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Vienna University of Technology

Hydrogen from biomass via thermo-chemical route – Status of development and perspectives

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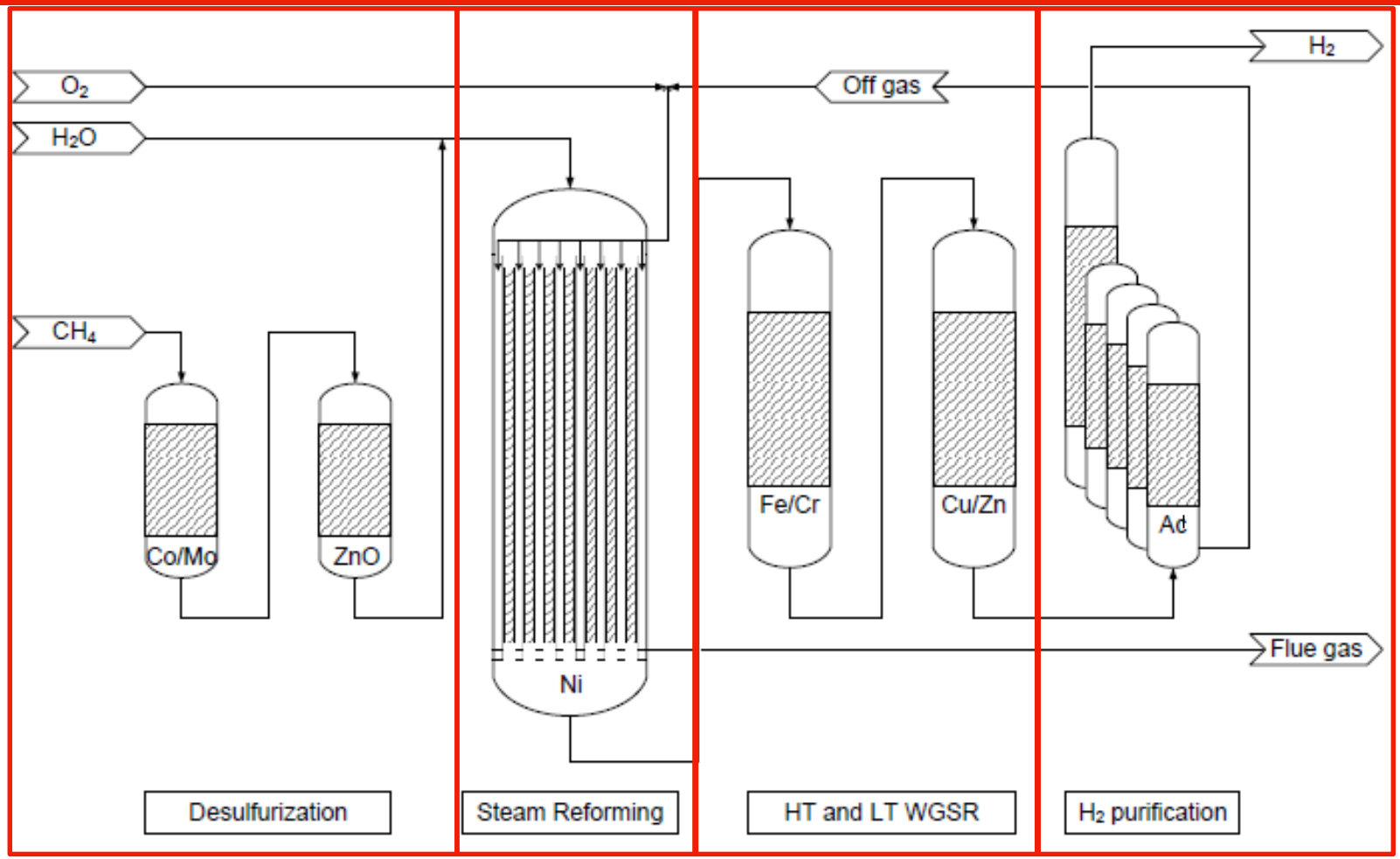
COMET

Competence Centers for Excellent Technologies

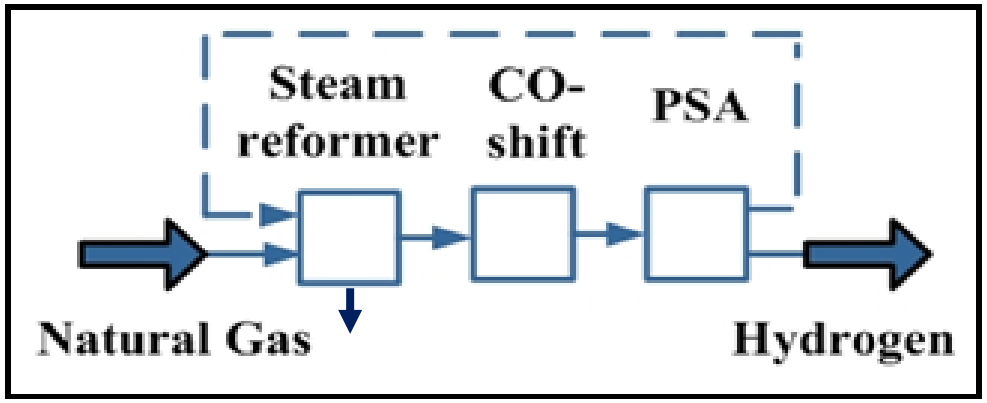
Content

- Process chains for hydrogen production
  - Methane to hydrogen
  - Biomass to hydrogen
  - Chemical reactions and maximal yields
- Polygeneration with hydrogen production
  - Definition
  - CHP and pilot plant Oberwart
  - Polygeneration process chains
  - Experimental results
- hydrogen-electric vision
- Conclusions

Conventional process chain: Natural gas to hydrogen



Conventional process chain: Natural gas to hydrogen



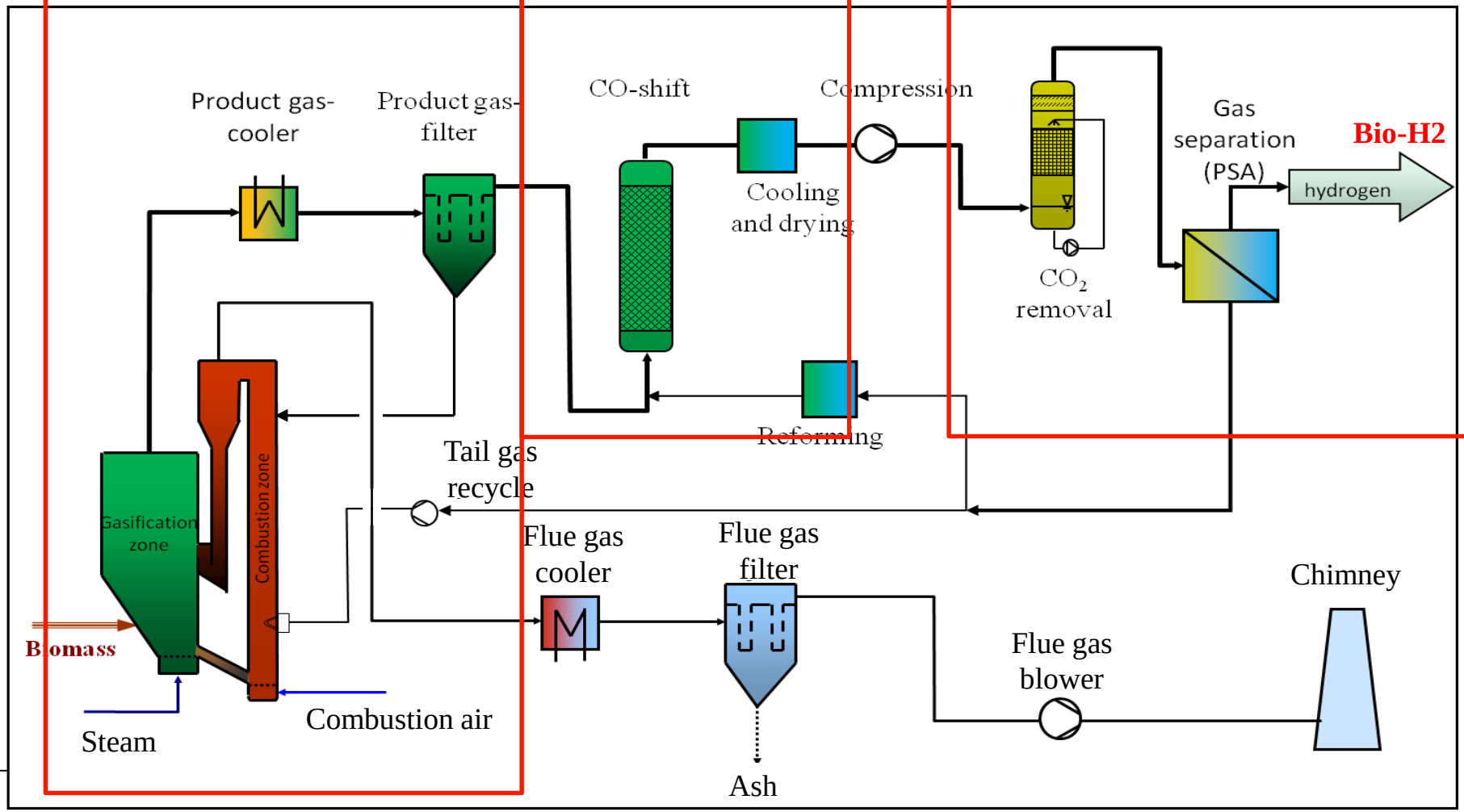
Plant Input *		
Natural Gas	Nm^3/h	3 822
Natural Gas (lhv)	MJ/Nm^3	36.91
Natural Gas (chem. en.)	MW	39.2
Electricity	MW	0.3
Steam (26 bar_{abs})	t/h	8.7
*Plant size [4] reduced to 30 MW H_2 Output (~16%)		

Plant Output *		
Hydrogen	Nm^3/h	10 040
Hydrogen (lhv)	MJ/Nm^3	10.79
Hydrogen (chem. ener.)	MW	30
Steam (48 bar_{abs})	t/h	12.4

H_2-Efficiency: 76 %

Process chain: Biomass to hydrogen (1)

Project: „BioH$_2$-4Industries“

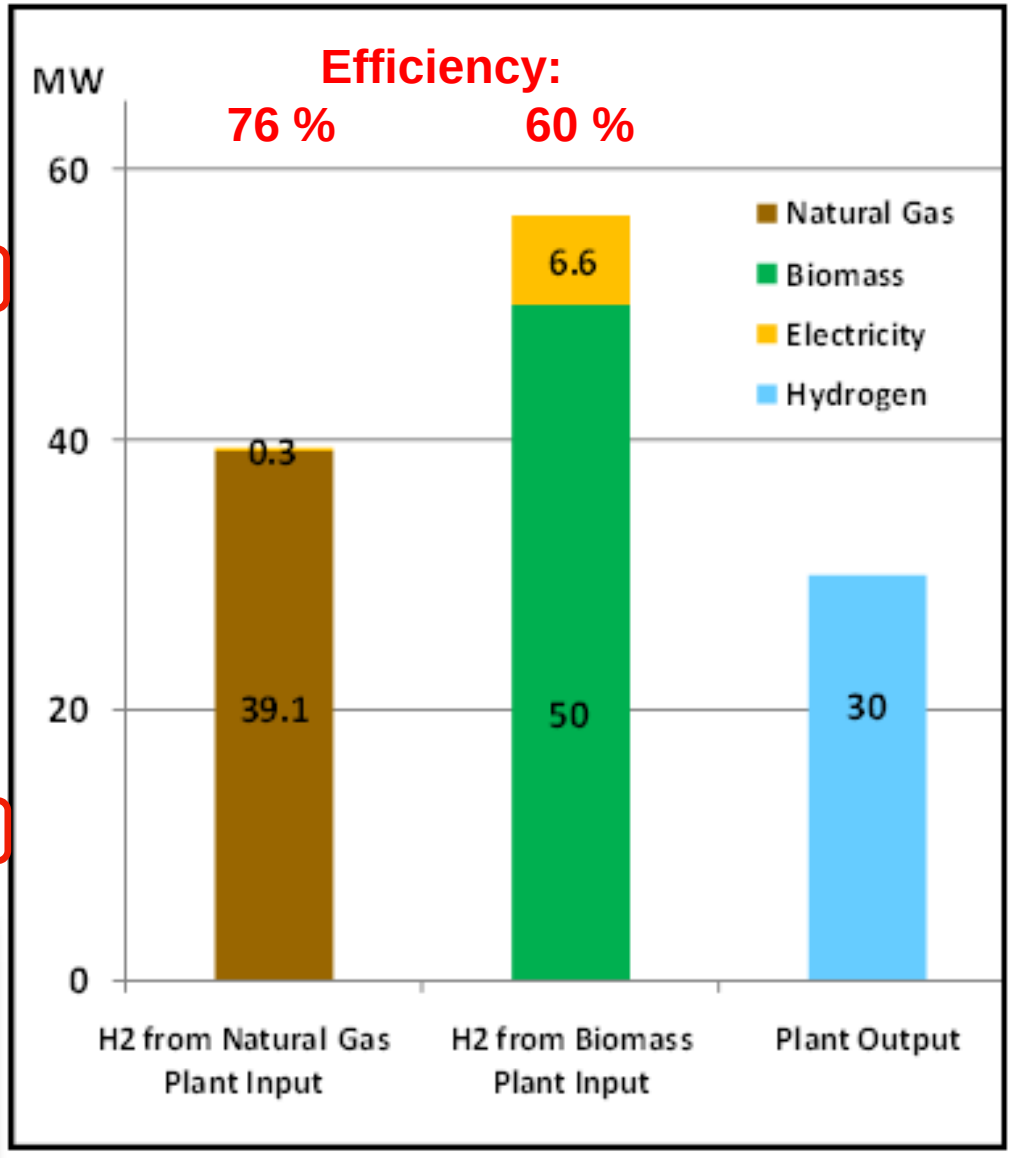


Process chain: Biomass to hydrogen (2)

Project: „BioH$_2$-4Industries“ - Results from simulation

Plant input		
Biomass (wood chips)	kg/h	18 760
Biomass (water content)	wt%	40
Biomass (lhv)	MJ/kg	9.59
Biomass (chem. energy)	MW	50
Electricity *	MW	6.58
RME	kg/h	100
Air	Nm^3/h	57 400
Water	kg/h	3 327
* excl. Electricity for cooling and CO_2 separation		

Plant output		
Hydrogen	Nm^3/h	10 040
Hydrogen (lhv)	MJ/ Nm^3	10.79
Hydrogen (chem. energy)	MW	30
Pure CO_2 (from separ.)	Nm^3/h	5 923
District heating	MW	8.9
Ash	kg/h	1 036
Flue gas	Nm^3/h	61 800



Production of hydrogen
Steam reforming

General

$$CH_nO_m + (1-m).H_2O = CO + (1+n/2-m).H_2$$

Methane (n=4, m=0)

$$CH_4 + H_2O = CO + 3.H_2$$

Biomass (n=1,44, m=0,66)

$$CH_{1,44}O_{0,66} + 0,34.H_2O = CO + 1,06.H_2$$

Reaction conditions: 800-900 °C

Catalysts: Ni, Ca, Fe

Production of hydrogen
Water-Gas-Shift-Reaction (WGSR)

Water-Gas-Shift-Reaction (WGSR)

$$CO + H_2O = CO_2 + H_2$$

Maximum Yields

Methane:

$$CO + 3.H_2 + H_2O = CO_2 + 4.H_2$$

500 g_{H2} / $kg_{nat.gas}$

~ 10 kg_{H2} / GJ

Biomass:

$$CO + 1{,}06.H_2 + H_2O = CO_2 + 2{,}06.H_2$$

172 g_{H2} / kg_{wood}

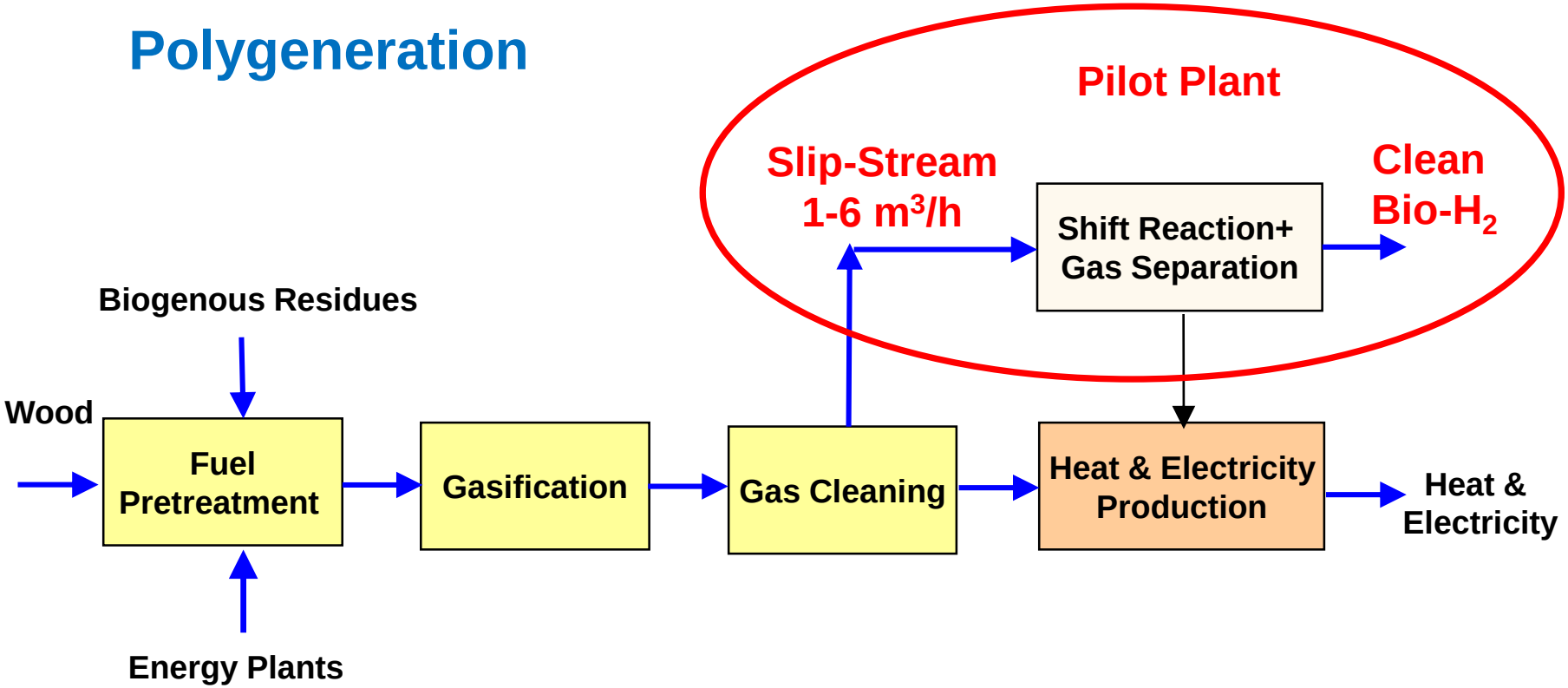
~ 10 kg_{H2} / GJ

WGSR conditions: 350-450 °C

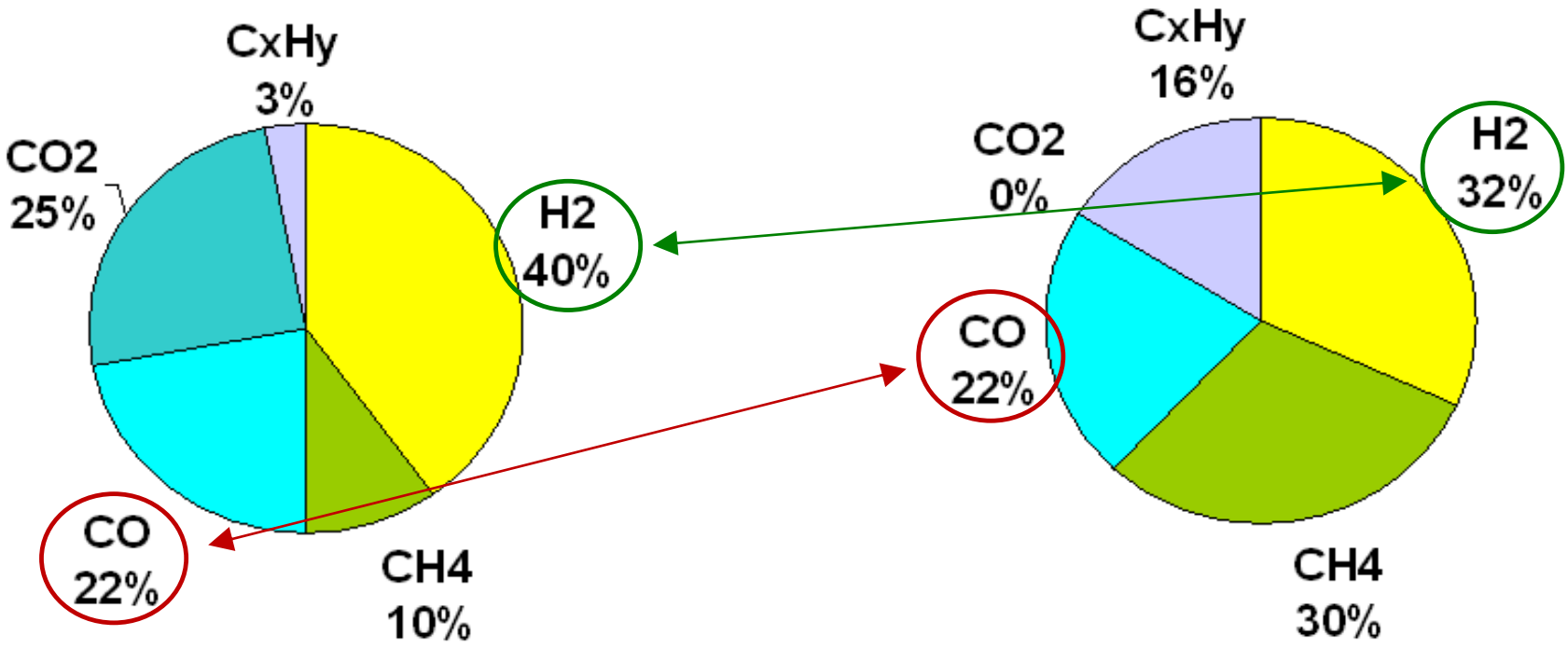
Catalysts: Fe, Cr, Co, Mo, Sn

Polygeneration process chain
Biomass to hydrogen and other products

Polygeneration



Product gas from biomass steam reforming



Volume based

Energy based

Gasification plant Oberwart

8 MW fuel input

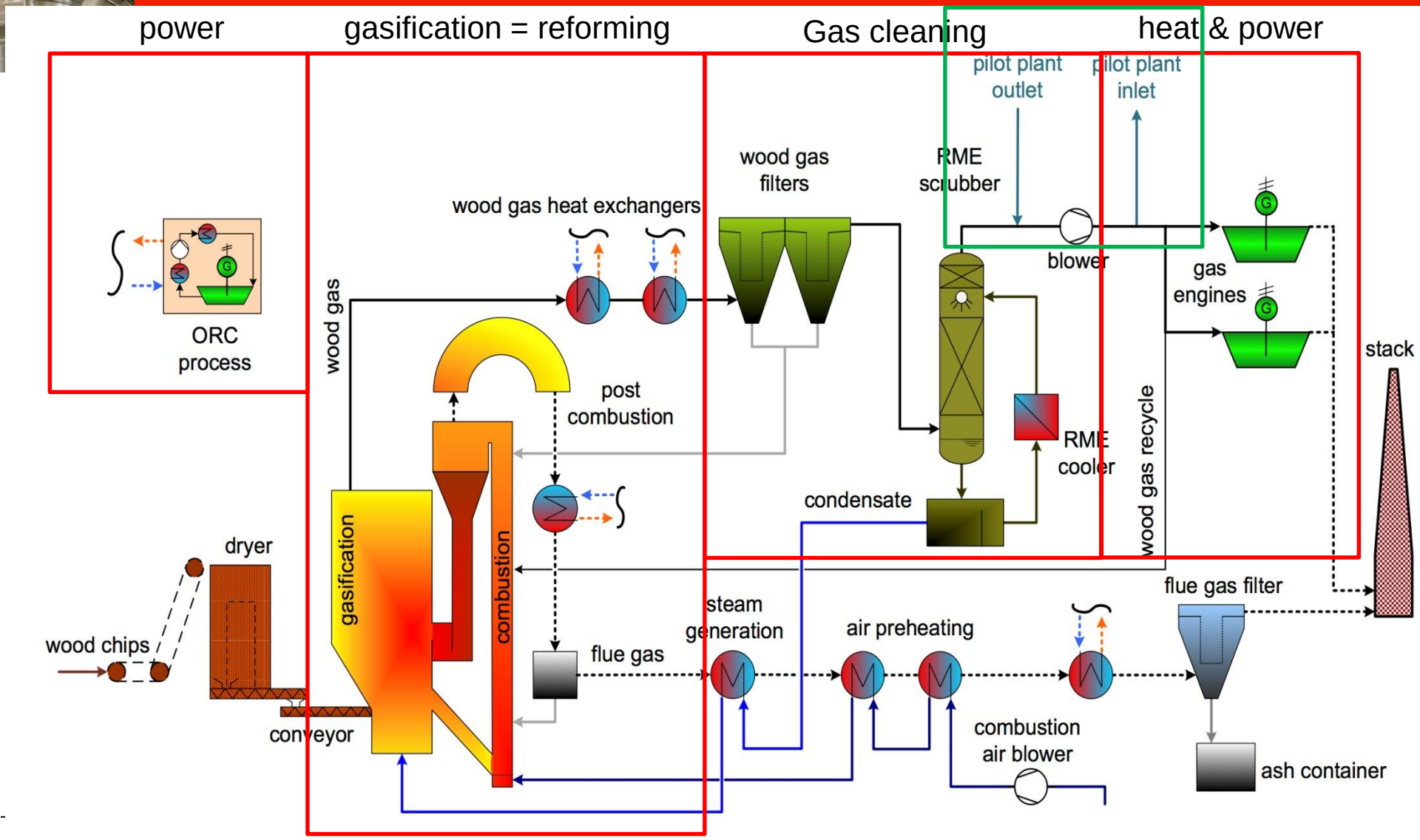
2000 kg/h wood chips

2000 m^3/h product gas

30 % electrical efficiency

30.000 operation hours

Dual Fluidized Bed (DFB) gasification Oberwart



Polygeneration

Full process chain for hydrogen production

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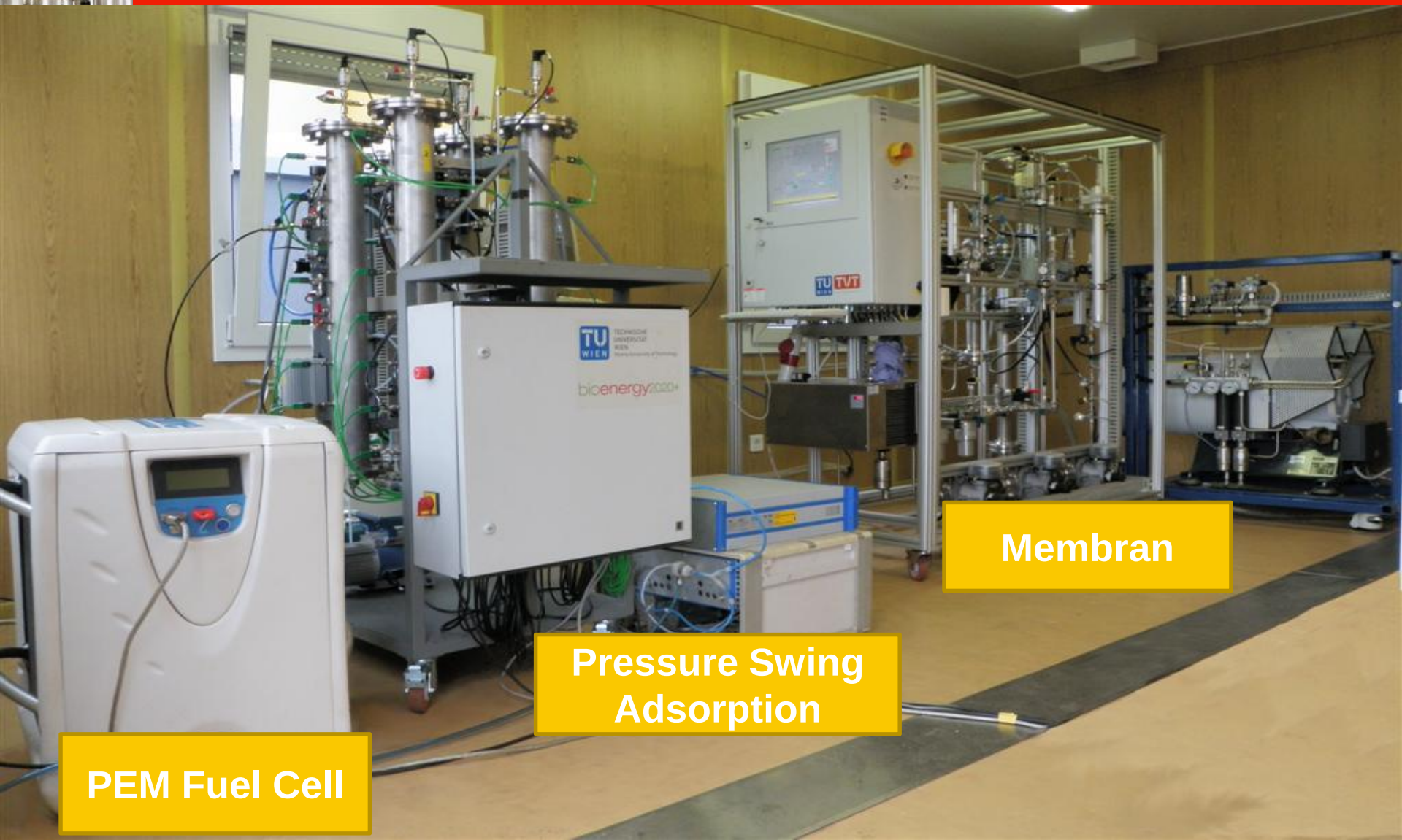
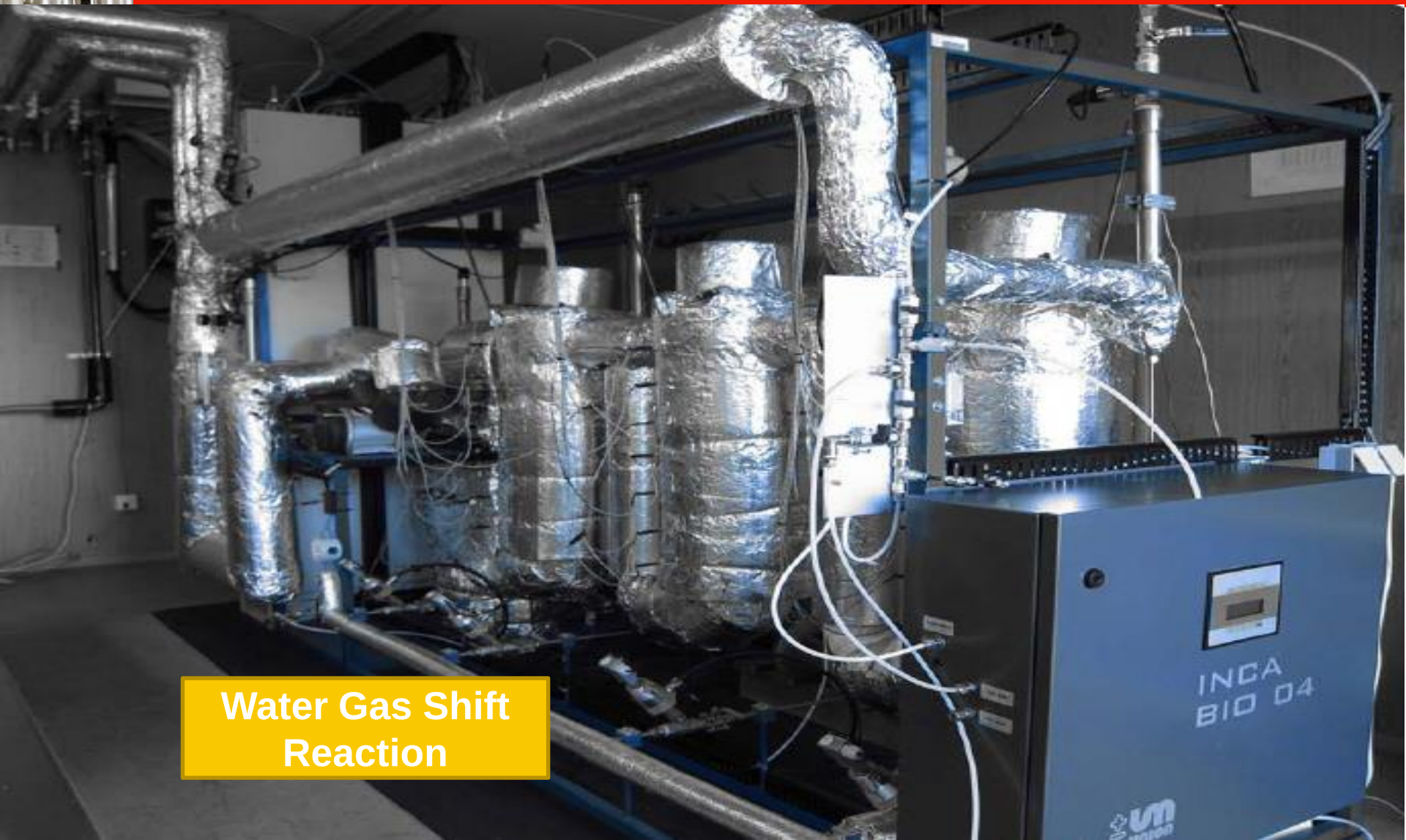
Container with pilot plant at CHP Oberwart

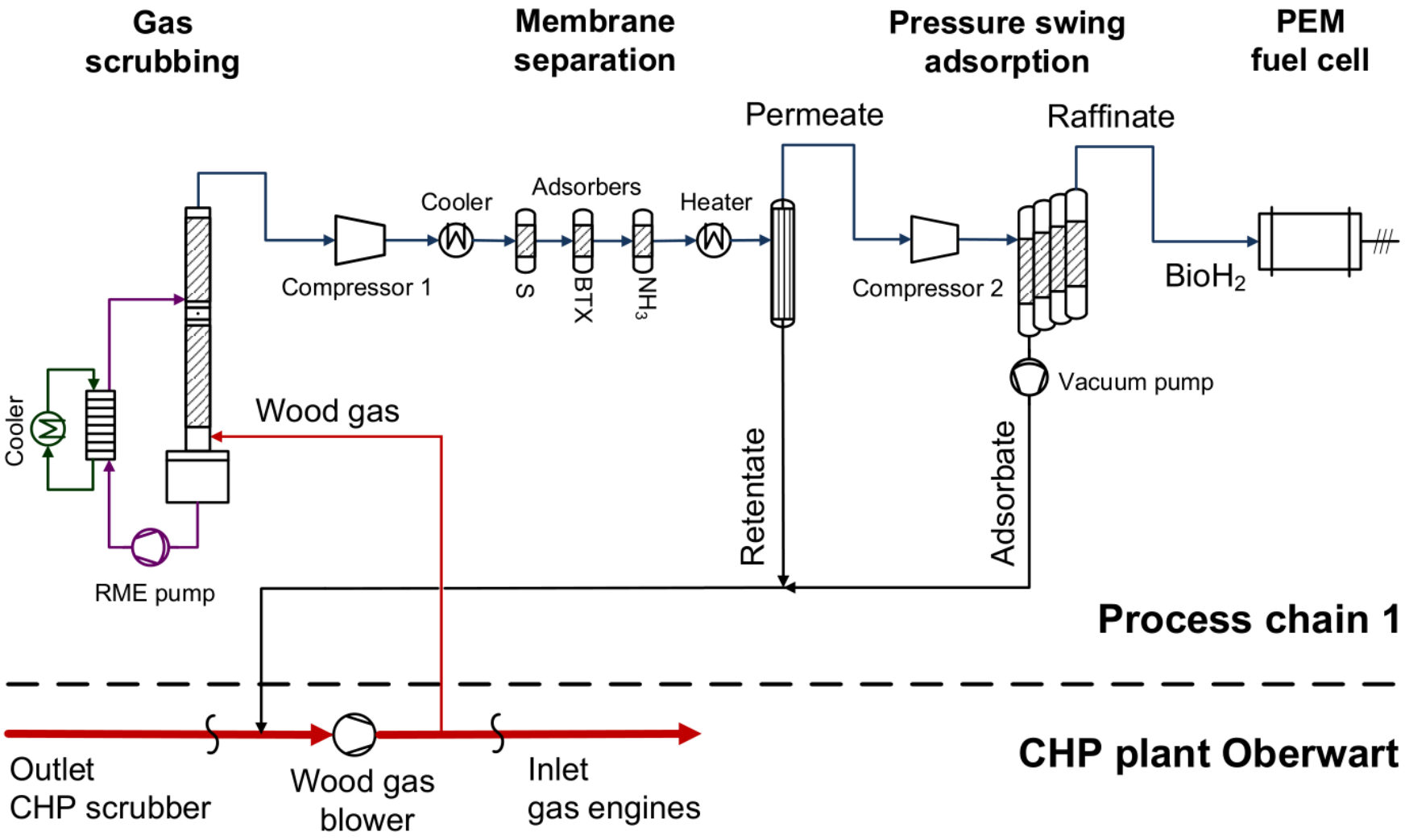
View into research container (1)
left hand side



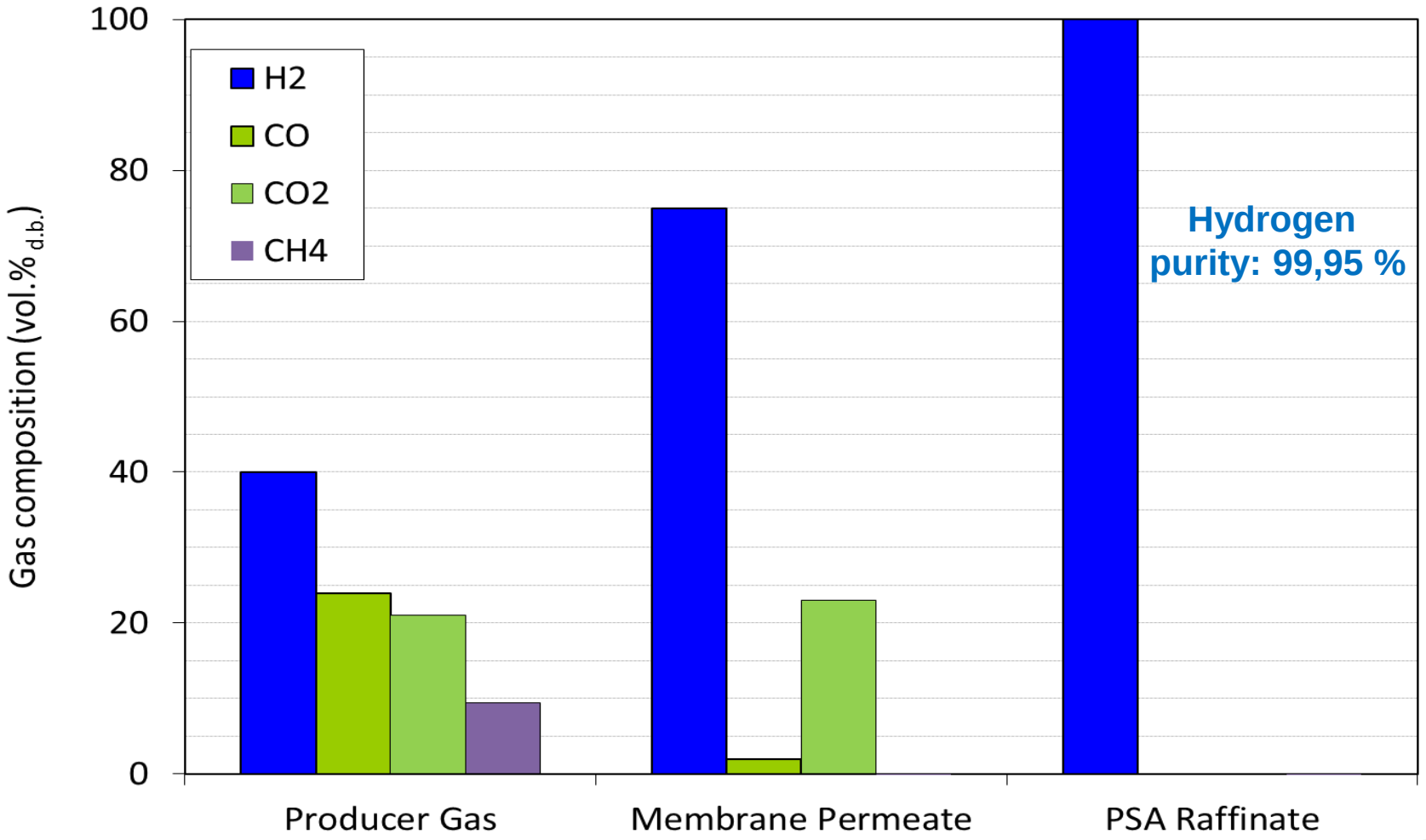
View into research container (2)
right hand side



Polygeneration
Process chain 1 for hydrogen production



Main gas components along the process chain 1

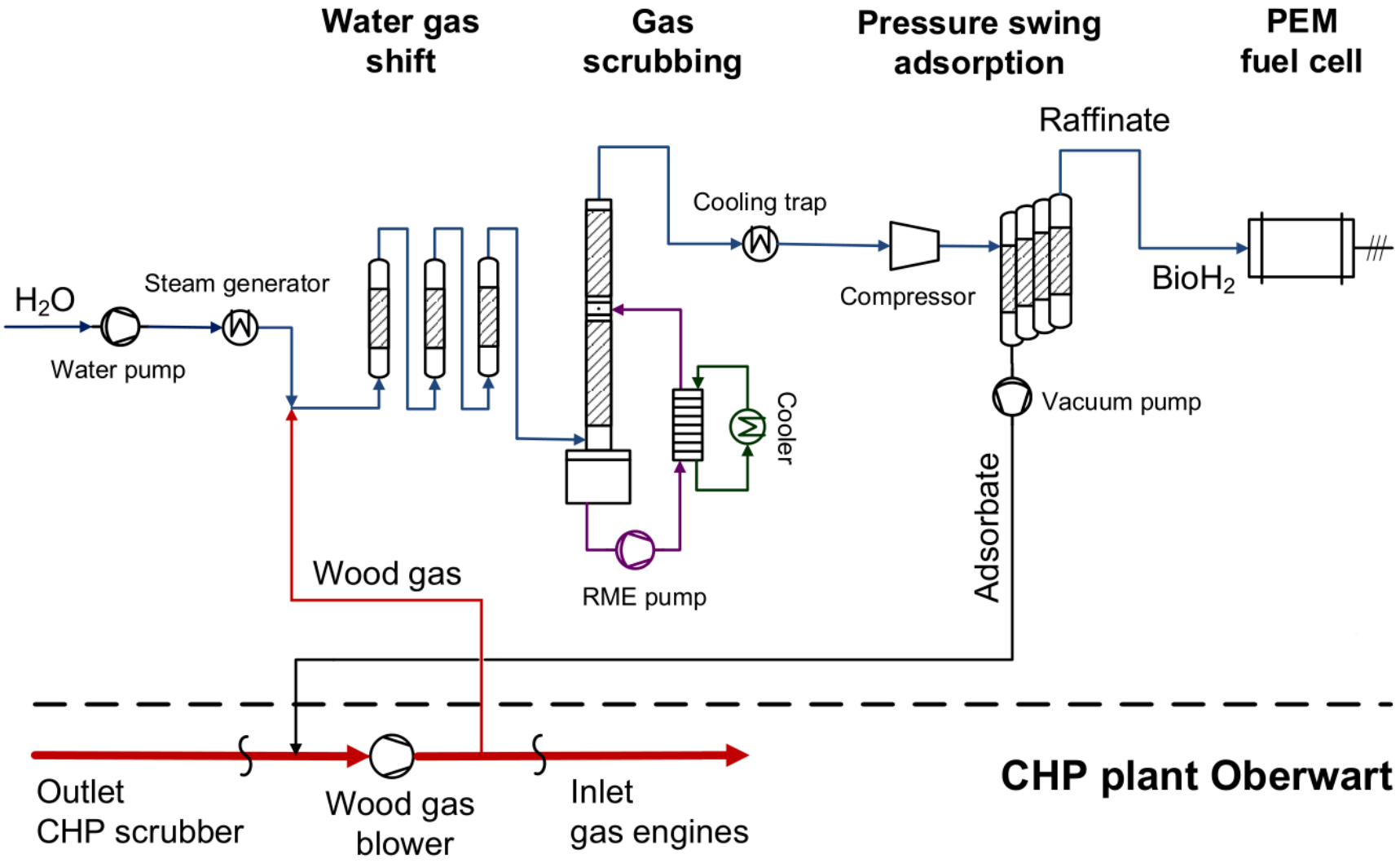


Data for PEM-fuel cell

- Type: PEM FC „Mobixane“
- Nominal load: 2500W
- Minimal load: 500W
- Electrical efficiency: about 50 %

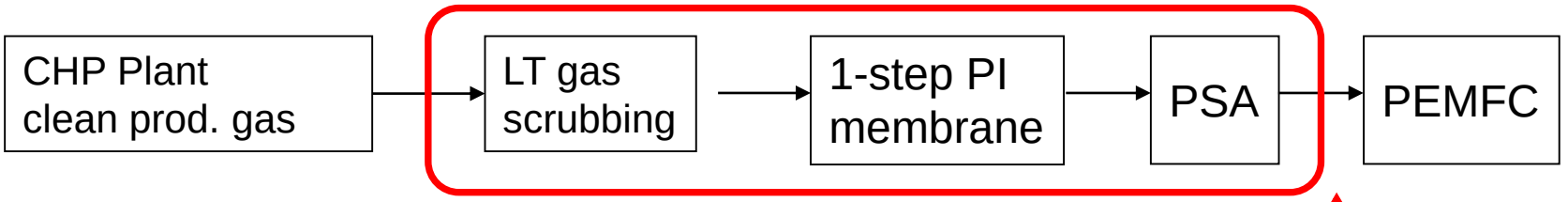
Polygeneration

Process chain 2 for hydrogen production

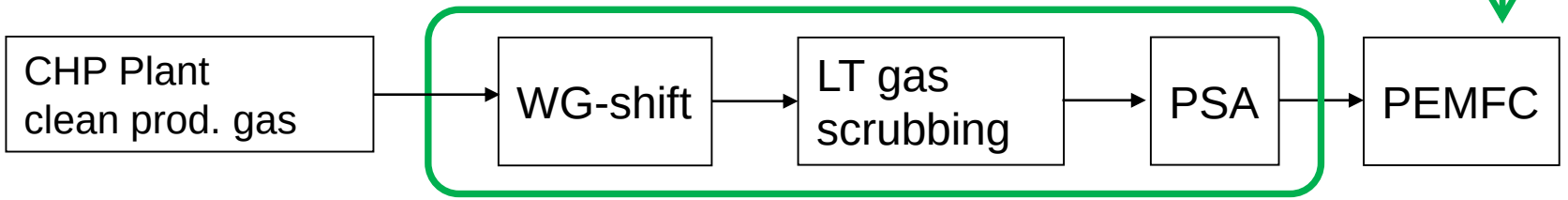


Comparison of performance data of process chain 1 and 2

Process chain 1

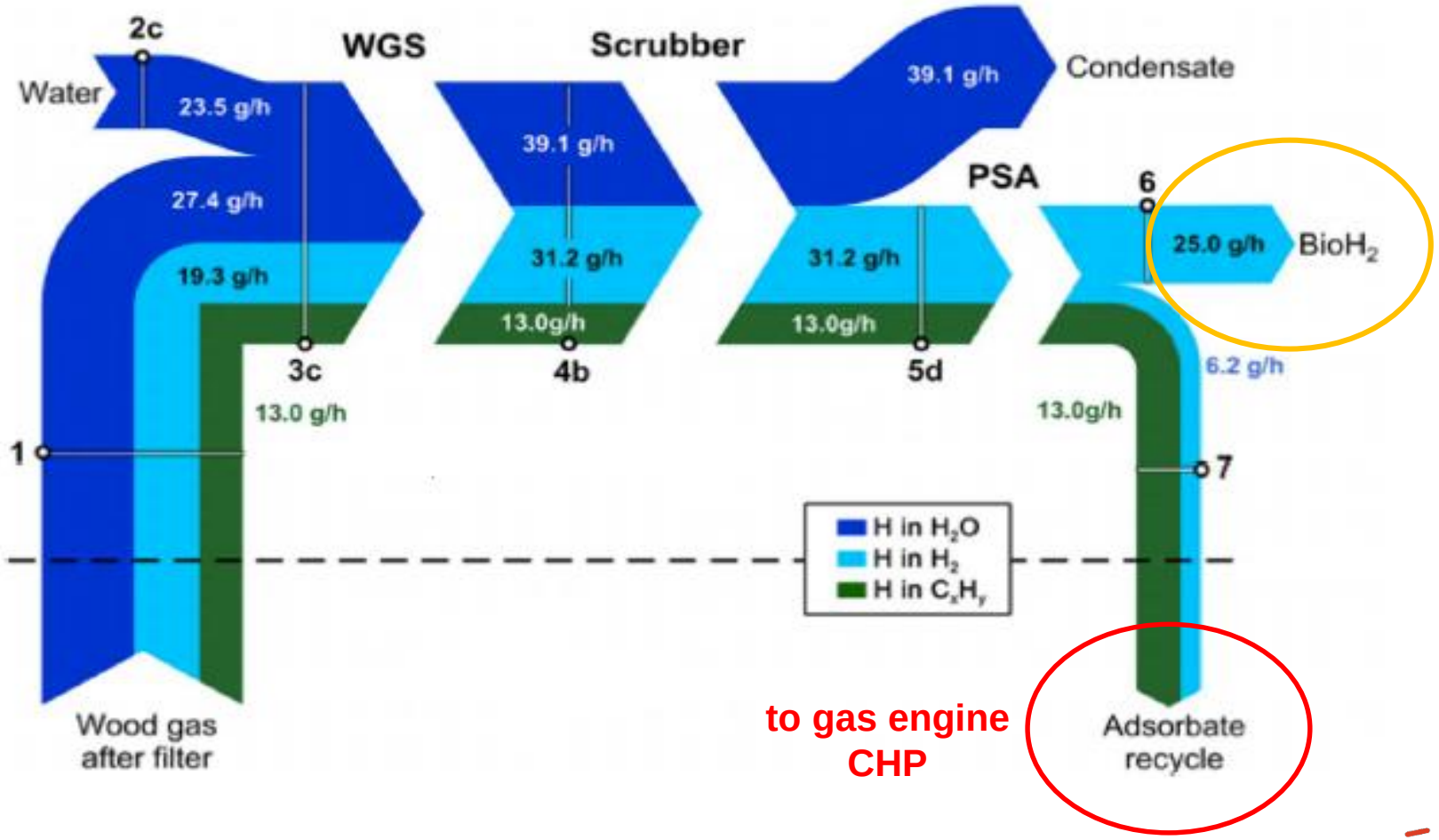


H_2 - Recovery	% $Nm^3_{BioH2}/Nm^3_{H2\ in\ PG}$	40	128
Electricity consumption	kWh_{el}/Nm^3_{BioH2}	1,69	0,46
Specific $BioH_2$ production	g_{BioH2}/kg_{Wood}	13,5	47,9

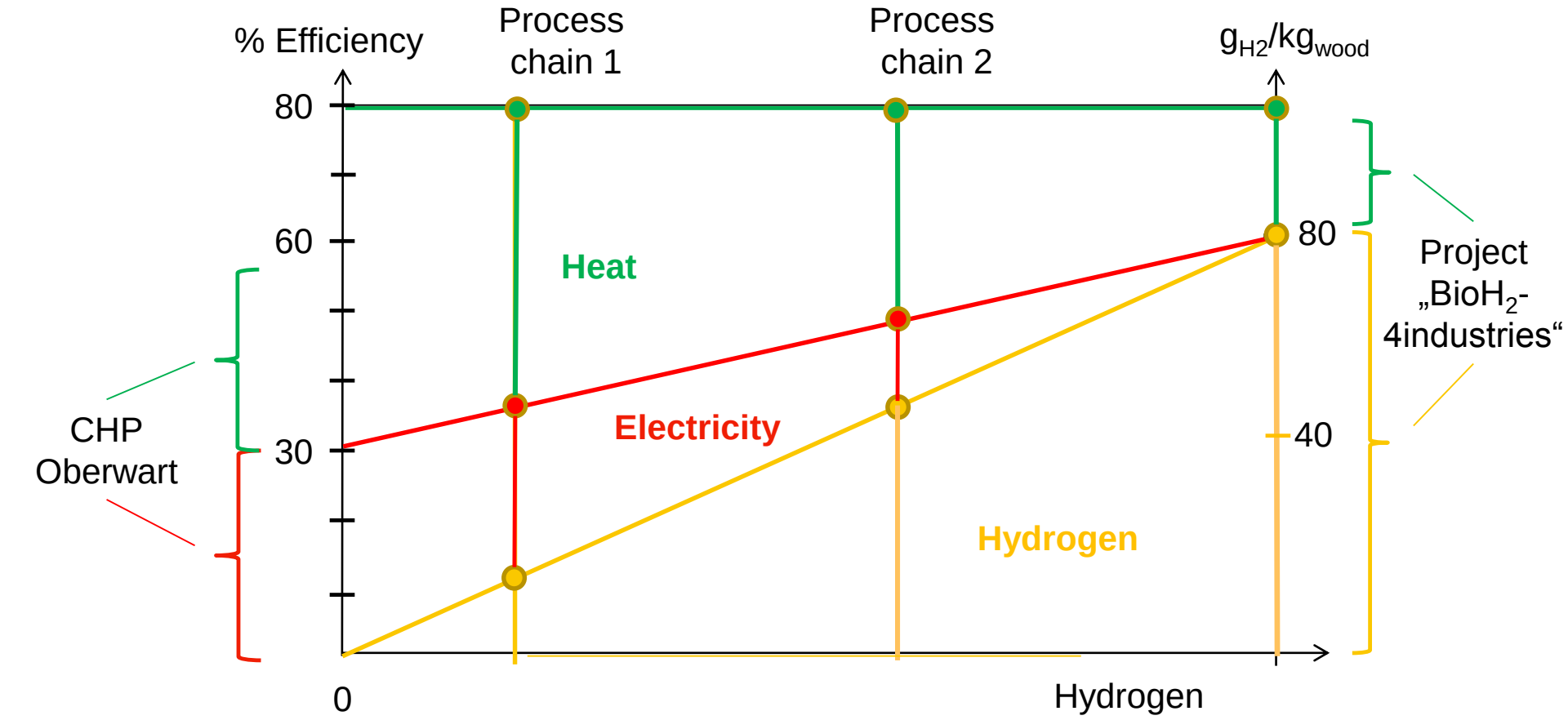


Process chain 2

Hydrogen mass flows of process chain 2

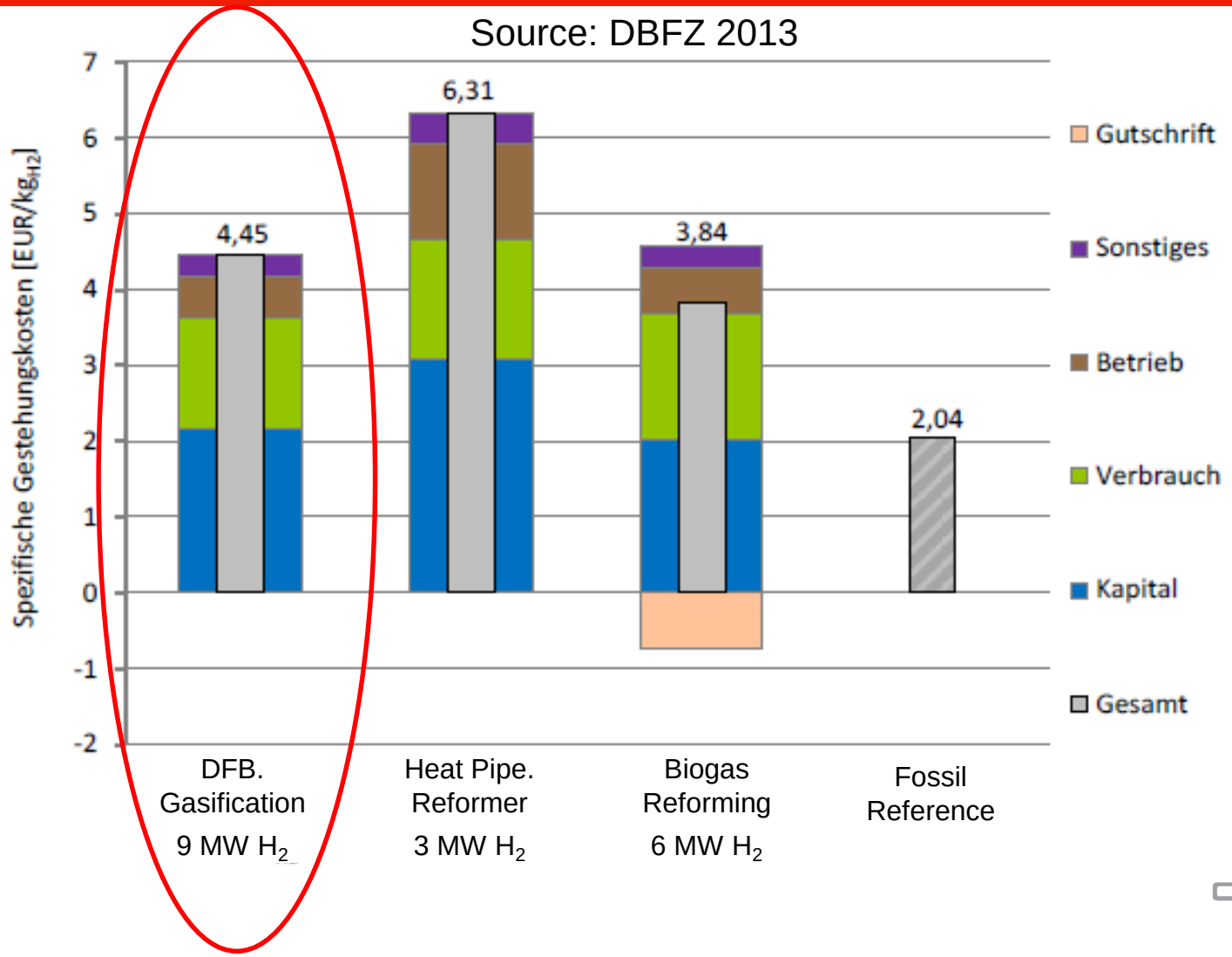


Polygeneration – flexibility & potential



Economic analysis of hydrogen production based on steam reforming

Source: DBFZ 2013

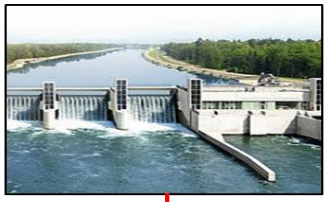


hydrogen-electric vision

hydrogen-electric vision

Biomass = Stored solar energy

Wind and hydro power



Primary energy

Regional generation

H_2-Storage

Electrolysis

Fuel cell

Transformation and storage

Transport

H_2 / Bio-H_2-grid

Electricity grid

Decentral generation

Further users

Final energy

Thank you for your kind attention !

energie BURGENLAND

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AIR LIQUIDE

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BioH2

BIOMASS-TO-HYDROGEN

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