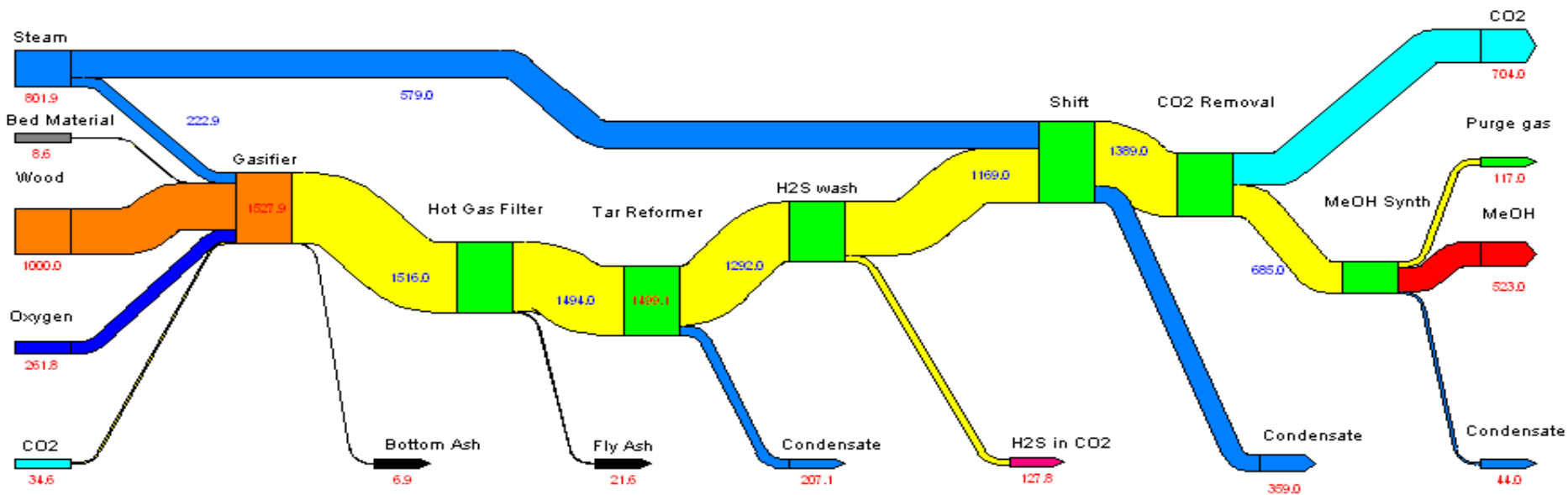
Power to Gas Exergy Efficiency 79.8 %



GreenSynFuel Project



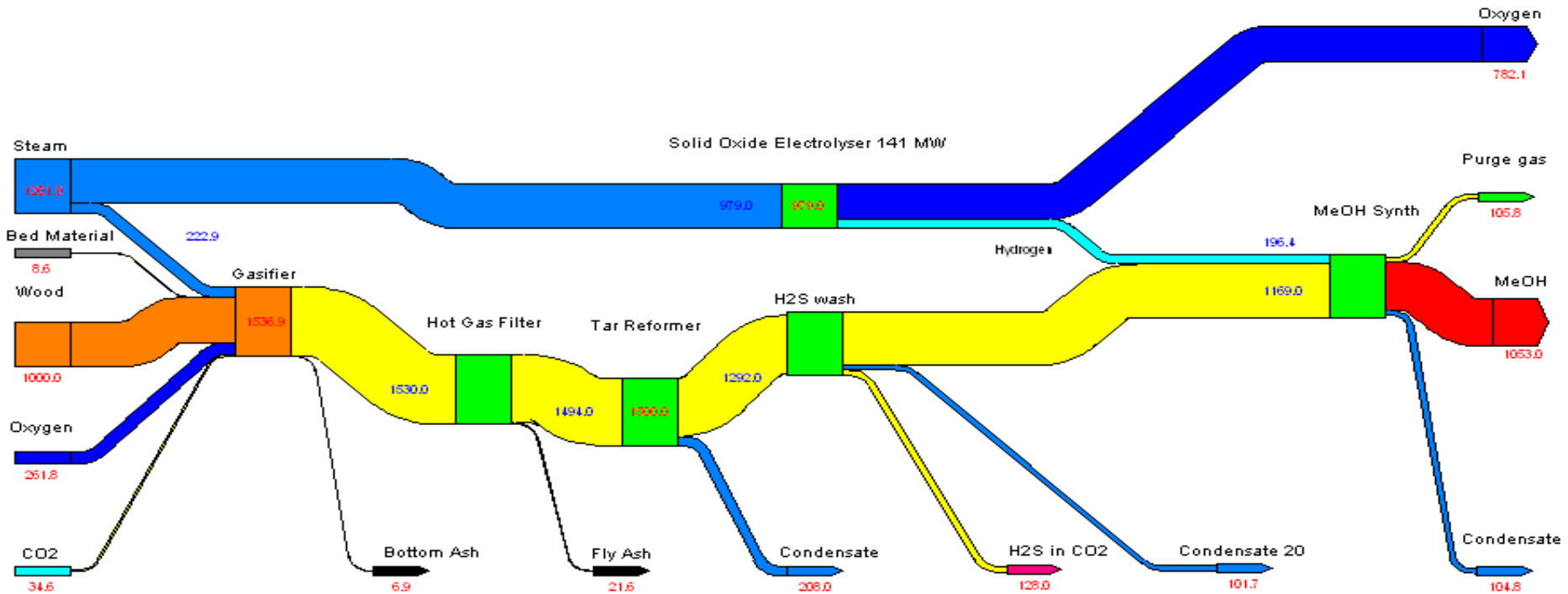
Mass Flows in Wood to MeOH



Mass balances for Wood Gasification to MeOH

Flows in Metric Tons per day

Mass Flows in Wood + SOEC to MeOH



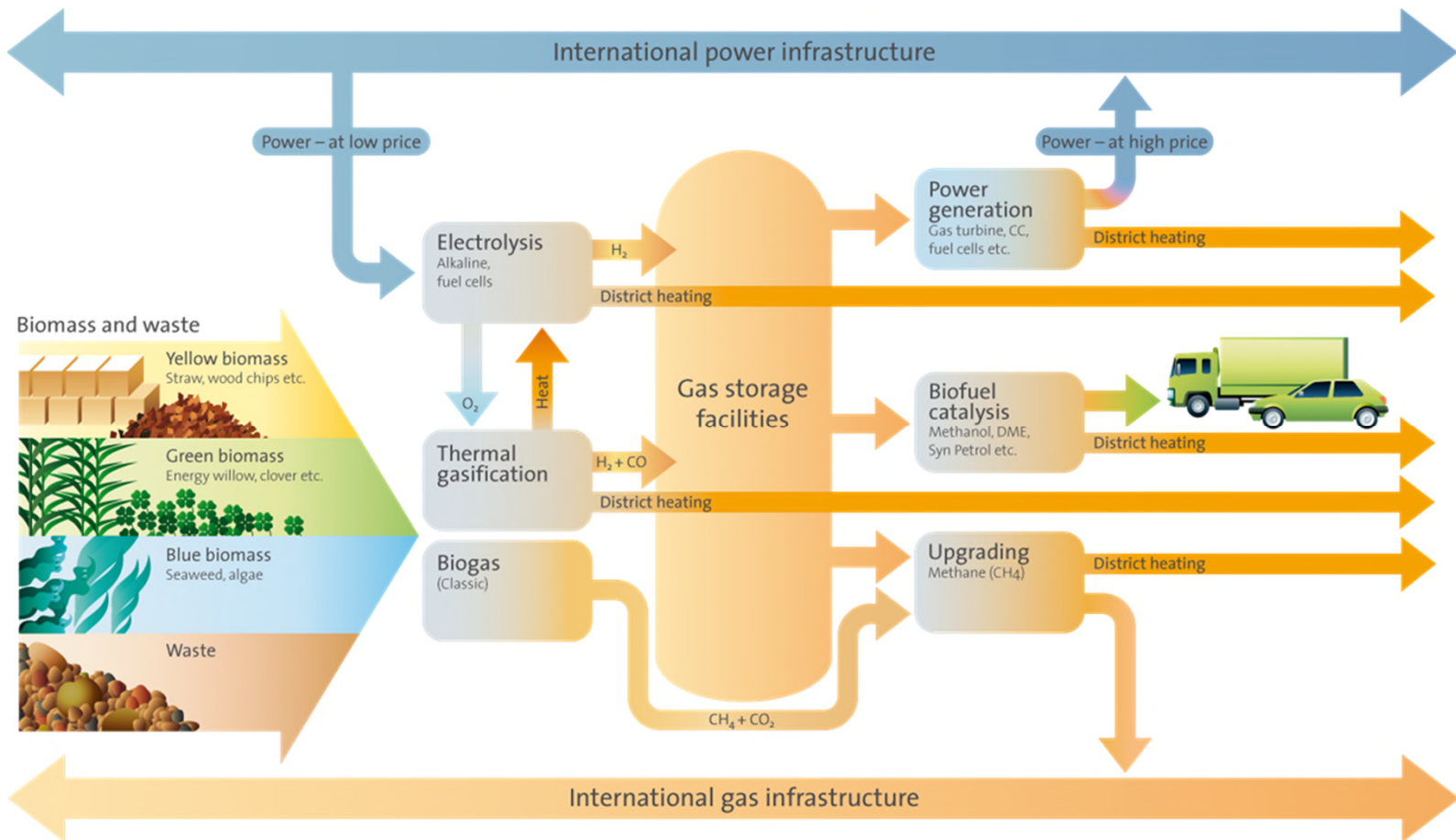
Mass balances for combined Wood Gasification and SOEC to MeOH

Flows in Metric Tons per day

Conclusions

- Dusty tar reforming is now commercially proven
- Clean tar reforming has been demonstrated in connection with successful MeOH/DME and gasoline synthesis at 25 bbl/day
- Sustained black liquor to DME has been proven at 4 MTPD scale and truck operation as well
- Coupling SOEC with biomass gasification can double the biomass potential by converting excess carbon.

Using the gas system as a key integrator



Biogas in the future
integrated energy system