Liquid transportation fuels by biomass steam gasification – Status of Winddiesel and scaling up

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

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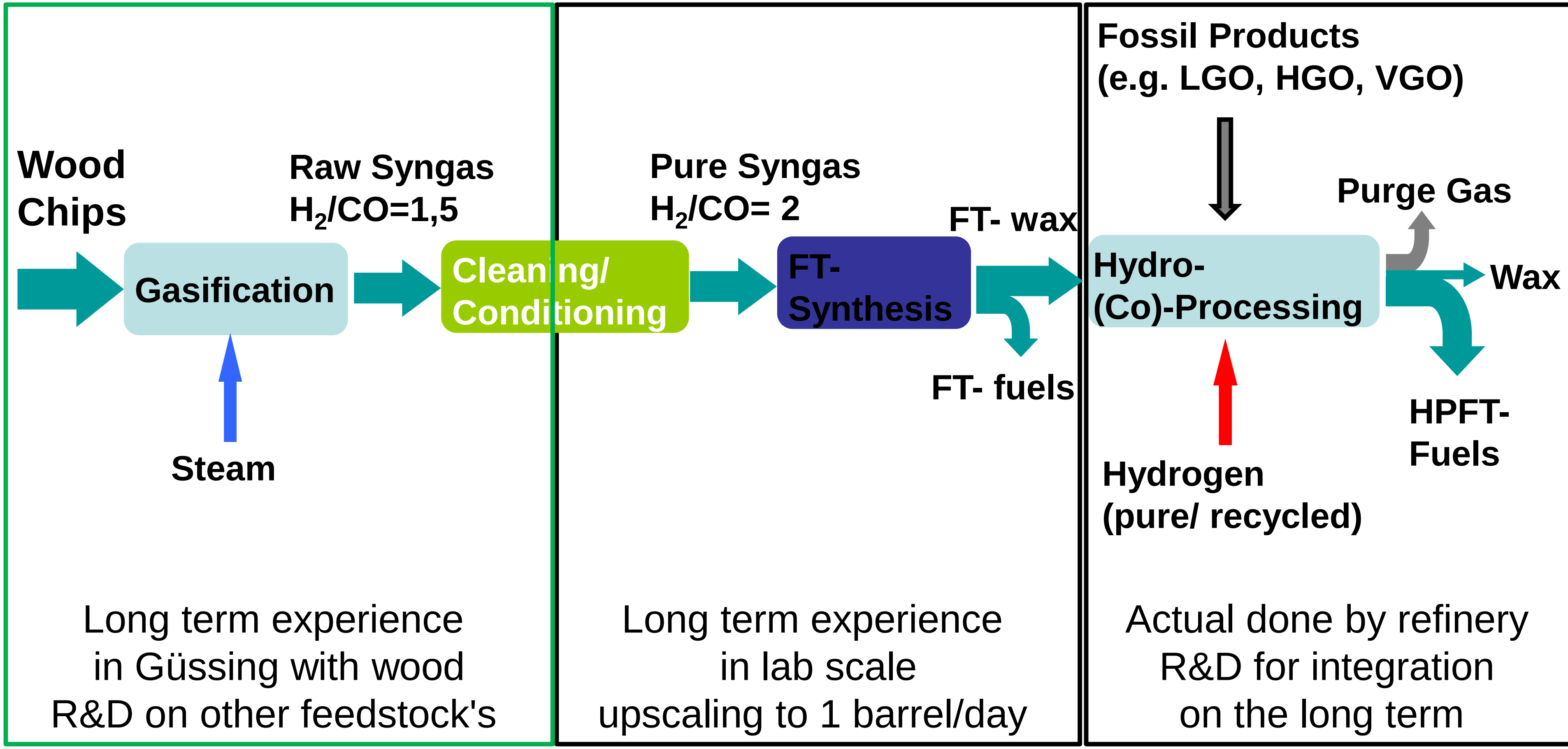
Schema of FT


Wood Chips
Gasification
Steam
Raw Syngas
$H_2/CO=1,5$
Cleaning/ Conditioning
Pure Syngas
$H_2/CO= 2$
FT- Synthesis
FT- wax
FT- fuels
Fossil Products
(e.g. LGO, HGO, VGO)
Hydro- (Co)-Processing
Purge Gas
Wax
HPFT- Fuels
Hydrogen
(pure/ recycled)
Long term experience
in Güssing with wood
R&D on other feedstock's
Long term experience
in lab scale
upscaling to 1 barrel/day
Actual done by refinery
R&D for integration
on the long term

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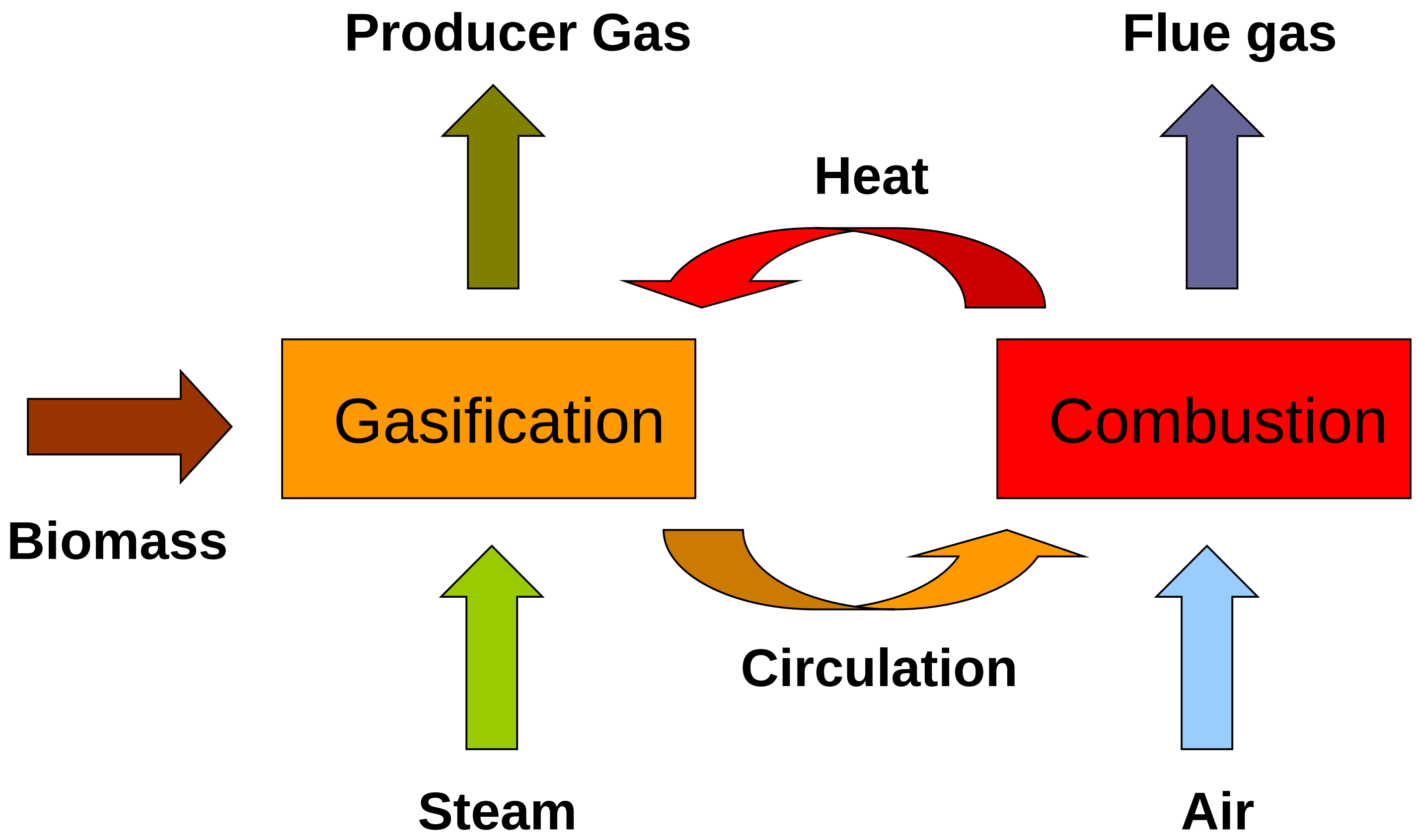
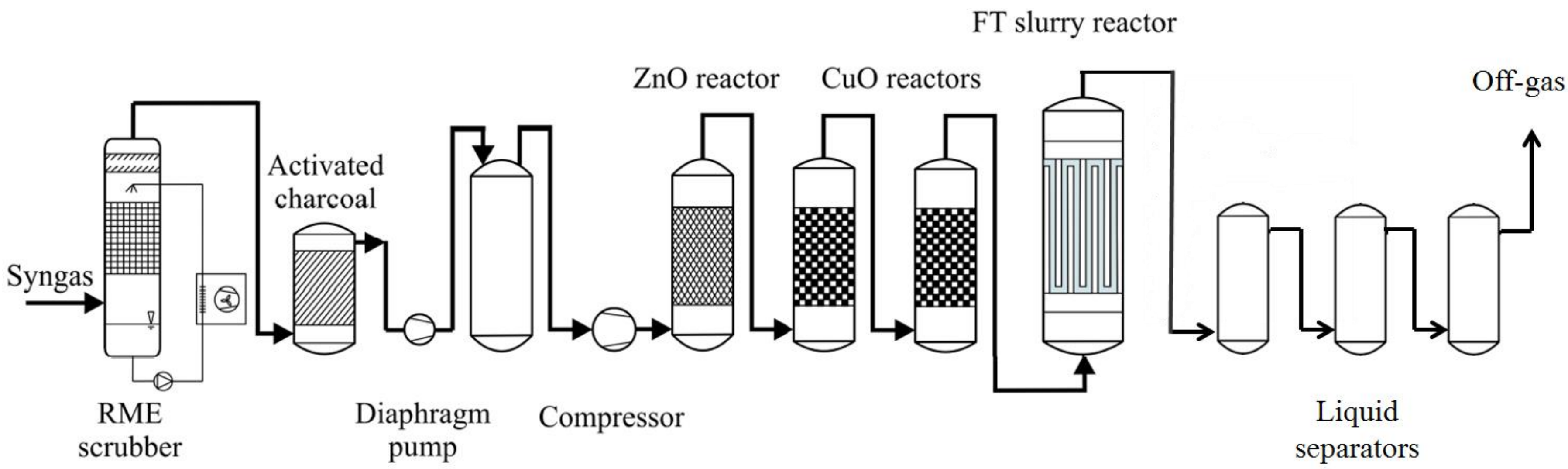
Gasification Concept of Dual Fluid



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

FT lab scale plant



FT raw product

In operation since 2005

5-10kg/day of FT raw product

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

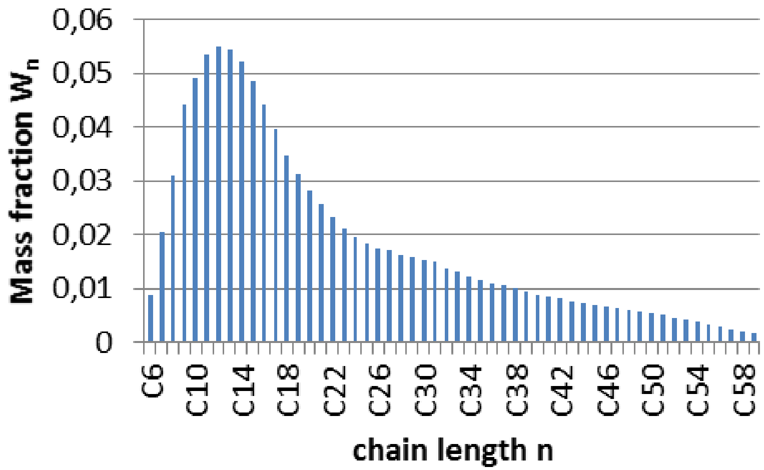
Gas treatment removes Sulphur to below 10ppb

Cobalt and Iron- based catalyst were tested

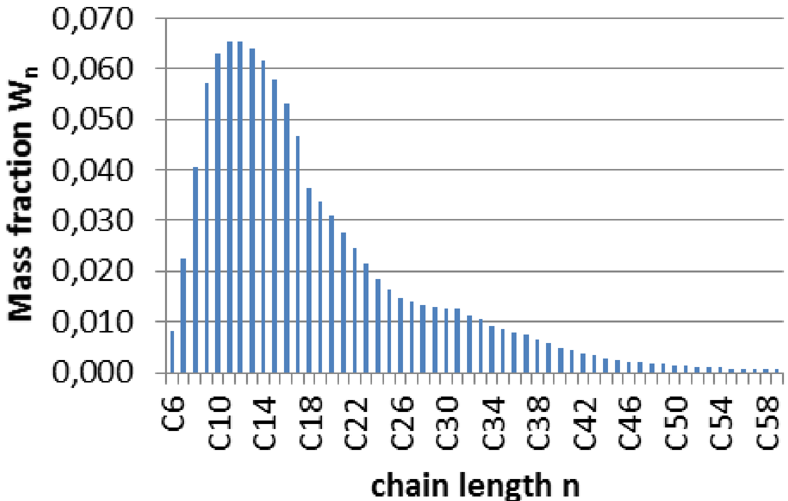
Fully automatic

ASF MODEL AND CORRECTED PRODUCT DISTRIBUTION

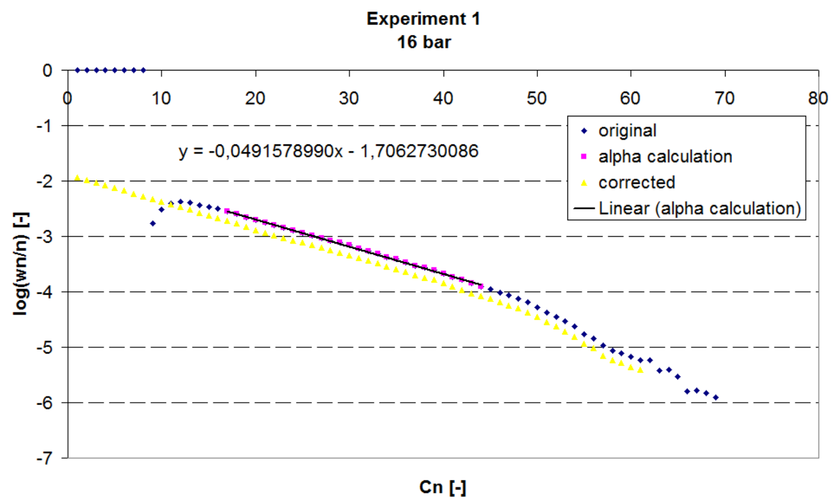
Product distribution 1000 h cat A



Product distribution 500 h catalyst D



Experimental data for input in simulation of M&E balances



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

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

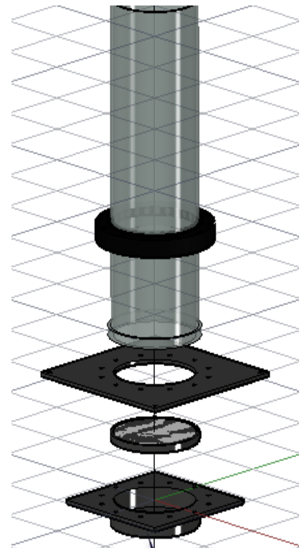
Scaling up to 1 bpd

5 liters per day
in operation

1 barrel per day
In commissioning

Smaller Cold Flow Model
(100 mm inner diameter Ø)

Hot Reactor
and Pilot Plant



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

Scaled-up
Plant for 1 bpd

COMET project 1bpd

Scientific partners

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Vienna University of Technology

Výzkumný ústav anorganické chemie, a.s.
ČLEN SKUPINY UNIPETROL

UNIVERSITY OF CHEMISTRY AND TECHNOLOGY PRAGUE

Industrial partners

GÜSSING RENEWABLE ENERGY
GUSSINGRENEWABLE.COM

BILFINGER Bohr- und Rohrtechnik GmbH

Unipetrol
ORLEN GROUP

ORLEN

Funded by

COMET
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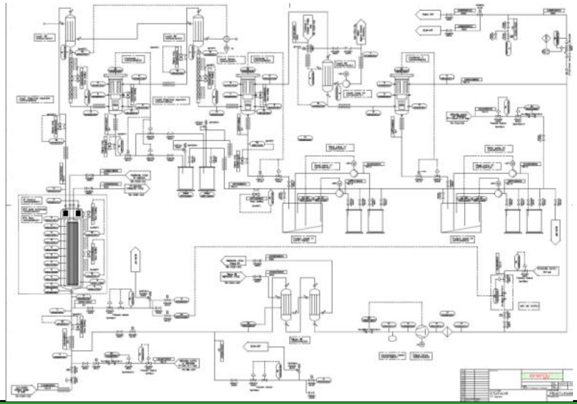
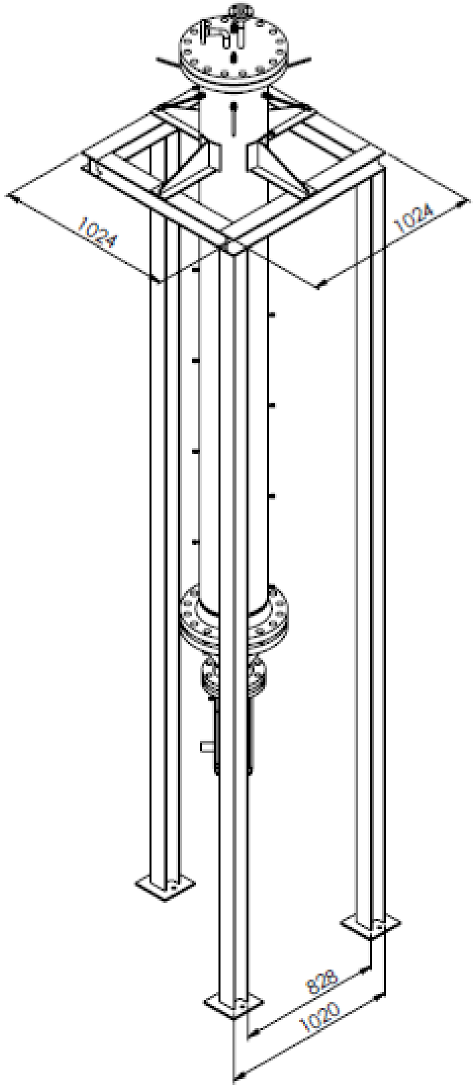
FFG

Work planed in the project

- ✓ 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





Upscaling of FT slurry reactor

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

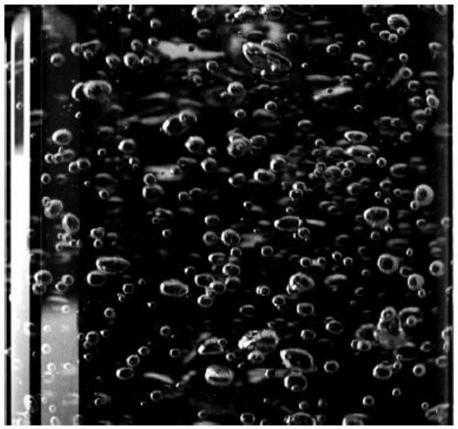


Figure 5: Gas velocity U_{gas} = 0,0053 m/s

Homogenous Regime

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

Transition Regime

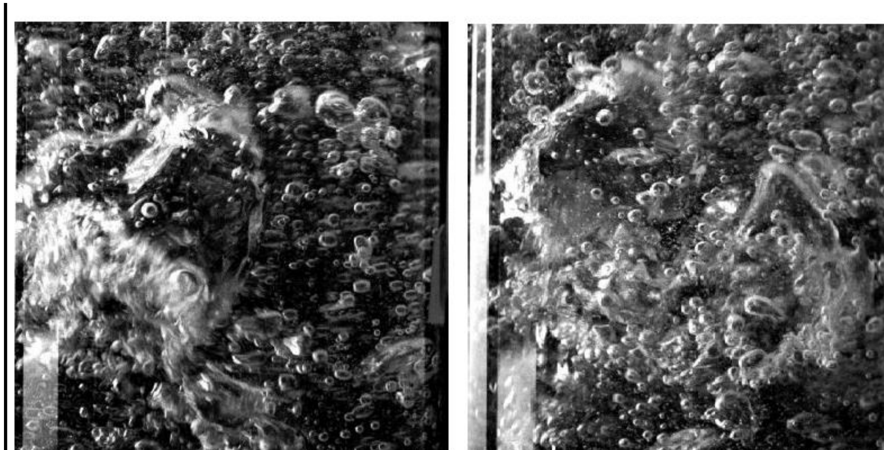


Figure 5: Gas velocities 0,0212 and 0,0371 m/s, respectively

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]:

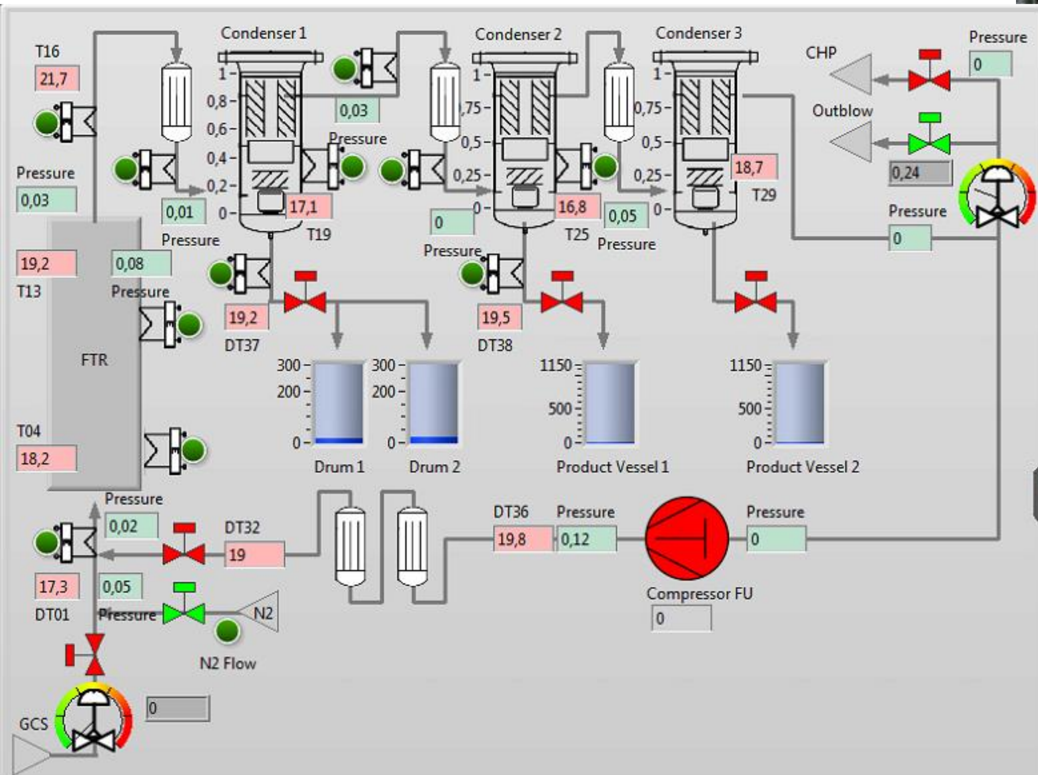
$$d_{bubble} = \left[\frac{6 * d_{orifice} * \sigma_{liquid}}{g * (\sigma_{liquid} - \sigma_{gas})}\right]^{1/3} \quad (2)$$

With g equals 9,81 m^2/s.

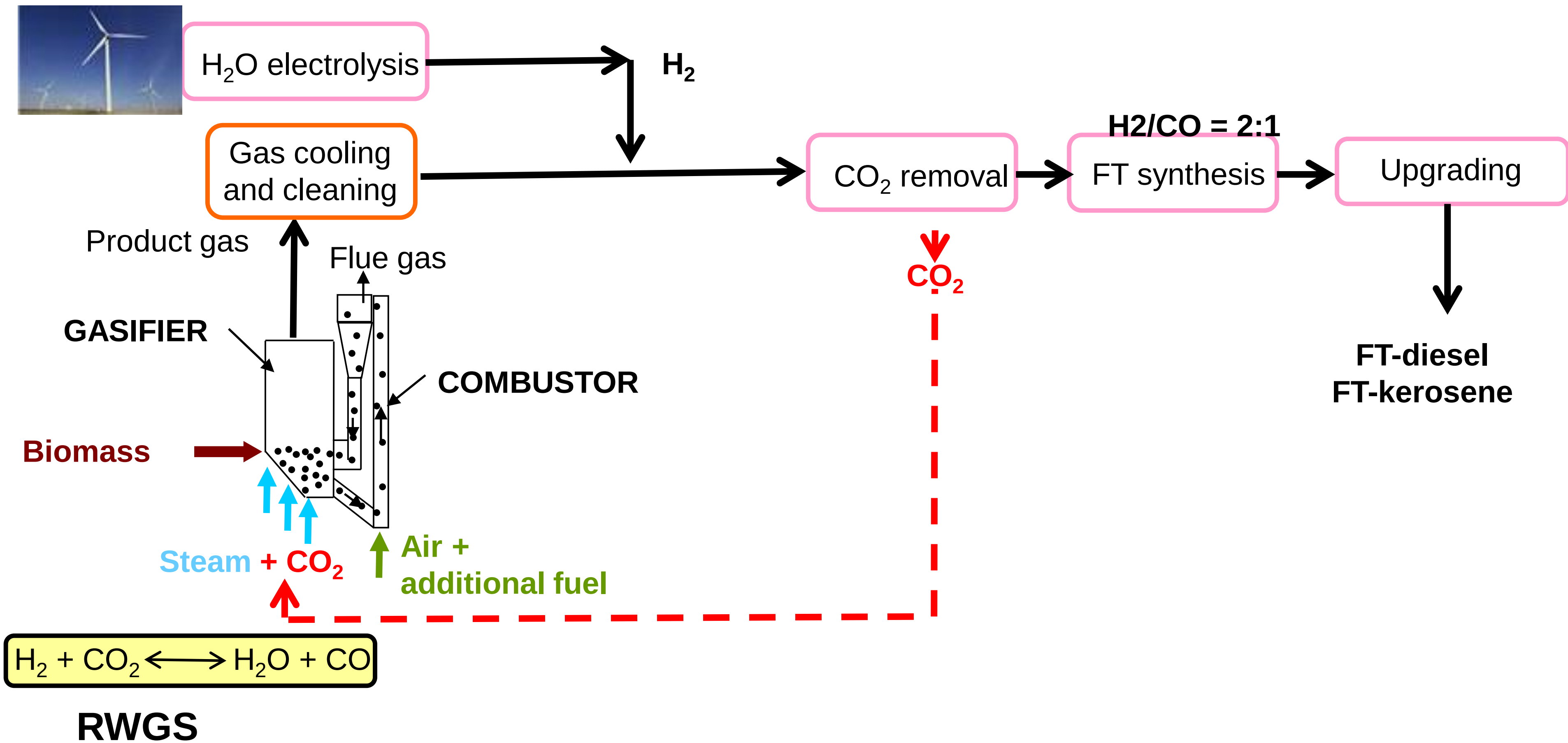
We > 2 bubble breaking and axial mixing => heterogeneous regime!

Actual status

- ➢ **Commissioning is ongoing**
- ➢ **First experiments are planned for this week**



Conversion of wind and photovoltaic to transportation fuels



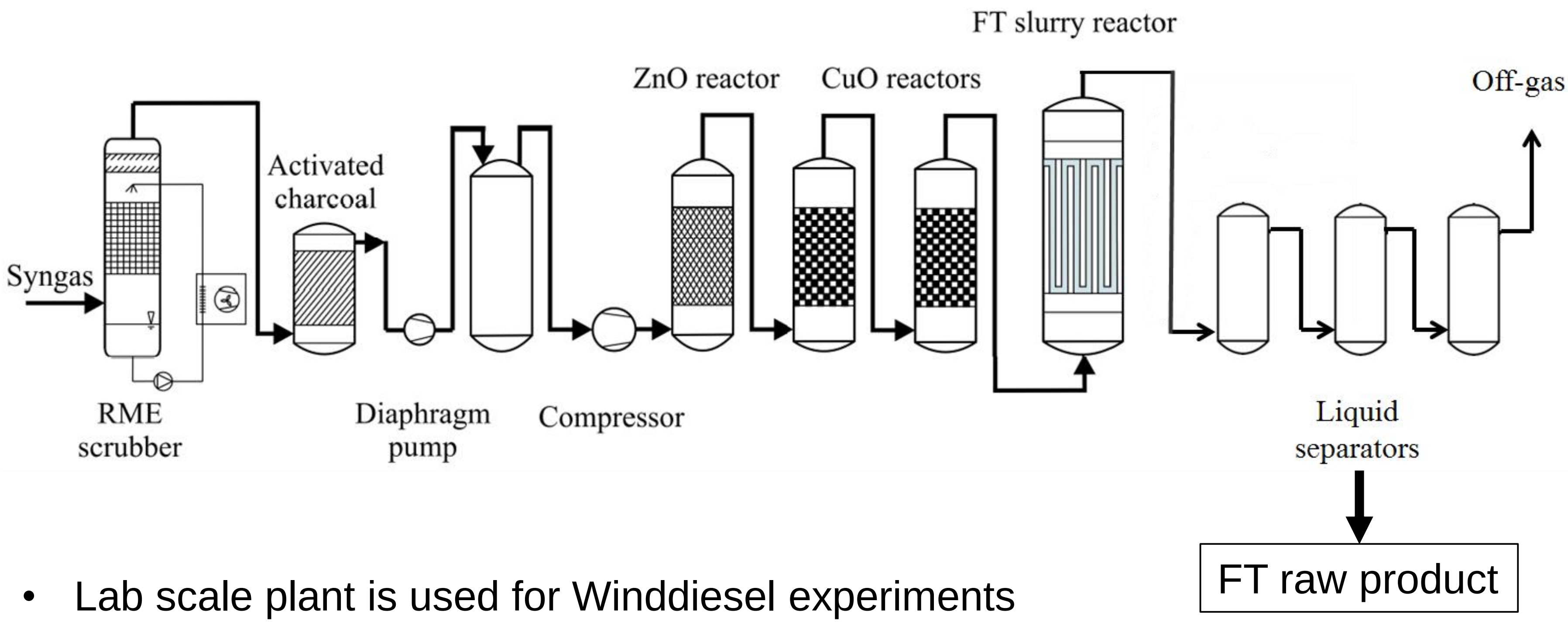
Winddiesel

Funded by:

Work Programme

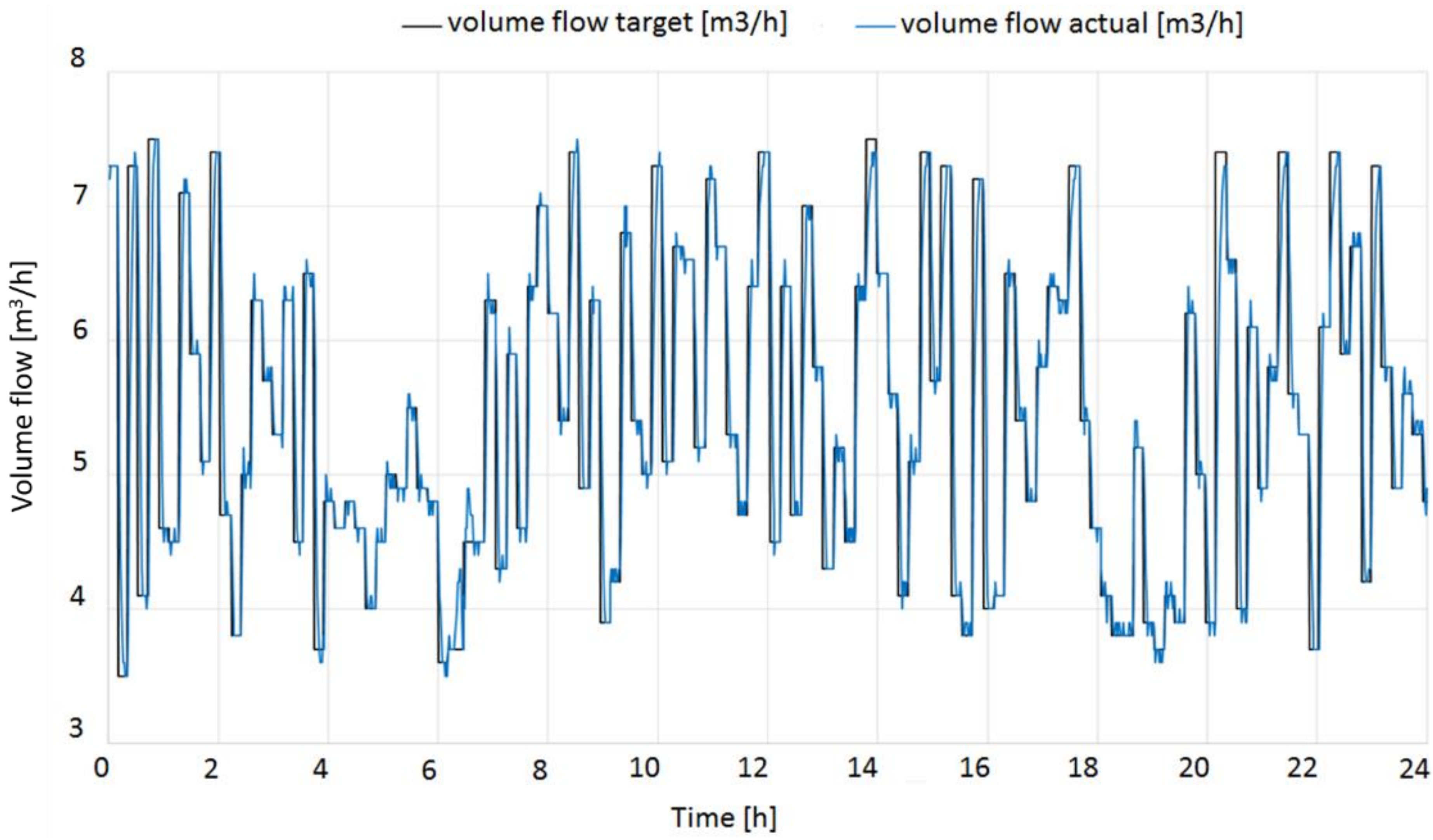
- Experimental:
  - Load change behavior, catalyst selection,
  - verification of the simulation
- Simulation:
  - Design parameter of a large-scale plant,
  - process comparison of competing technologies
- Economics:
  - Determination of the investment and operating costs of large-scale facilities,
  - comparison with competing technologies

FT lab scale plant

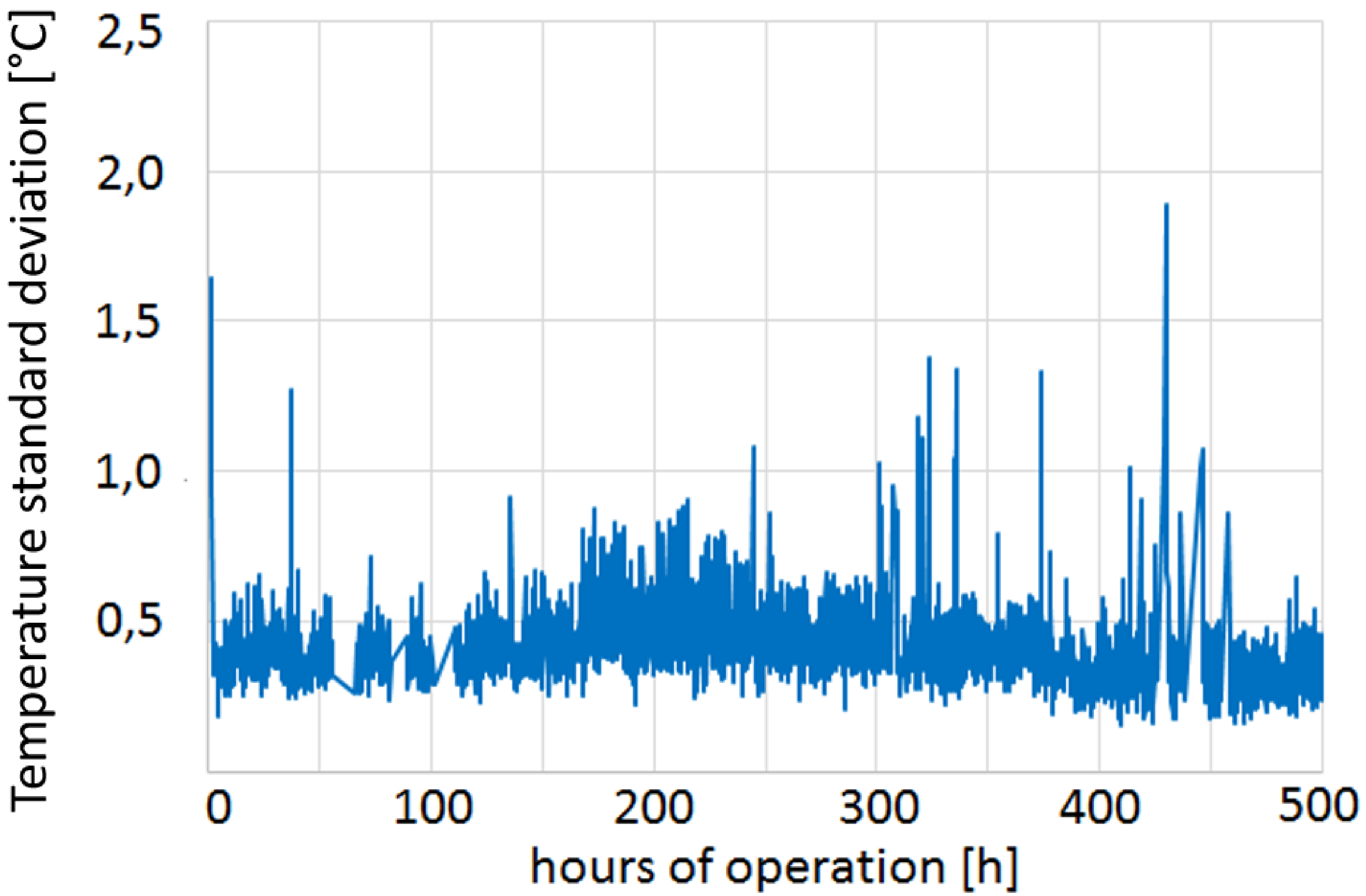


- Lab scale plant is used for Winddiesel experiments
- Long term test over 500 hours are done to compare standard operation with winddiesel operation
- Gas volume flow is changed all the time
- Temperature and pressure is kept constant (isothermal operation is necessary for FT synthesis)
- Change in CO-conversion, selectivity and catalyst aging are investigated

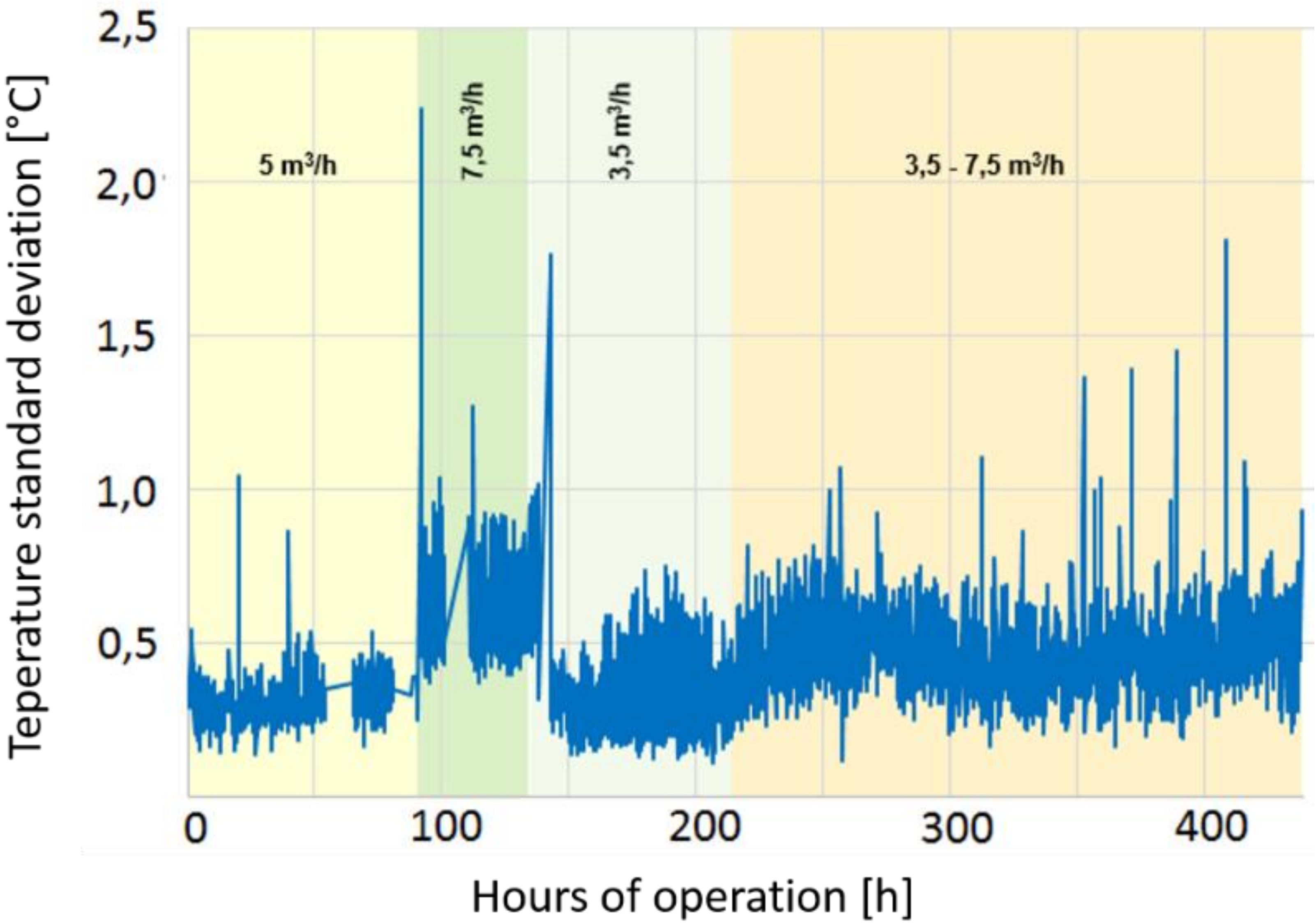
Load change in slurry



Normal operation



Winddiesel operation



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Conclusion Winddiesel

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- Conversion of electricity to transportation fuels, especially to kerosene and diesel for heavy transport (no chance with electric mobility)
- One possibility to increase the carbon conversion in from biomass to biofuels
- First results are very promising, as slurry reactor is ideal for very fast load changes
- Catalyst aging depends on type of catalyst (some are influenced, some not)

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