bioenergy2020+

Biomass steam gasification - A platform for synthesis gas applications

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COMET

Competence Centers for Excellent Technologies

Team of R&D

- Scientific partners

TU WIEN VIENNA UNIVERSITY OF TECHNOLOGY Institute of Chemical Engineering

bioenergy2020+

- Engineering (as example)

repotec renewable power technologies

- Operators (as example)

BIOMASSE KRAFTWERK GUSSING

energie BURGENLAND

bioenergy2020+

Bioenergy 2020+ is a Competence Centre funded according to the rules of the COMET program from Austria

Start of the project in COMET Program:	01st April 2008
Foundation of company „bioenergy 2020+“:	29th January 2009
Headquarter:	Graz
Research locations:	Güssing, Wieselburg
Additional research locations:	Pinkafeld, Tulln
Budget per year:	4.5 Mio.€
Funding:	55%
Personal:	about 70 full time equivalents
Homepage	http://www.bioenergy2020.eu/

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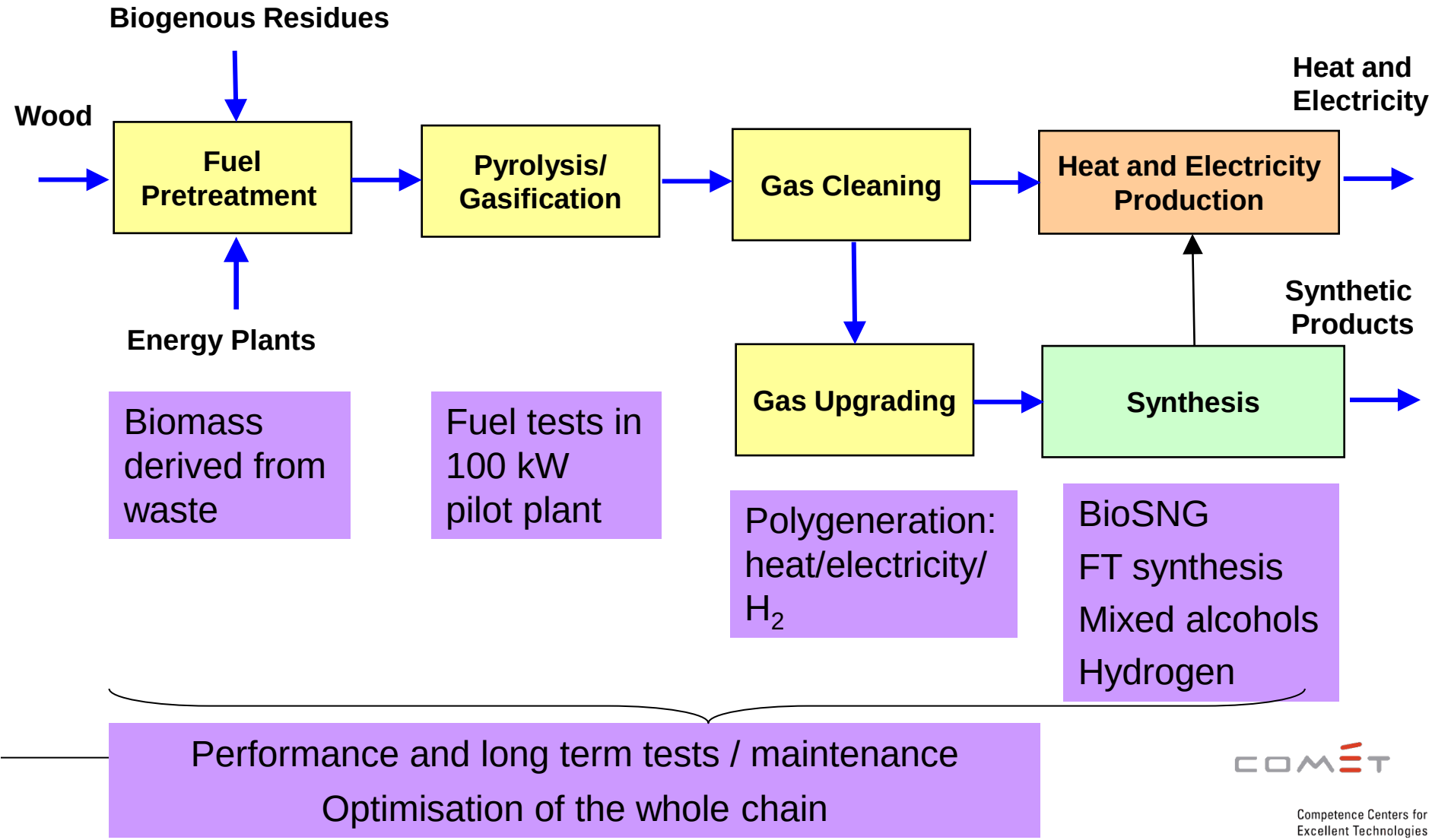
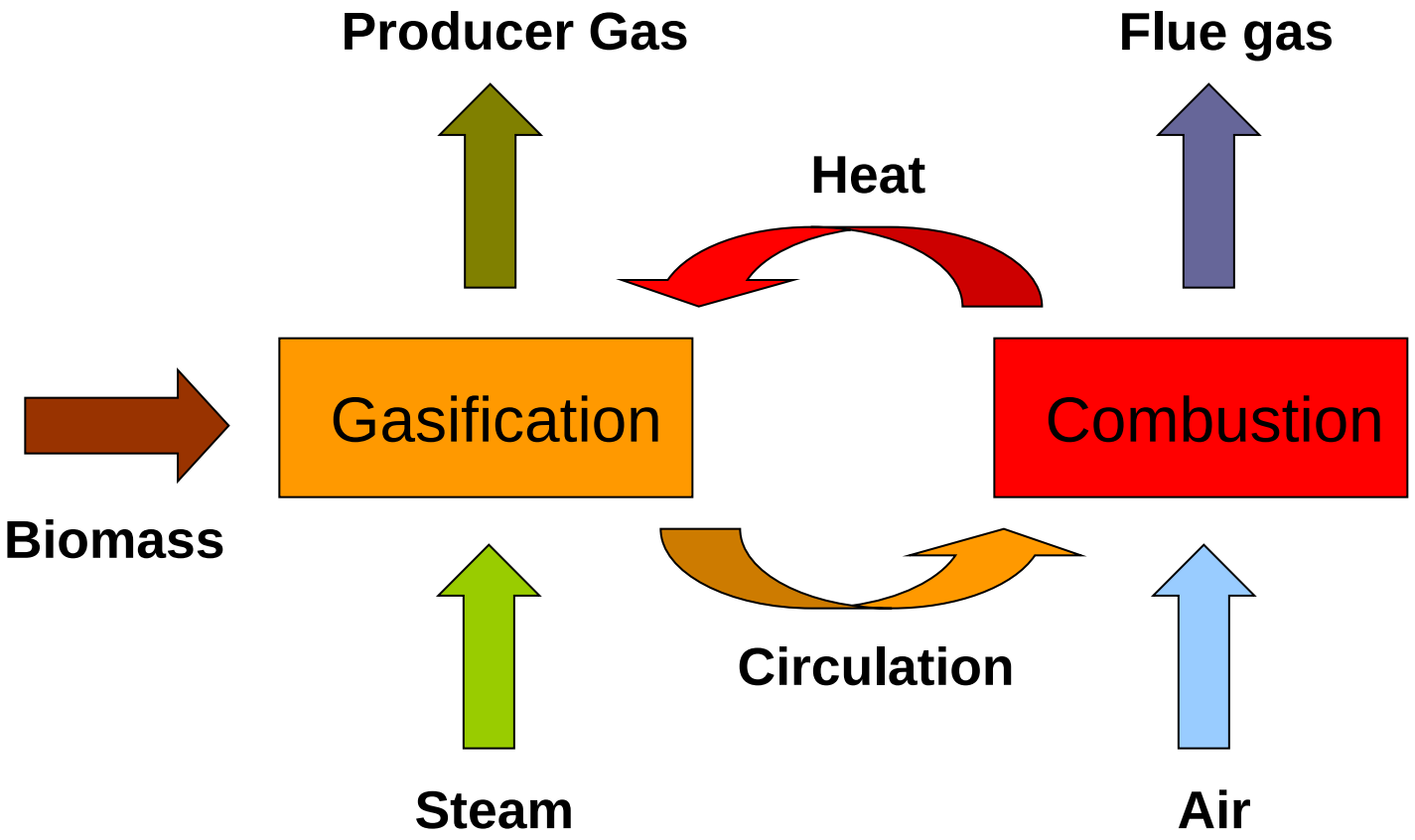
Bioenergy 2020+ Vision

State of science		Vision of BIOENERGY 2020+
Area I: Biomass combustion		
conventional biomass fuels (wood fuels, straw)	→	new biomass fuels (annual crops, short rotation plants, waste materials from the agricultural and the food industry, etc.)
modern biomass combustion technologies	→	next generation biomass combustion systems (towards zero emission technologies)
conventional CHP technologies	→	innovative small- and micro-scale CHP systems advanced highly efficient medium-scale systems
Area II: Biomass gasification, fermentation and liquid biofuels		
gasification based CHP (heat & power)	→	polygeneration plants (heat & power & BioSNG/BioFIT/hydrogen)
engine based CHP	→	combined cycles (e.g. IGCC) and fuel cells
1st generation biofuels (biooils, biodiesel, ethanol form sugar/starch)	→	2nd generation biofuels (synthetic biofuels e.g. BtL, upgraded biogas, ethanol from ligno-cellulosic materials, hydrogen)
Area III: Modelling and simulation		
single model development	→	virtual biomass conversion plant

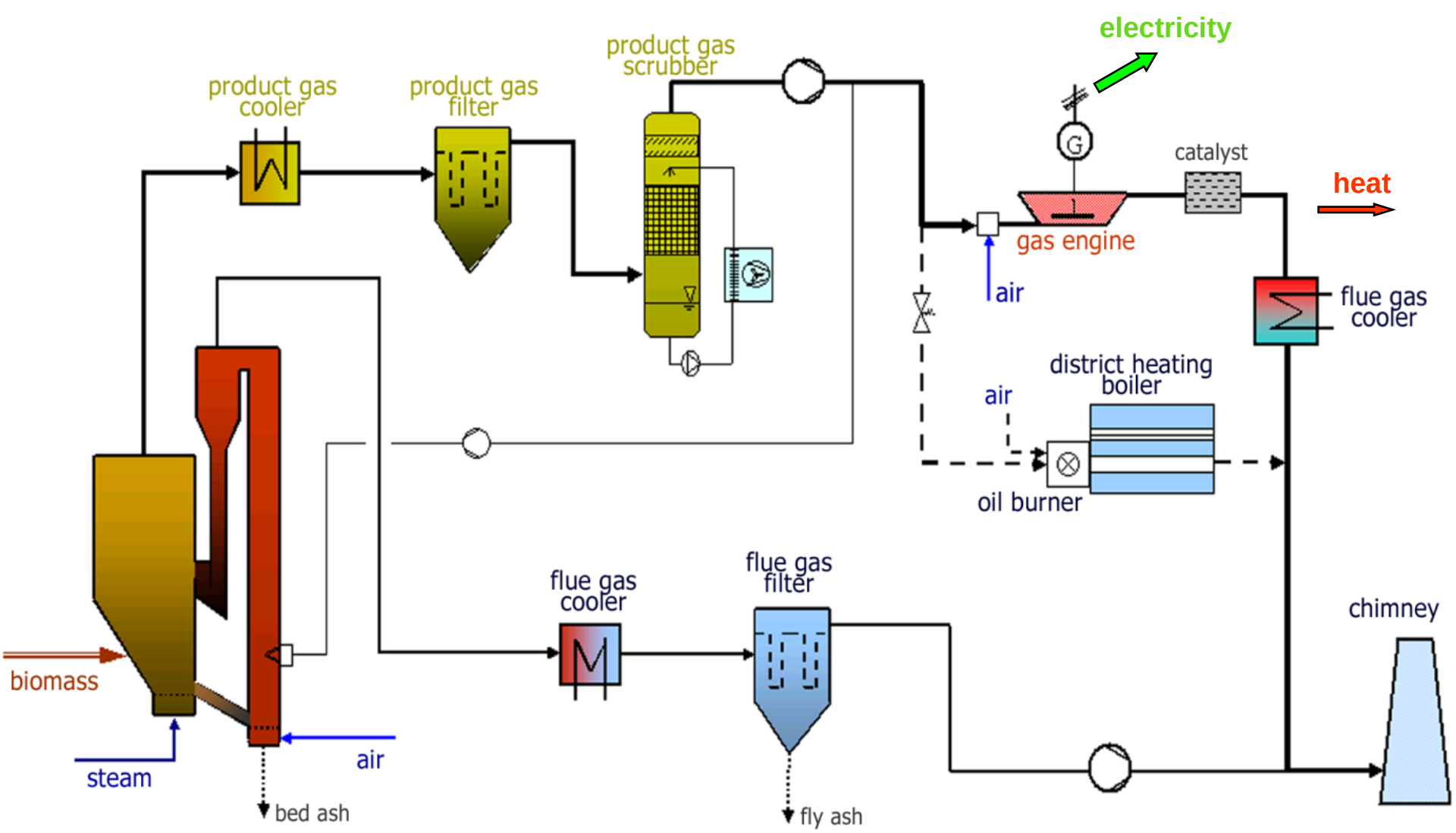
Research along the process chain



Gasification Concept of FICFB



CHP-PLANT GÜSSING



Gas Composition (after gas cleaning)

Main Components		
H_2	%	35-45
CO	%	20-25
CH_4	%	~10
CO_2	%	20-25

Minor Components		
C_2H_4	%	2-3
C_2H_6	%	~0.5
C_3H_4	%	~0,4
O_2	%	< 0,1
N_2	%	1-3
C_6H_6	g/m³	~8
C_7H_8	g/m³	~0,5
$C_{10}H_8$	g/m³	~2
TARS	mg/m³	20-30

Possible poisons		
H_2S	mgS/Nm³	~200
Mercaptans	mgS/Nm³	~30
Thiophens	mgS/Nm³	~7
HCl	ppm	~3
NH3	ppm	500-1000
Dust	mg/Nm³	< 20

H_2:CO = from 1.5:1 to 2:1

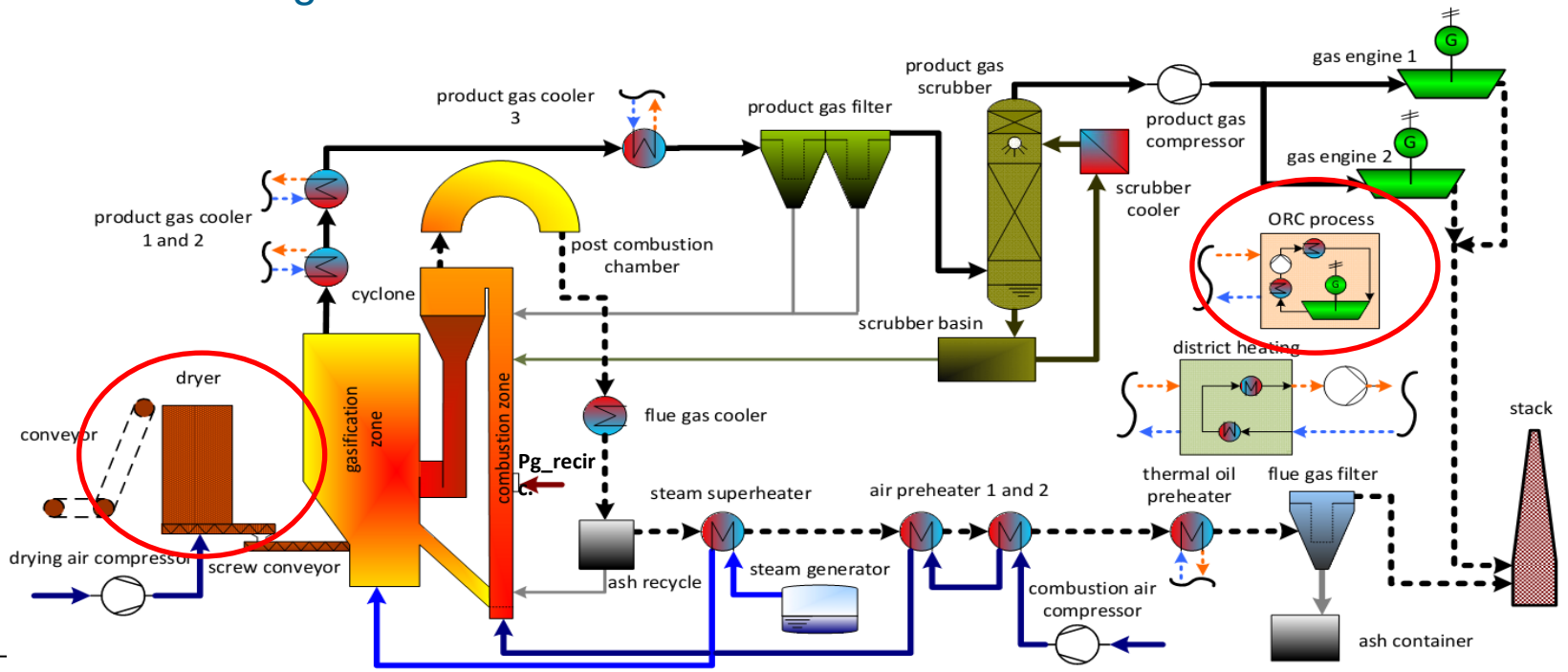
Commercial FICFB gasifiers

Location	Usage / Product	Fuel / Product MW, MW	Start up	Supplier	Status
Güssing, AT	Gas engine	8.0_{fuel} / 2.0_{el}	2002	AE&E, Repotec	Operational
Oberwart, AT	Gas engine / ORC / H_2	8.5_{fuel} / 2.8_{el}	2008	Ortner Anlagenbau	Operational
Villach, AT	Gas engine	15_{fuel} / 3.7_{el}	2010	Ortner Anlagenbau	Operational
Klagenfurt, AT	Gas engine, BioSNG	25_{fuel} / 5.5_{el}	?	Ortner Anlagenbau	Planing
Senden/Ulm DE	Gas engine / ORC	14_{fuel} / 5_{el}	2011	Repotec	Commissioning
Göteborg, Sweden	BioSNG	32_{fuel}/20 $_{BioSNG}$	?	Metso/ Repotec	Construction
Vienna, OMV	Hydrogen	50_{fuel}/30 $_{hydrogen}$	?	Repotec	Planing – decision end of 2012

FICFB Oberwart

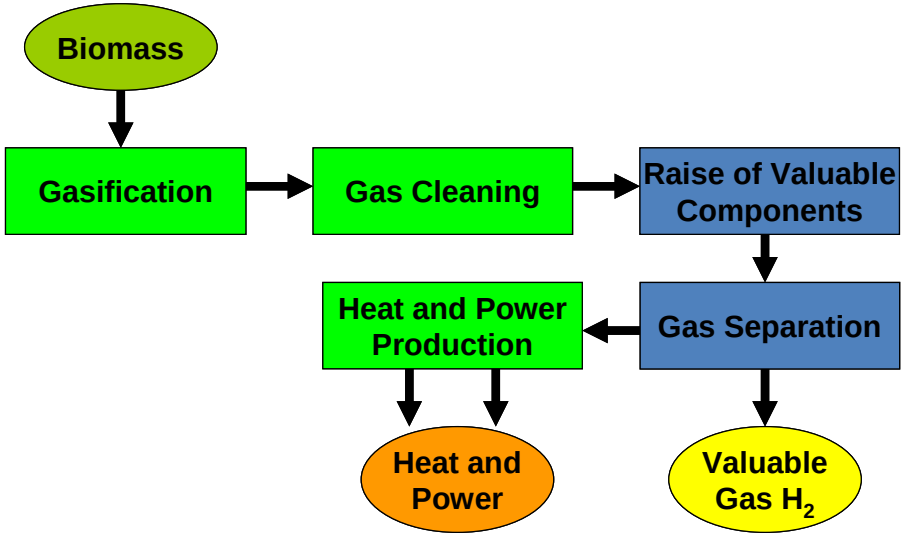
- FICFB, gas engine, ORC
- 8.5 MW_{fuel}, 2.8 MW_{el}
- 17.000 t wood chips/year
- District heating distance 5.2 km

Product gas composition	
H_2	35 - 45 vol. %
CO	18 – 23 vol. %
CO_2	20 – 24 vol. %
CH_4	7 – 10 vol. %
C_xH_y	1-3 vol. %

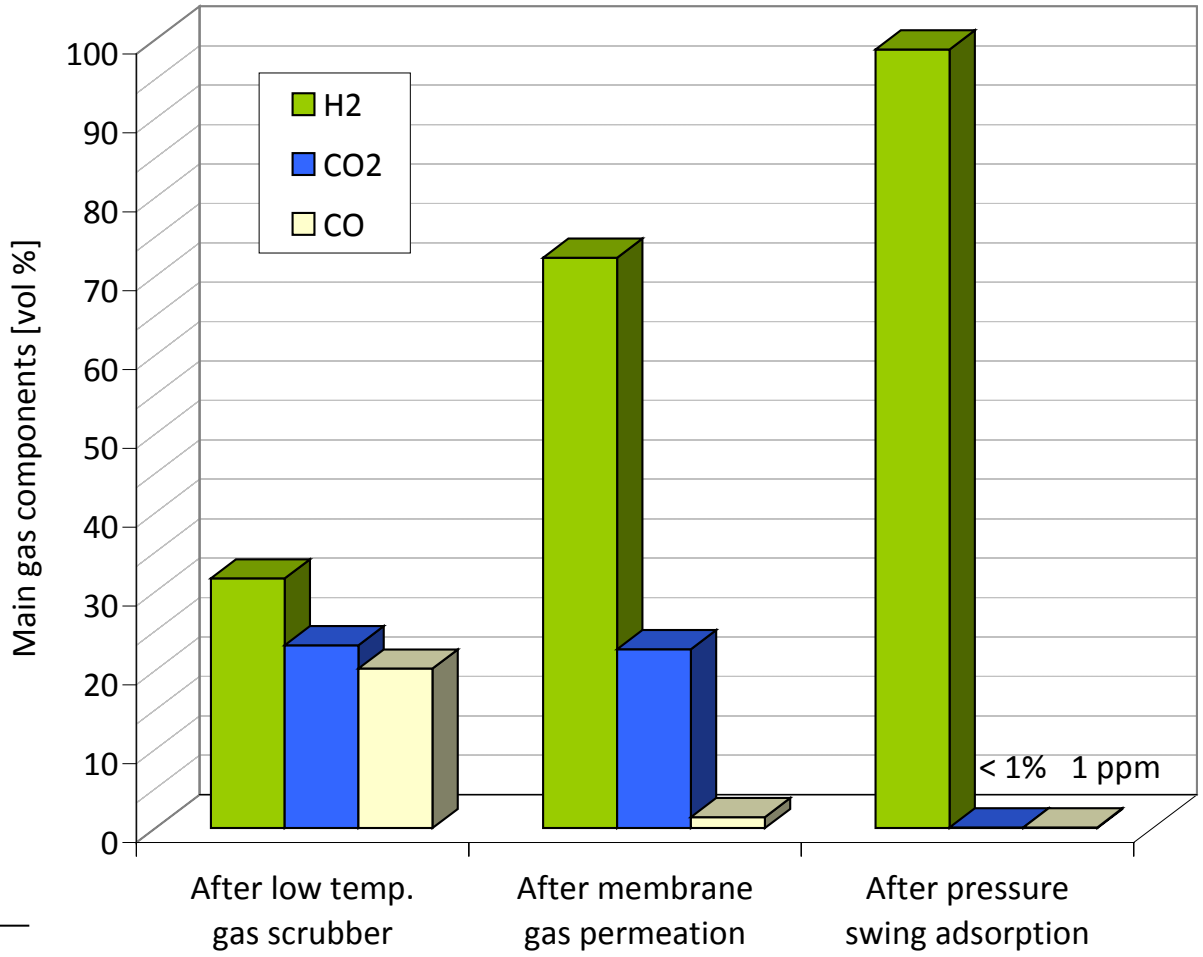


Polygeneration
Production of Valuable Gases, Electricity and Heat from Biofuels

- **Objective:**
- Develop economic feasible process configurations for the production of valuable gases, heat and electricity by using polygeneration strategies.
- **Milestones:**
  - Raise of valuable gases in producer gas
  - Separation of valuable gases from producer gas
  - Optimization of process chains
  - Design of pilot plant



Polygeneration – Results



Hydrogen is used in a PEM fuel cell

Biomass CHP Güssing

- FT synthesis
- Mixed Alcohols
- Hydrogen

Gasifier

BioSNG PDU

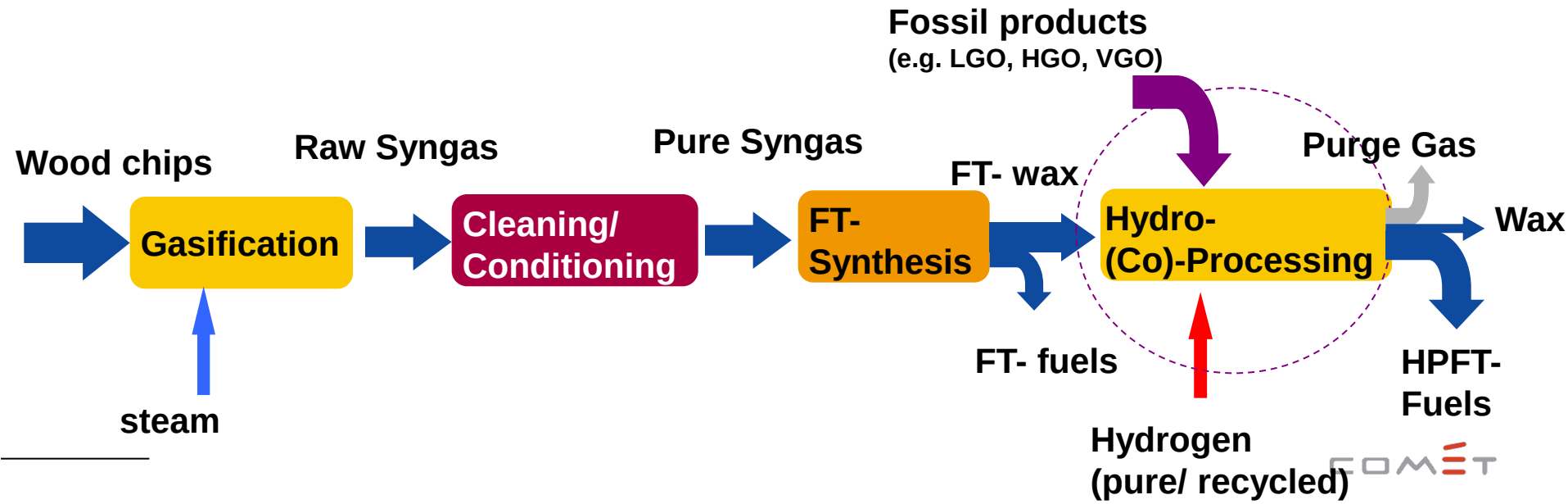
Technikum

Fuelling Station

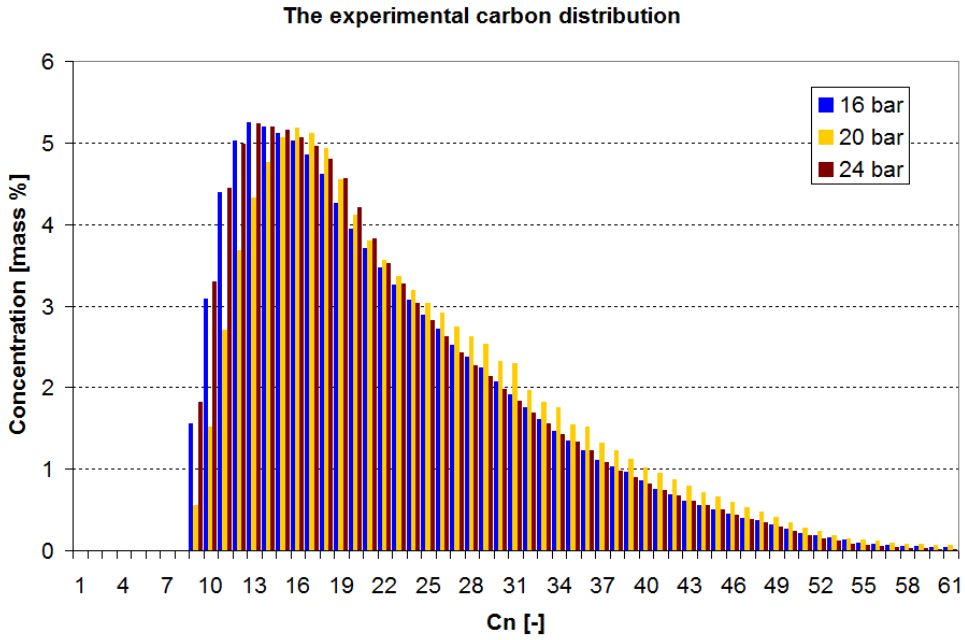
Synthetic biofuels (FT- Route)

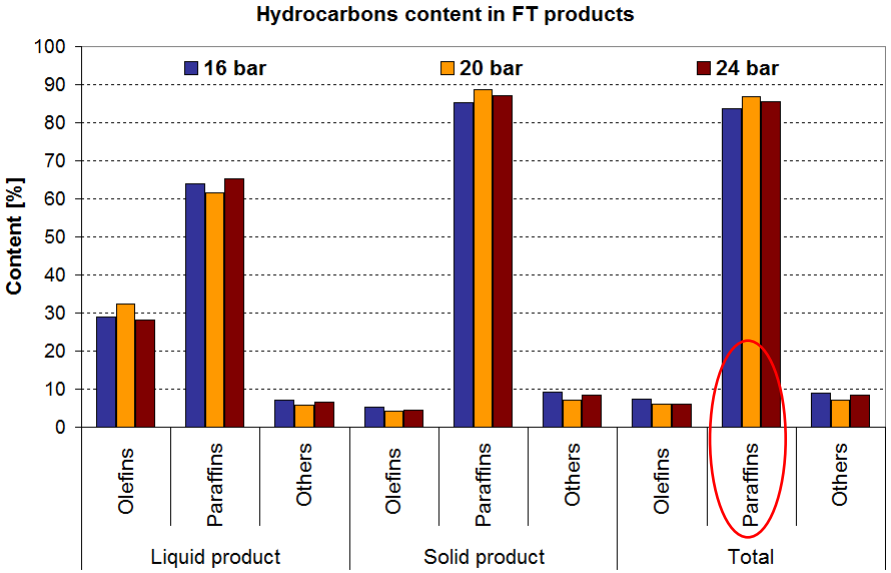
Cellulose, Polyose (Hemicellulose)
Lignin

i/n- paraffins
(hydrocarbons)



Product distribution and Hydrocarbons content



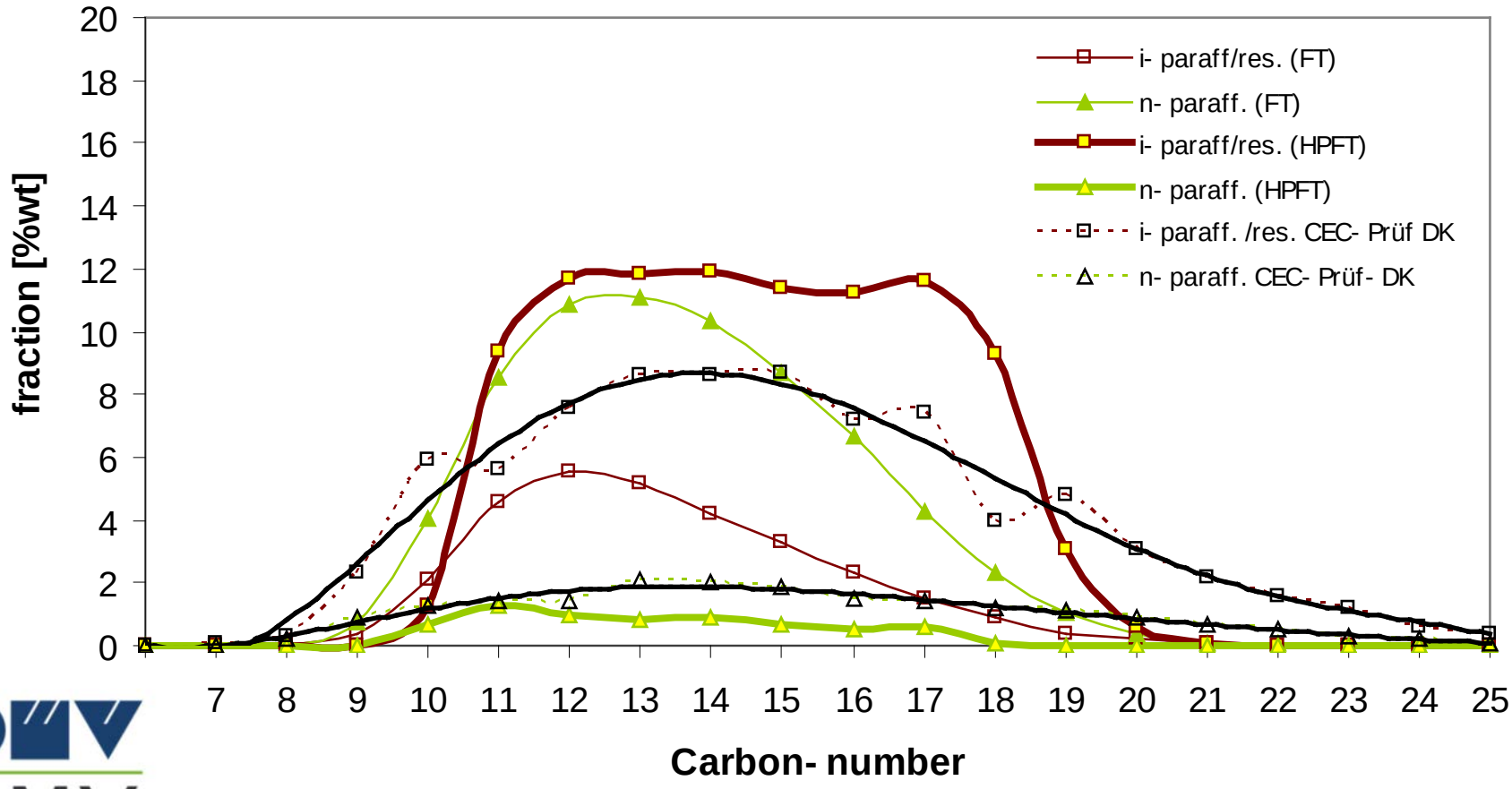


Performances of FT synthesis

Experiment	Pressure [bar]	CO conversion [%]	α value [-]	C_{5+} selectivity [%]	Par/Ole ratio [-]	H_2/CO ratio [-]
1	16	44.2	0.892	90.6	11.4	1.5
2	20	52.5	0.9	91.7	14.1	1.6
3	24	63.7	0.89	90.3	13.8	2.0

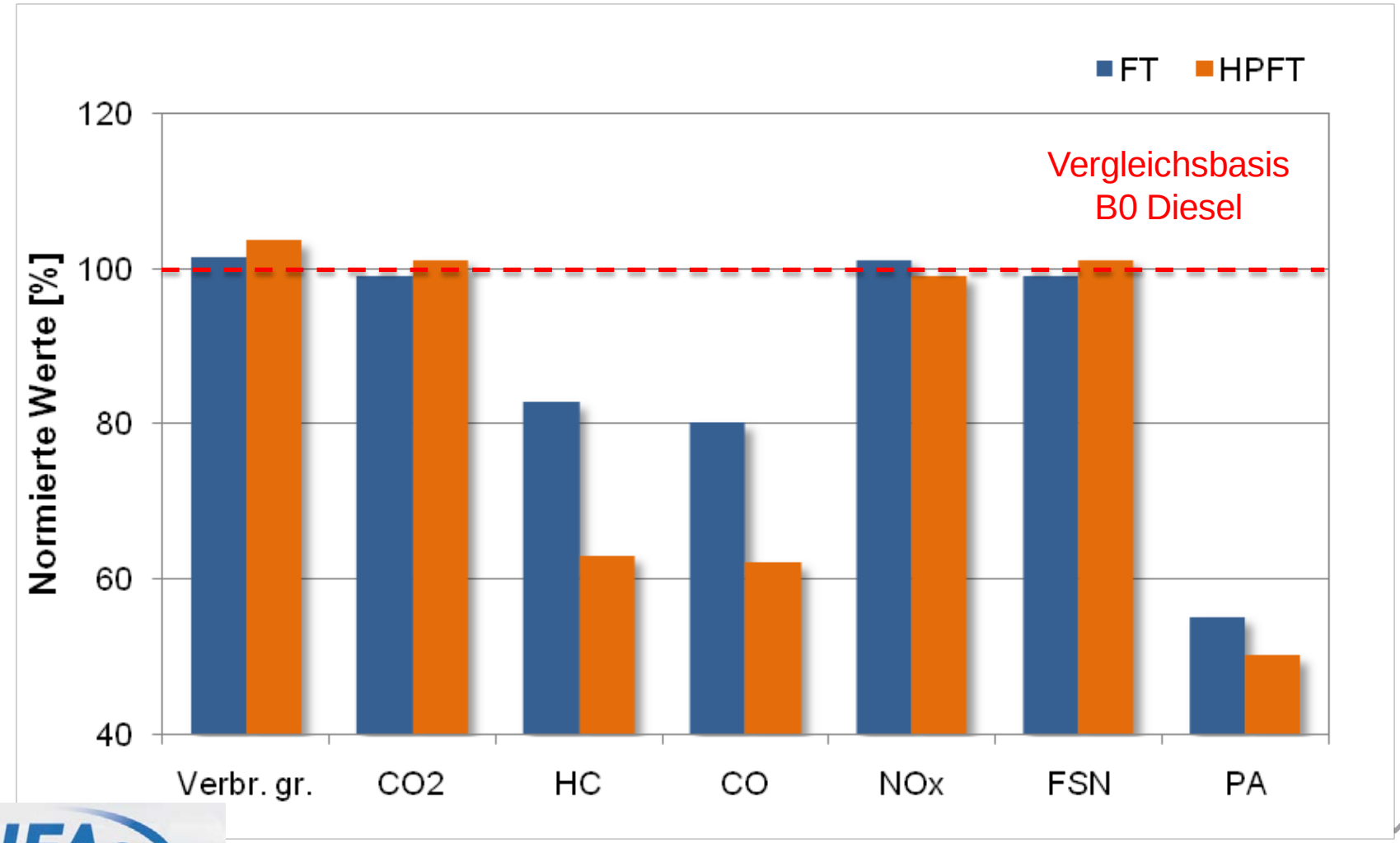
Comparison of produced FT Fuels

	FT- Diesel	HPFT- Diesel	CEC- Prüf.
ACN:	>72 t_d = 2,5 s	68,5 t_d = 2,91 s	>51,8 /
CFPP/CP/FP:	-12/ -9/ - °C	-62/ -60 / -98°C	-18/ -5 °C

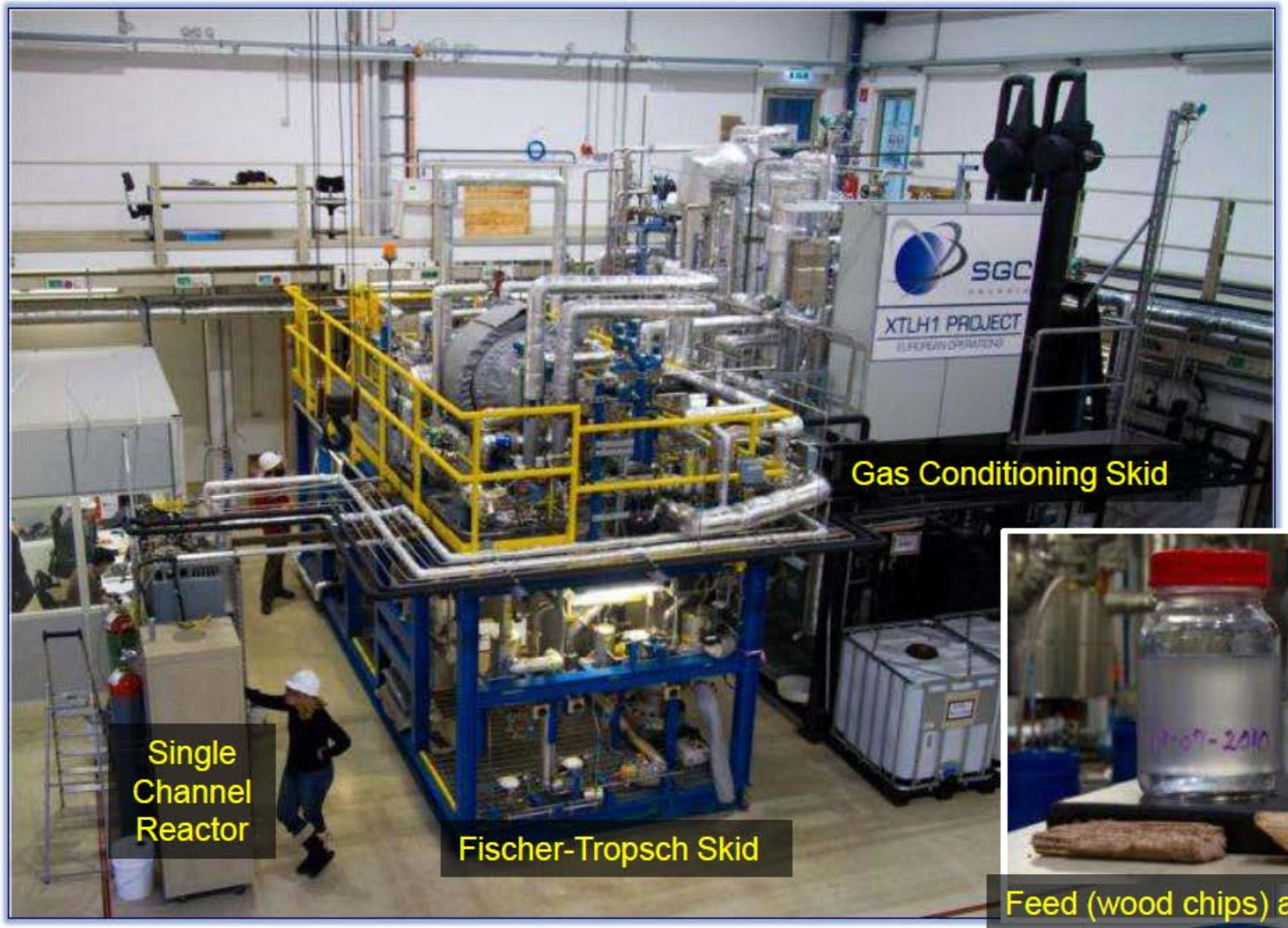


OMV

Results on engine tests with 20% blends



SGC Energia finished successfully their 1 bpd demo



Feed (wood chips) and FT Product

OXFORD CATALYSTS

VELOCYS

Mixed alcohols

- Funded by „Klima und Energiefonds“ and Bioenergy 2020+
- Aim is to get fundamental know how in the synthesis of mixed alcohols from biomass
- Main advantage is very simple gas cleaning, due to sulphur resistant catalyst

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Actual status: first experiments are done

Reformer

Drying
(glycol-scrubber)

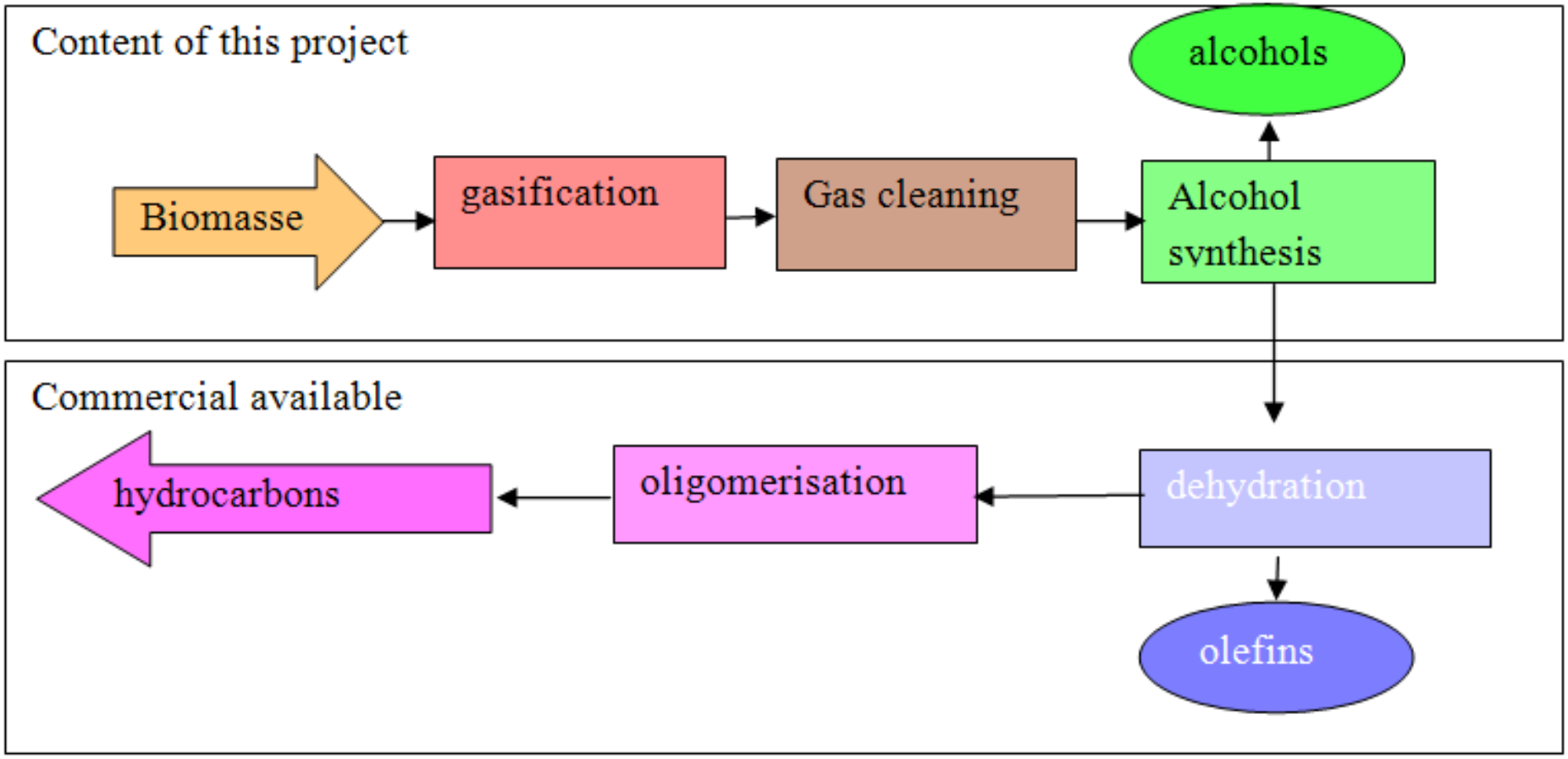
Compressor
(5-7 Nm³/h;
90-300 bar)

Reactor

Molybdenum Catalysts

- The MoS based catalysts need about 50-100ppm of H_2S in the synthesis gas to keep the sulfidation status constant which is necessary for a constant activity. So a removal of sulphur is not necessary, which reduced the investment costs dramatically.
- These catalysts are not sensitive to CO_2 in the synthesis gas. Only for CO_2-contents above 30% a removal of CO_2 is necessary.
- Carbon deposits (coking) are normally no problem, also at H_2/CO ratios smaller than 2.
- Mainly linear alcohols are produced.

Synfuel plant



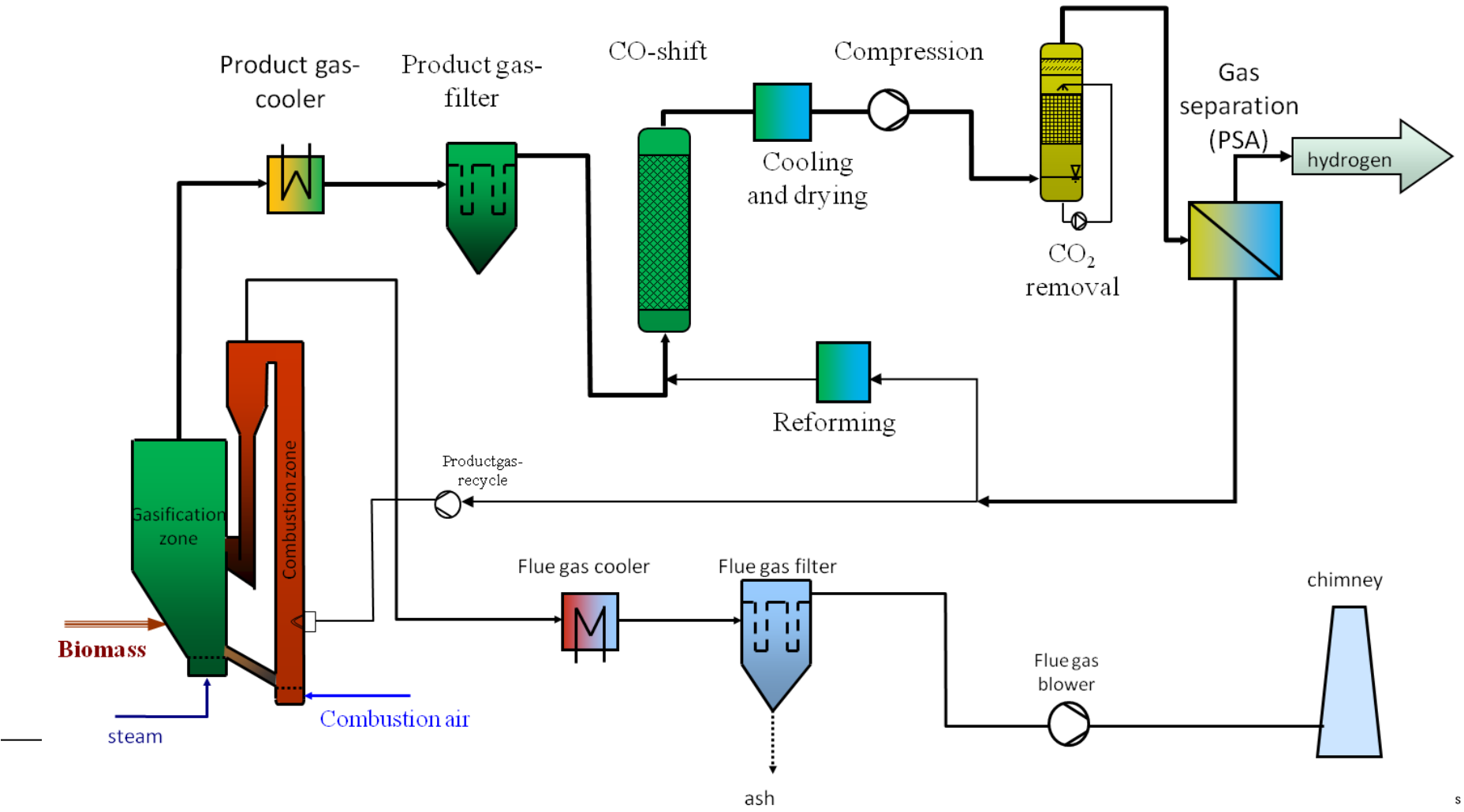
BioH2-4Refineries

Economic evaluation of production of hydrogen for a refinery

- Coordination by OMV
- 50 MW fuel plant to replace fossil hydrogen
- Evaluation of the biomass resources available for such a plant
- Basic - engineering of the gasifier as well as of all other sub units, including pipelines, utility systems, logistic needs
- Optimal use of by-products
- Economic evaluation

klima+ energie fonds

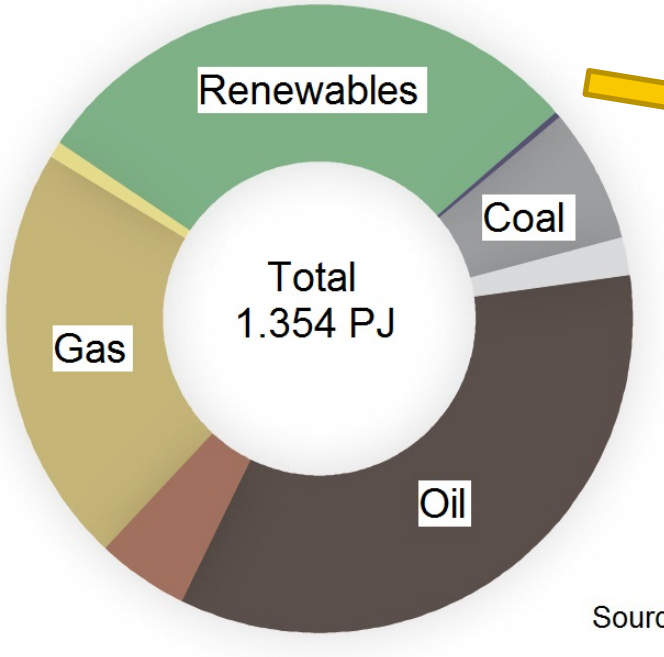
Simplified flow chart



Current Status and Outlook

- Successful scale up of a dual fluidized bed steam gasification system from laboratory to industrial scale **(within 10 years)**
- Industrial plant available with
  - High electrical efficiency (> 30 % with combined gas engine and ORC-process)
  - No solid residues (only ash, carbon content <0,5 %)
  - No liquid condensates
  - European emission requirements are met
  - High availabilities (>90 %)
  - Three plants are already in operation (8-15 MW_{fuel})
- High potential for biofuels (BioSNG, BioFiT)
  - BioSNG, most suitable, 1 MW (100 m^3/h BioSNG), demonstration plant is in operation (soon again)
  - BioFiT, research ongoing, scale up to 1 bpd is ongoing
- Biomass CHP Güssing optimal for research, as cheap synthesis gas is available for 7000 hours per year

Future

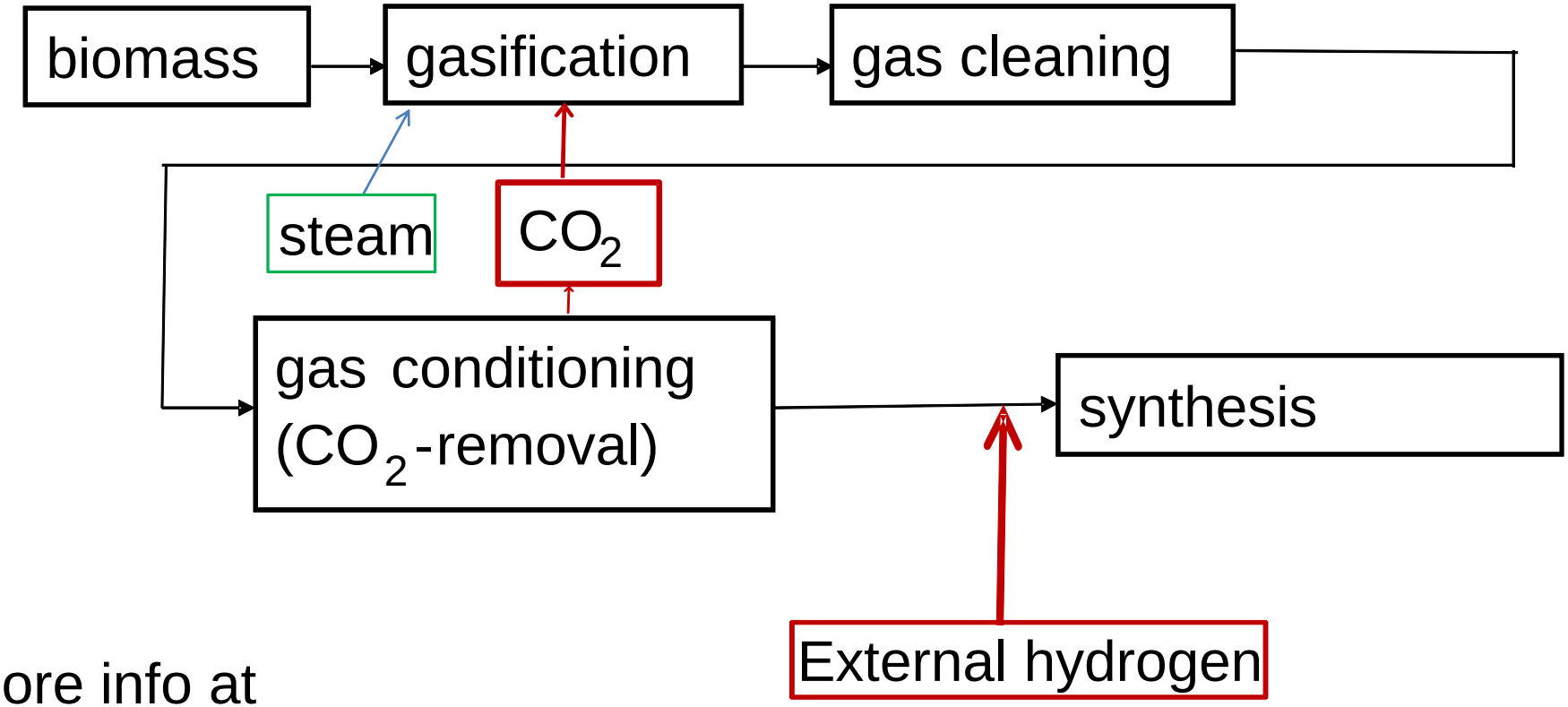


29,3 %	Renewables and wastes
0,2 %	Import electric energy
,9 %	Coal
.1 %	Coal, not energ. consumption
34,2 %	Oil
4,9 %	Oil, not energ. consumption
21,6 %	Gas
0,8 %	Gas, not energ. consumption

Source: Statistik Austria, Energiebilanzen 1970-2009, Österreichische Energieagentur

More info at
http://www.ficfb.at
http://www.vt.tuwien.ac.at
http://www.bioenergy2020.eu

Conversion of wind and photovoltaic to transportation fuels



More info at
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