Technische Universität Wien
Vienna University of Technology
Institute of Chemical Engineering
bioenergy2020+

Production of FT-diesel

Dr. Reinhard Rauch
Bioenergy 2020+
Vienna, University of Technology

Nationaler Workshop Biotreibstoffe
29th September 2016

Fulcrum Bioenergy Sierra Biofuels Plant

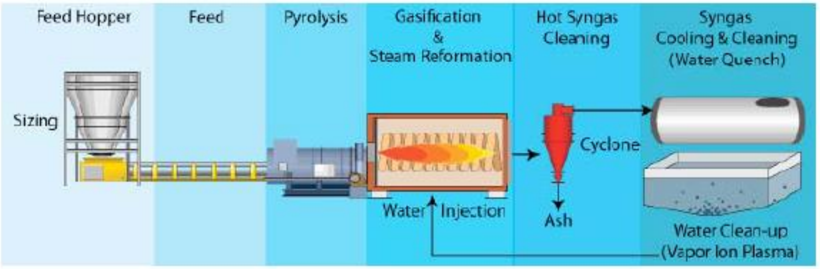
- Waste to FT fuels
- 200,000 t/y MSW
- Designed for 10 million gallons syncrude
- TRI gasifier
- Agreement with United Airlines
- Collaboration with Tesoro
- Startup expected late 2017

Fulcrum BIOENERGY

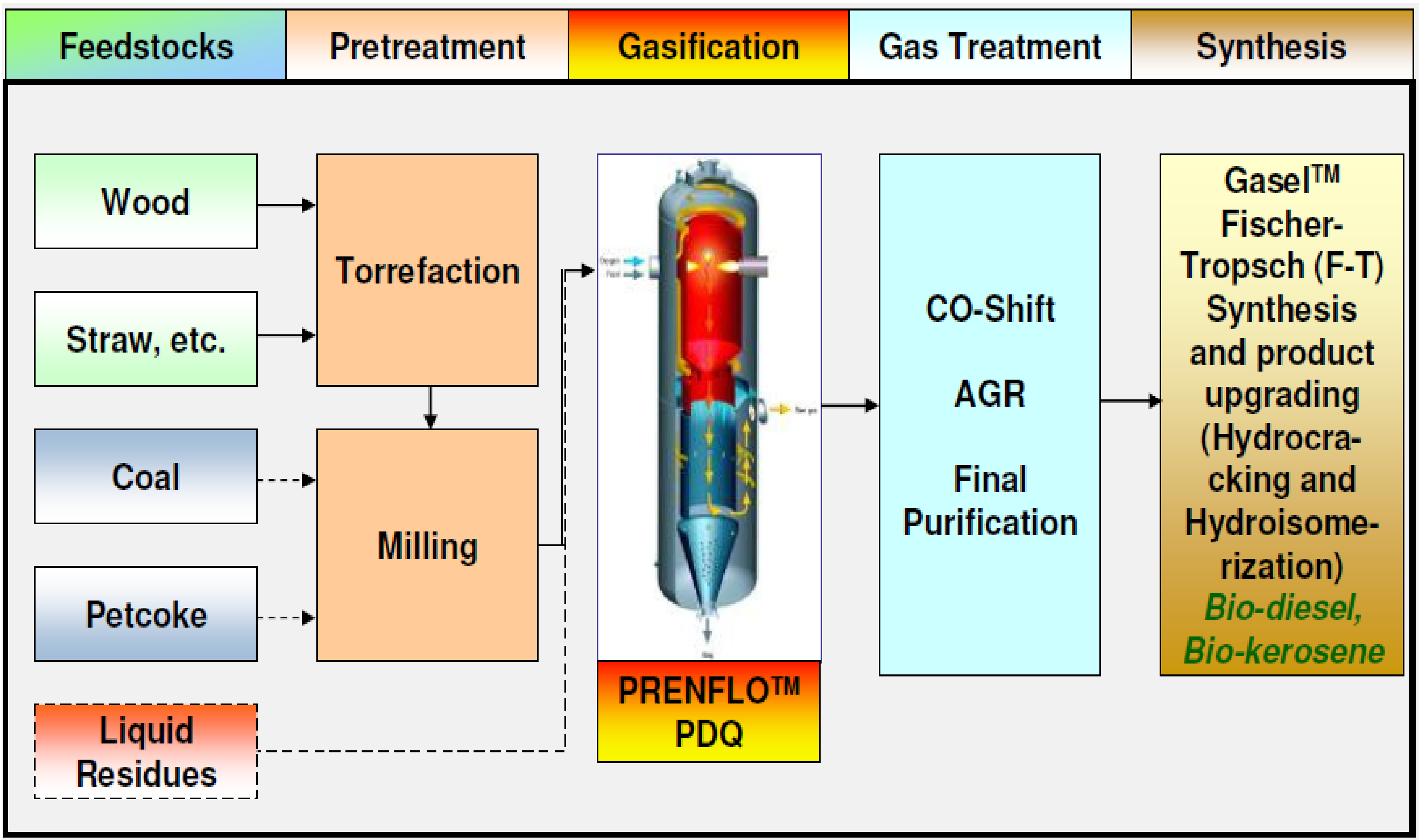
TESORO

Red Rock Biofuels

- Biomass to FT fuels
- Lakeview, Oregon
- TCG Global gasifier
- Veolocys for FT
- Targeting jet fuel
- Target completion 2016
- $182 million investment
- Recent partnership announced with FedEx
  - provide 3 million gal/y of biofuels
  - blended to 7 million gal/y
  - 2017 to 2024



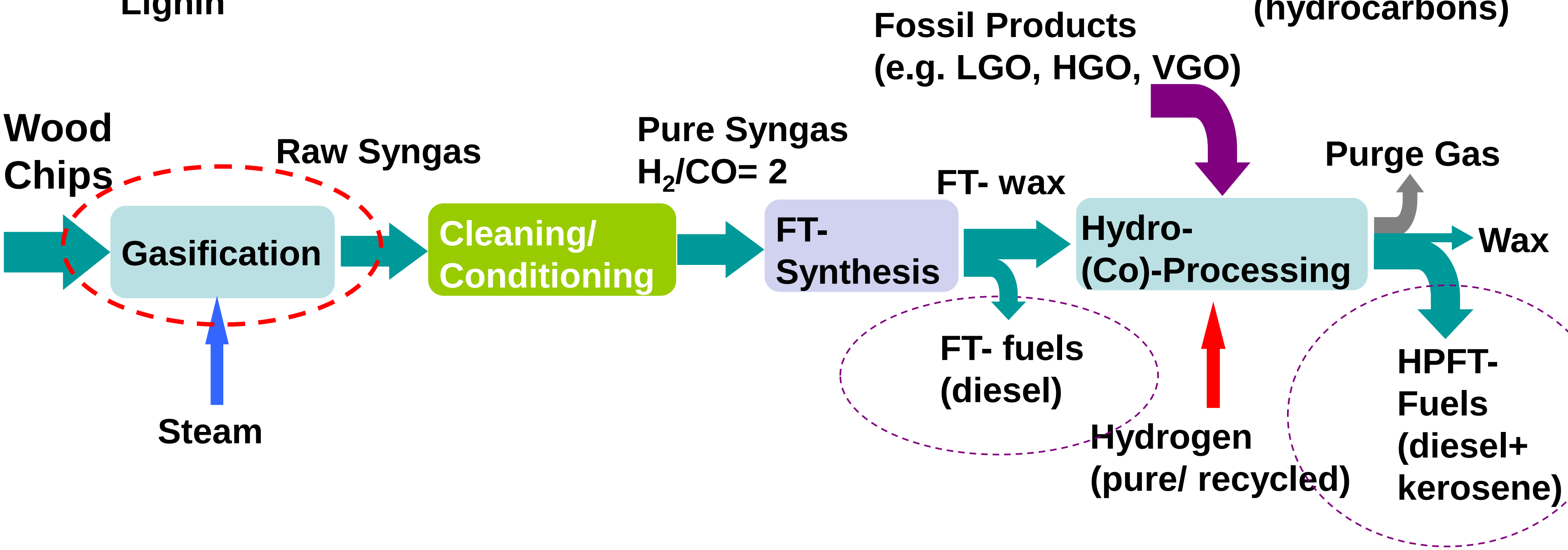
BioTfueL, Frankreich



Synthetic Biofuels (FT- Route)

Cellulose
Hemicellulose
Lignin

i/n- paraffins
(hydrocarbons)



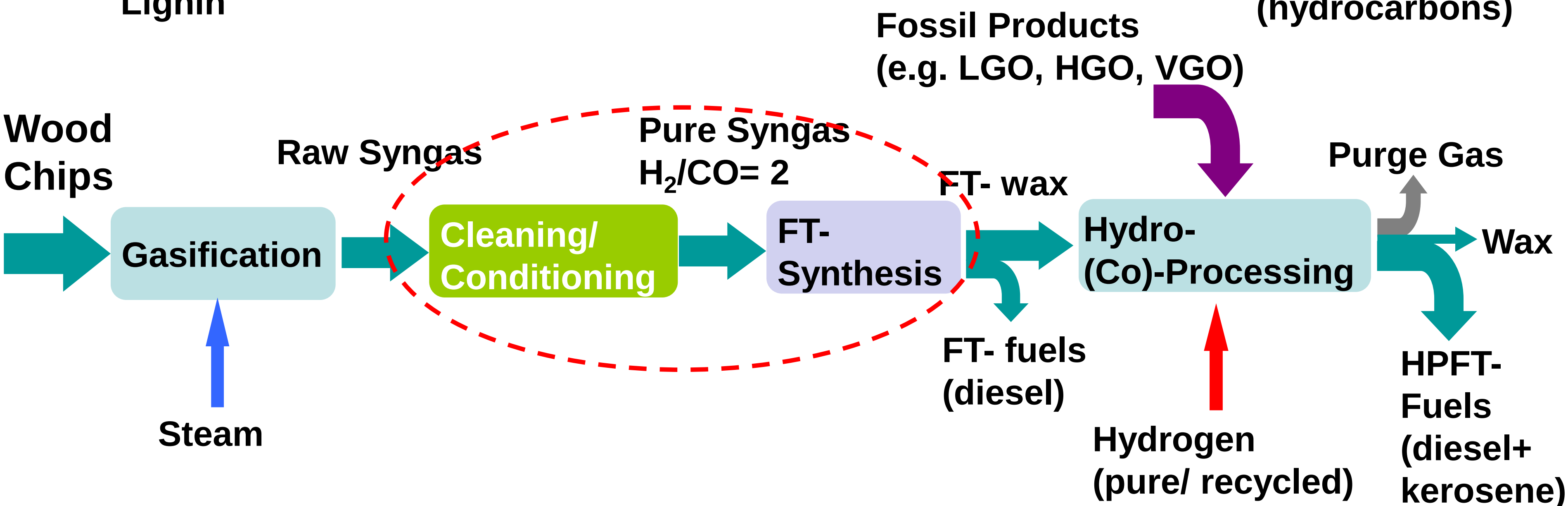
Commercial FICFB Gasifiers

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	On hold
Senden/Ulm, DE	Gas engine / ORC	14_{fuel} / 5_{el}	2011	Repotec	Operational
Burgeis, IT	Gas engine	2_{fuel} / 0.5_{el}	2012	Repotec, RevoGas	(Operational)
Göteborg, Sweden	BioSNG	32_{fuel}/20_{BioSNG}	2013	Repotec/ Valmet	Operational
California	R&D	1 MW $_{fuel}$	2013	GREG	Operational
Gaya, France	BioSNG R&D	0,5 MW $_{fuel}$	2016	Repotec	Commissioning
Thailand	Gas engine	4_{fuel} / 1_{el}	2016	GREG	Under construction

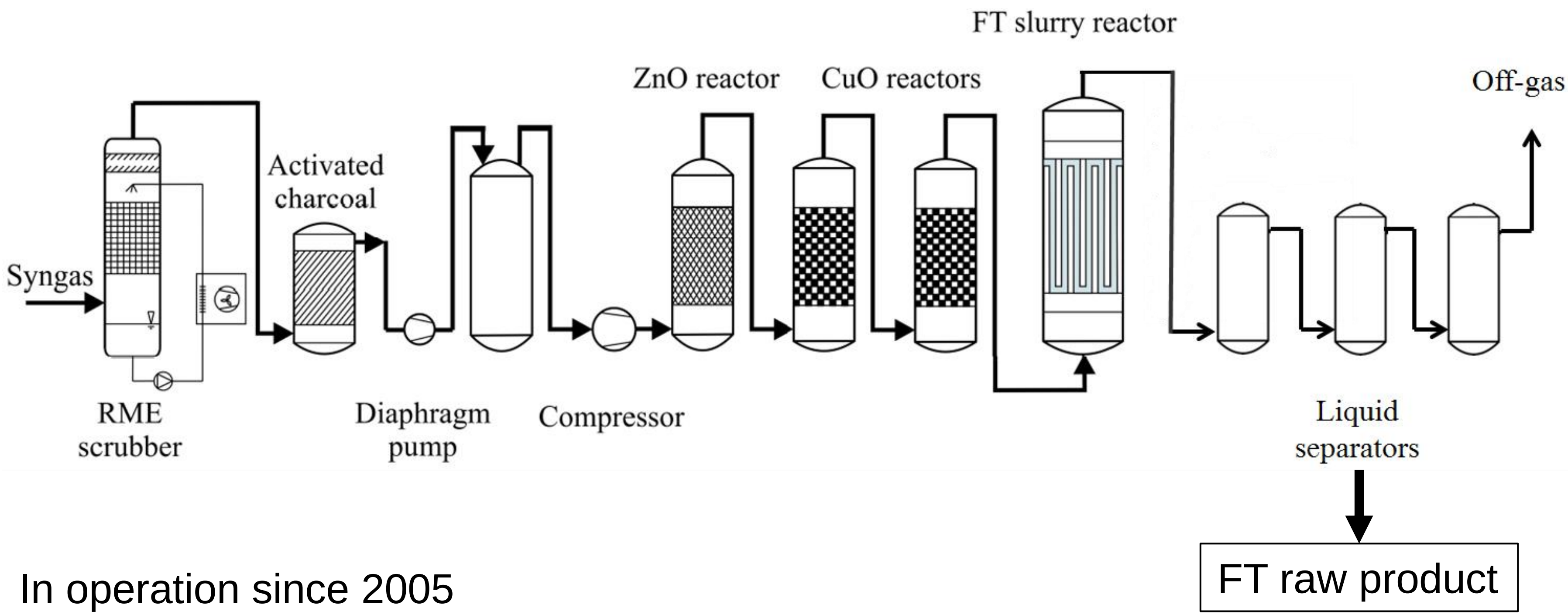
Synthetic Biofuels (FT- Route)

Cellulose
Hemicellulose
Lignin

i/n- paraffins
(hydrocarbons)



FT lab scale plant



In operation since 2005

5-10kg/day of FT raw product

Slurry reactor, because of excellent heat transfer and easy scaling up

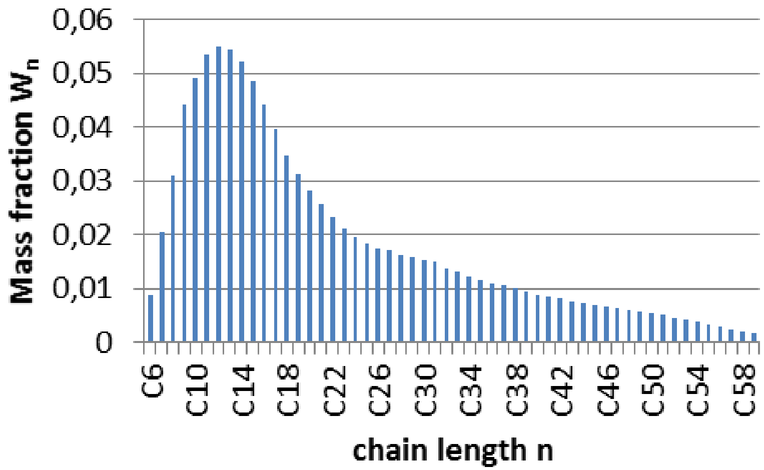
Gas treatment removes Sulphur to below 10ppb

Cobalt and Iron- based catalyst were tested

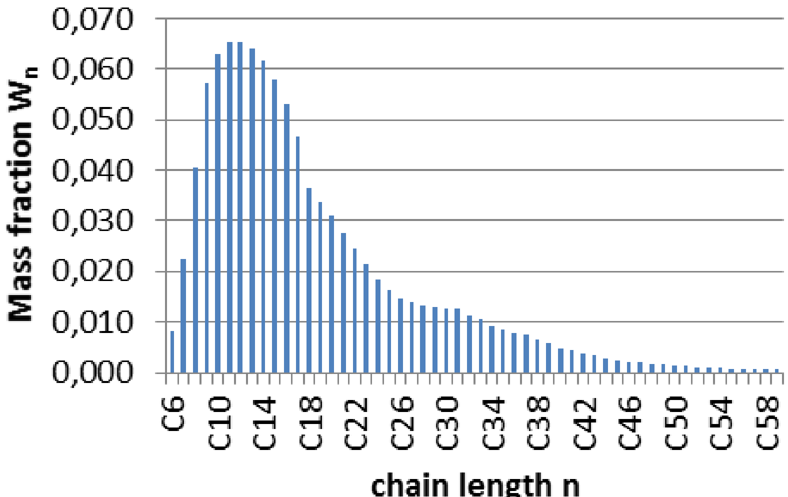
Fully automatic

ASF MODEL AND CORRECTED PRODUCT DISTRIBUTION

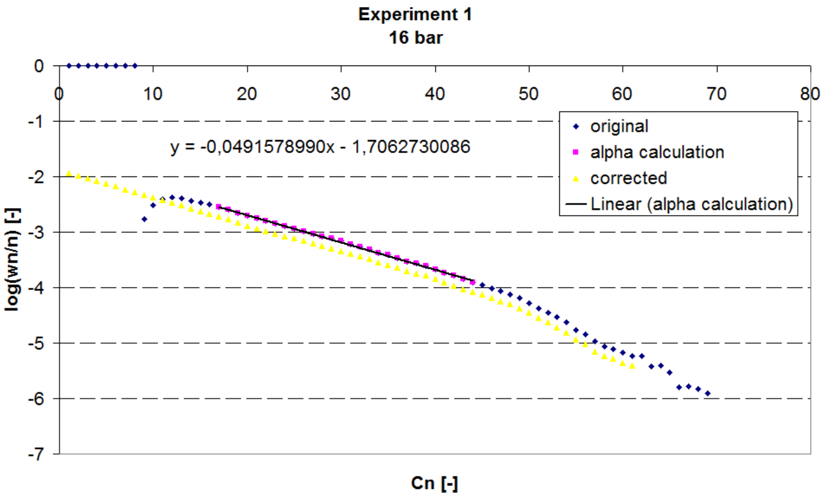
Product distribution 1000 h cat A



Product distribution 500 h catalyst D



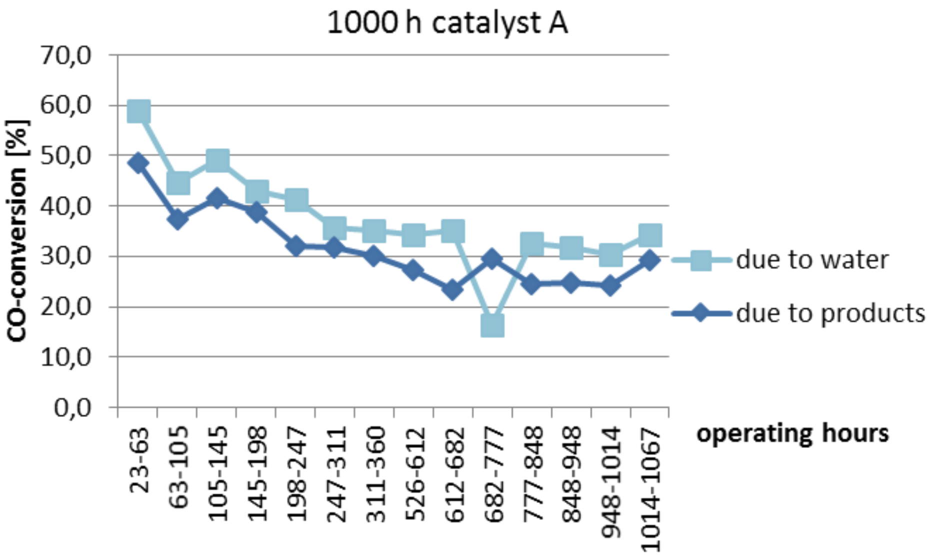
Experimental data for input in simulation of M&E balances

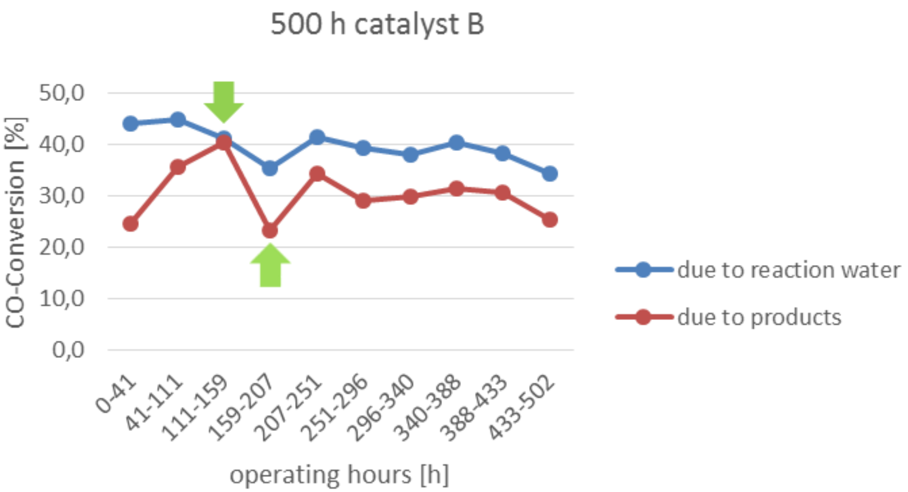


$$W_n = n(1-\alpha)^2 \cdot \alpha^{n-1}$$

$$\log \frac{W_n}{n} = n \log(\alpha) + \log \frac{(1-\alpha)^2}{\alpha}$$

Long time experience





Scaling up to 1 bpd

5 liters per day

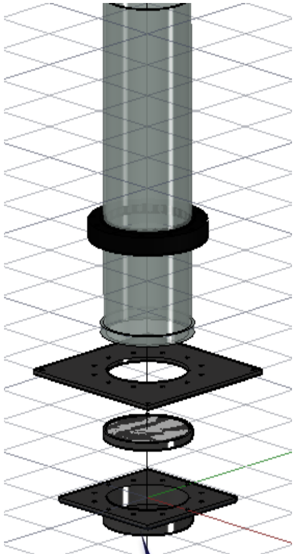
in operation

Smaller Cold Flow Model
(100 mm inner diameter Ø)

Hot Reactor
and Pilot Plant

1 barrel per day

In commissioning



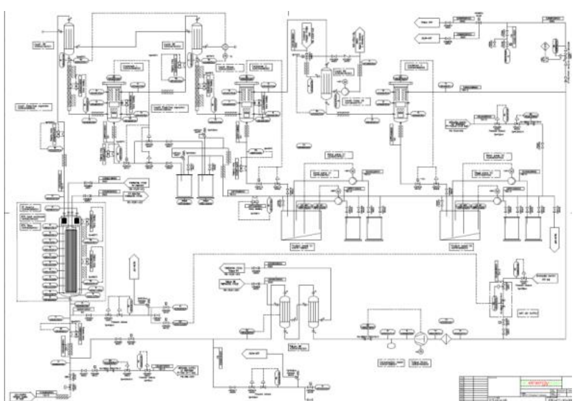
Design for the larger Cold
Flow Model (300 mm Ø)

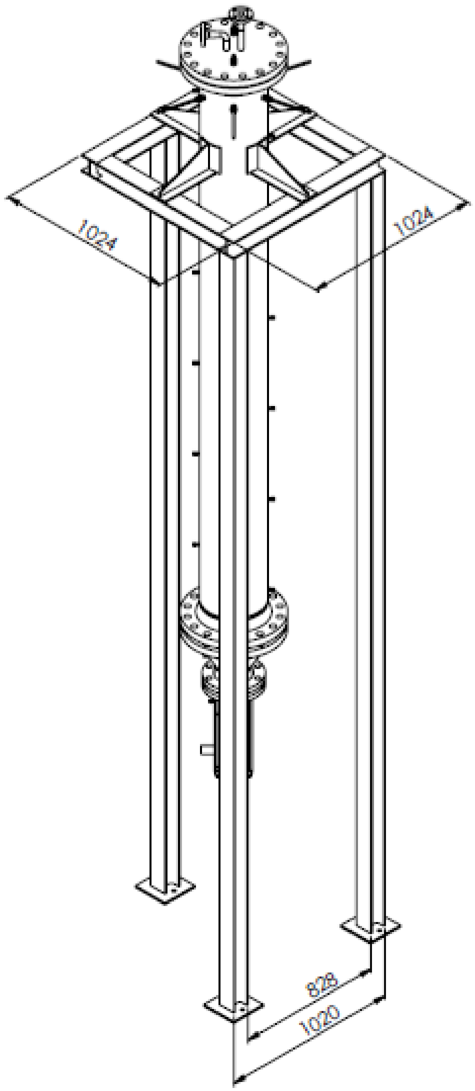
Scaled-up
Plant for 1 bpd

Work planed in the project

bioenergy2020+

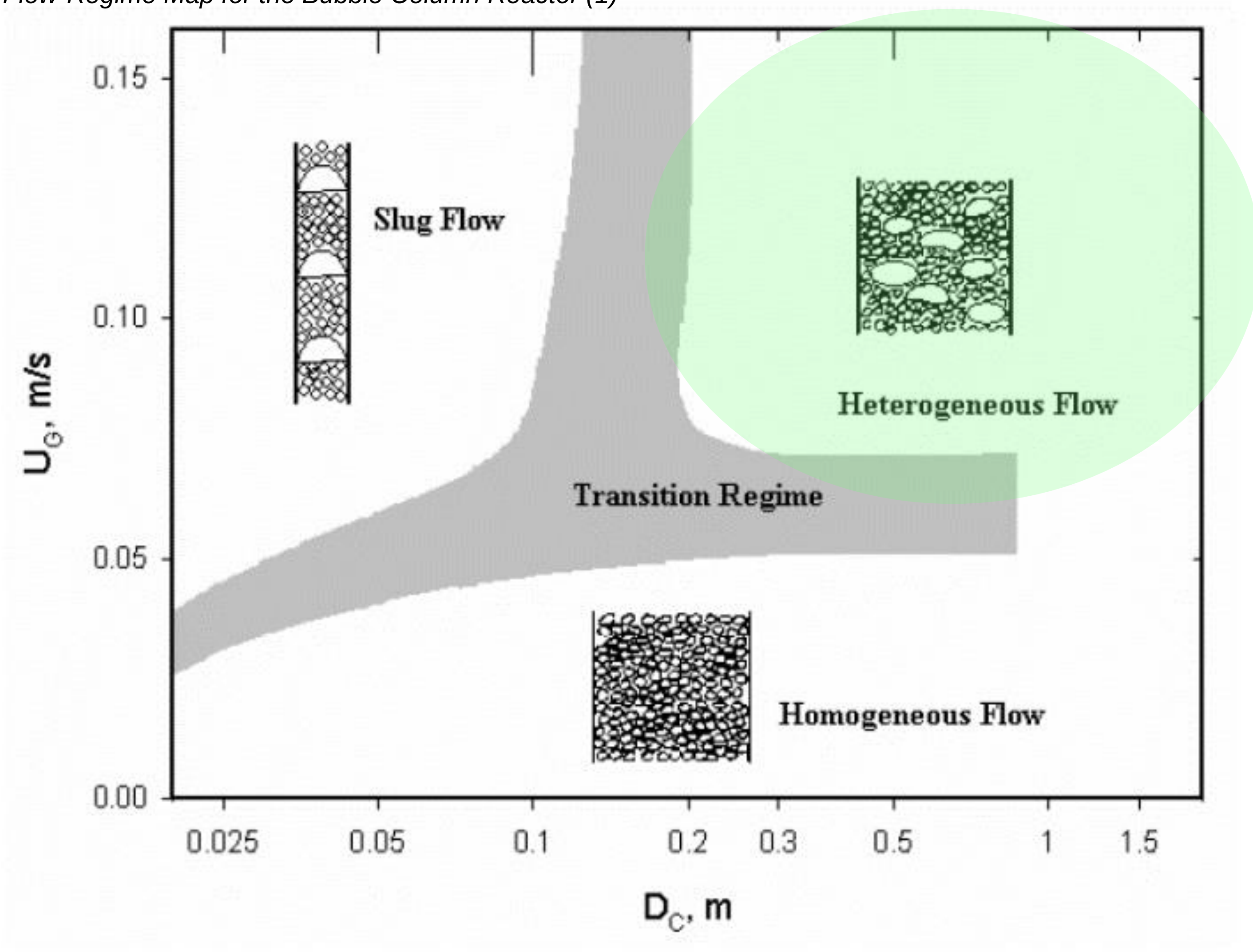
- ✓ Economic optimisation of gas treatment
- ✓ Scaling up of Slurry FT reactor
- Long term tests of FT synthesis with wood based synthesis gas
- Upgrading of the raw FT products
- Testing of FT products





Different Flow Regimes

Typical Flow-Regime Map for the Bubble Column Reactor (1)



Upscaling of FT slurry reactor

– **Efficiency of bubble column slurry reactor (BCSR) is strongly depended on the hydrodynamic regime of the bubble movement**

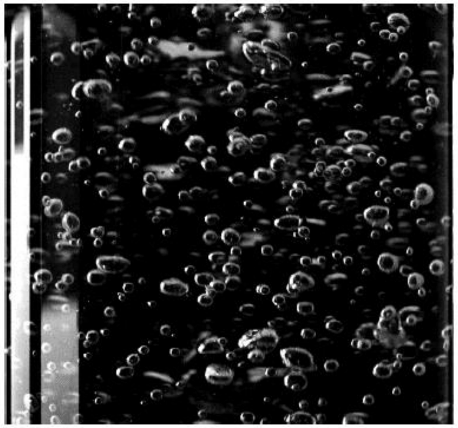


Figure 5: Gas velocity U_{gas} = 0,0053 m/s

Homogenous Regime

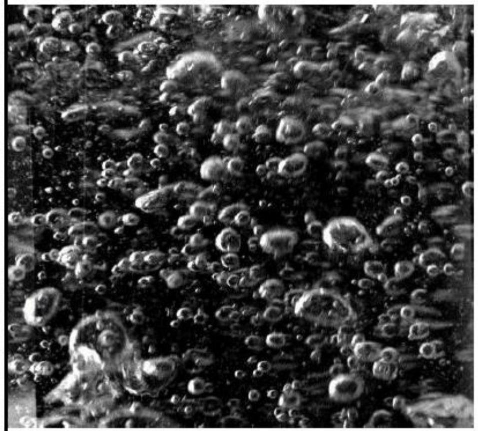


Figure 5: Gas velocity U_{gas} = 0,0106 m/s

Transition Regime

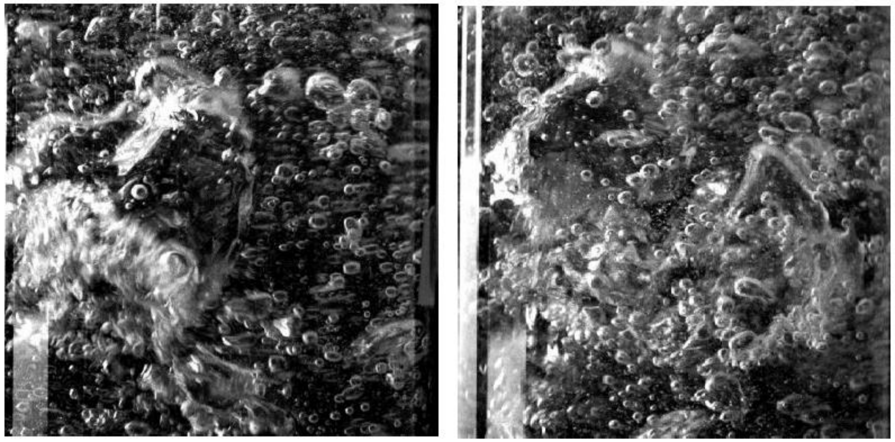


Figure 5: Gas velocities 0,0212 and 0,0371 m/s, respectively

Heterogeneous Regime

Churn up turbulence increase hold – up of small bubbles → 4 times more efficient than homogenous regime

Cold flow model

- Several tests with water and naphtha carried out with cold flow model laboratory plant
  - Variation of gas superficial velocity and slurry concentration
  - Investigation of effect on pressure drop and gas hold – up

» Switch from water to naphtha is changing hydrodynamics significantly, Weber number (We) can be employed for comparison

$$We = \frac{\rho_{liquid} * U_{gas}^2 * d_{bubble}}{\sigma_{liquid}} \quad (1)$$

Where, in our systems:

- ρ_{liquid} : density of the liquid;

- U_{gas} : superficial gas velocity through the gas distributor orifices;

- σ_{liquid} : surface tension of the liquid;

- d_{bubble} : initial bubble size at its formation, which can be calculated by [4]:

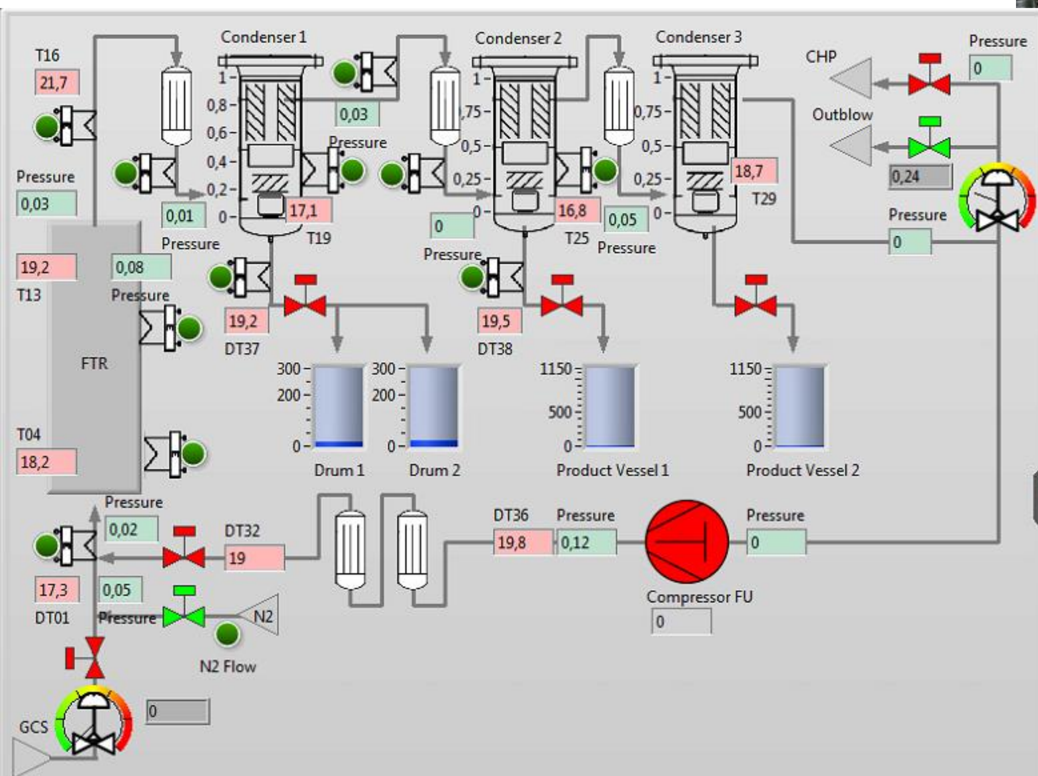
$$d_{bubble} = \left[\frac{6 * d_{orifice} * \sigma_{liquid}}{g * (\sigma_{liquid} - \sigma_{gas})}\right]^{1/3} \quad (2)$$

With g equals 9,81 m²/s.

We > 2 bubble breaking and axial mixing => heterogeneous regime!

Actual status

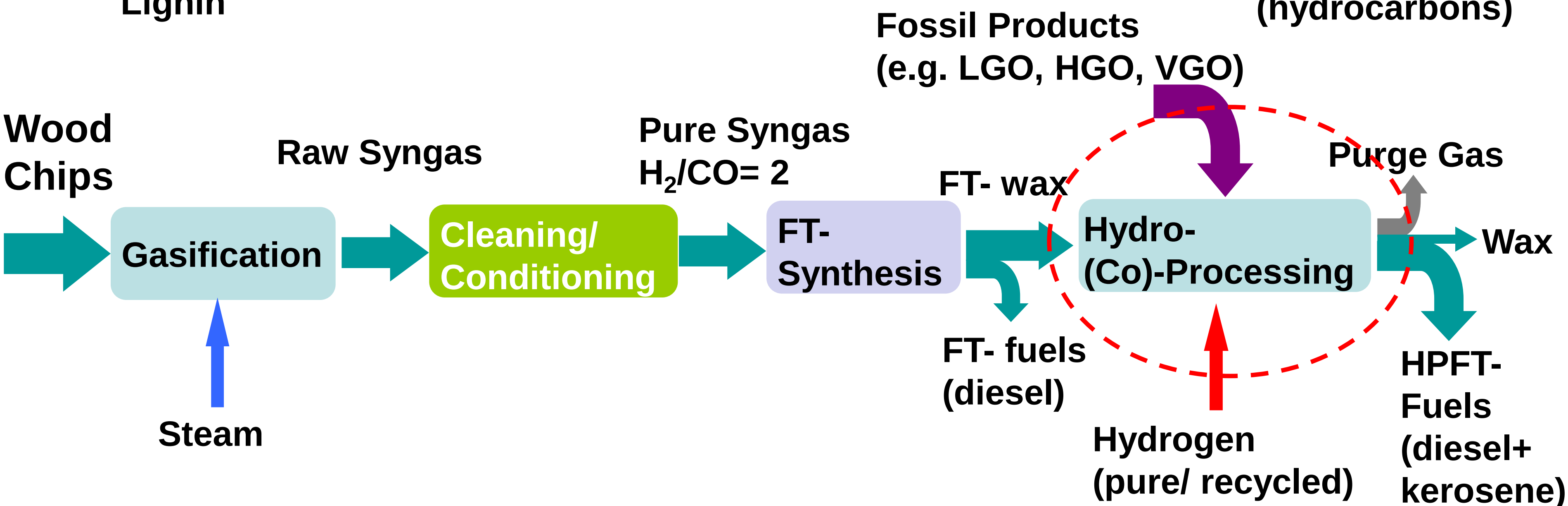
- **Commissioning is ongoing**
- **First experiments are planned for October 2016**



Synthetic Biofuels (FT- Route)

Cellulose
Hemicellulose
Lignin

i/n- paraffins
(hydrocarbons)

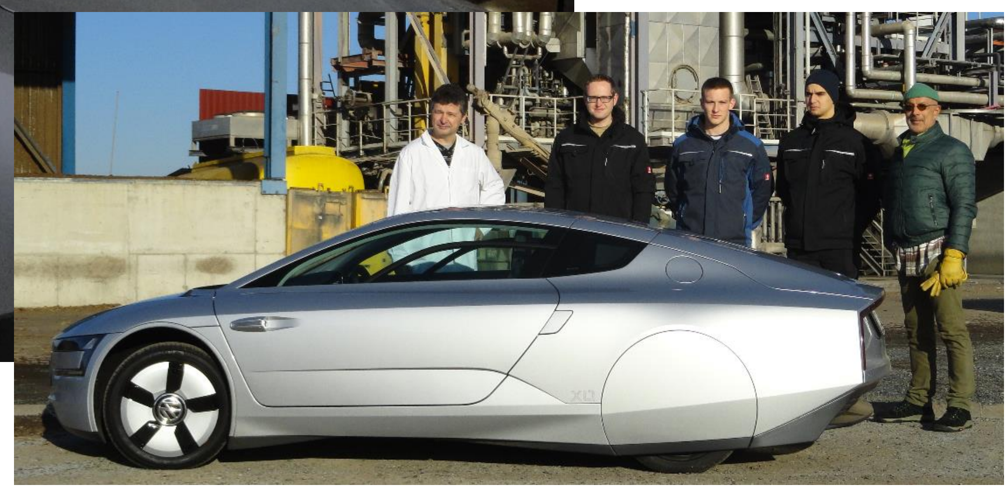


Hydroprocessing is done by partners

Future

Higher efficiency

Energy efficiency
e.g. VW XL1



Selected residues and waste


waste wood A


waste wood B

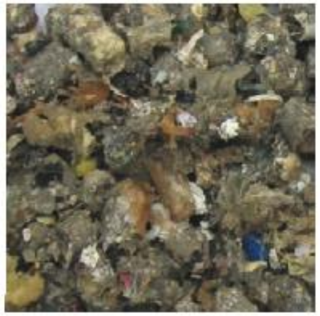

waste wood C


soft wood pellets


saw dust

PE regrind


SLF-plastics


MSW-plastics


PE+PS


virgin polymers


Information

Dr.Reinhard Rauch

Vienna University of Technology
Bioenergy2020+

Phone: (++43-676) 36 39 381
Email: reinhard.rauch@tuwien.ac.at
Skype: reinhard.rauch.tuwien

More info at
http://www.ieatask33.org
http://www.ficfb.at
http://www.vt.tuwien.ac.at
http://www.bioenergy2020.eu