Status of the bioliq®-process at KIT

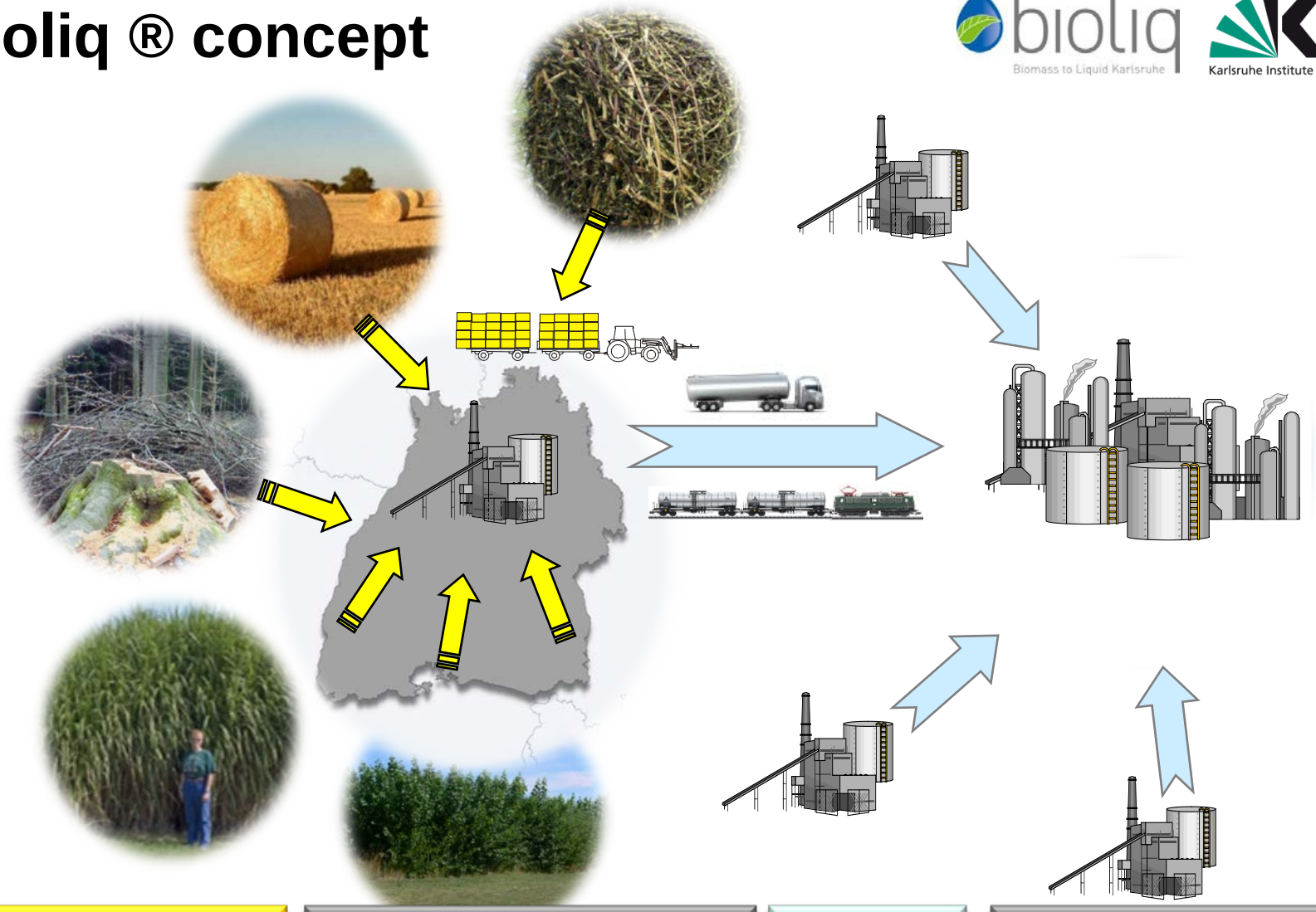
Bernd Zimmerlin, Thomas Kolb, Mark Eberhard, Nicolaus Dahmen

International Seminar on Gasification, Malmö, Sweden, October 19-20, 2016

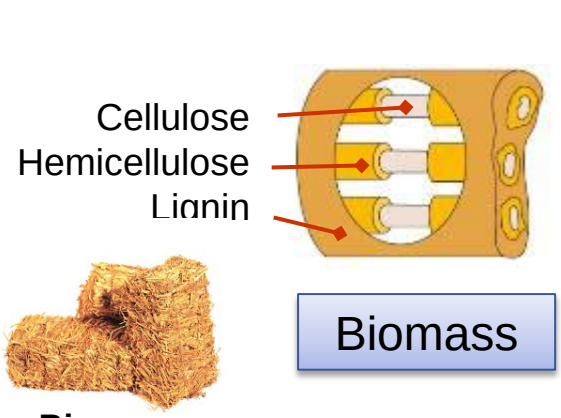
bioliq biomass to liquid

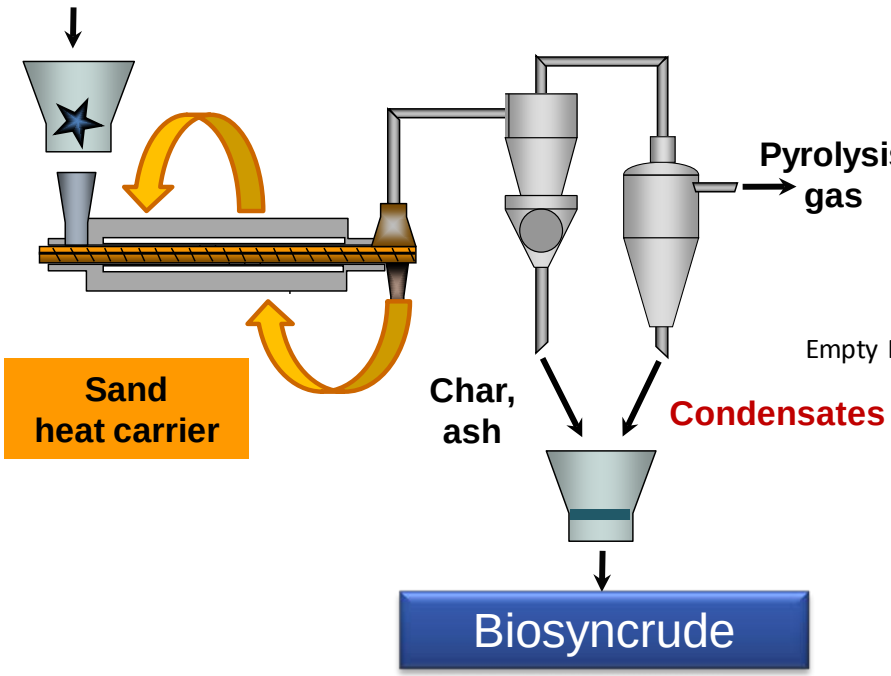
Engler-Bunte-Institute, Division 1, Fuel Chemistry and -technology, EBI ceb
Institute for Catalysis Research and Technologie, IKFT
Institute for Technical Chemistry, ITC

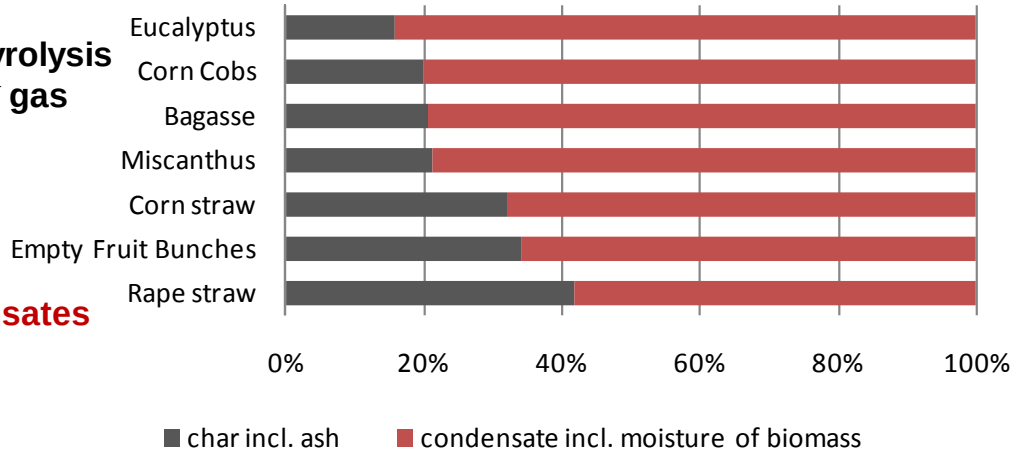
bioliq ® concept



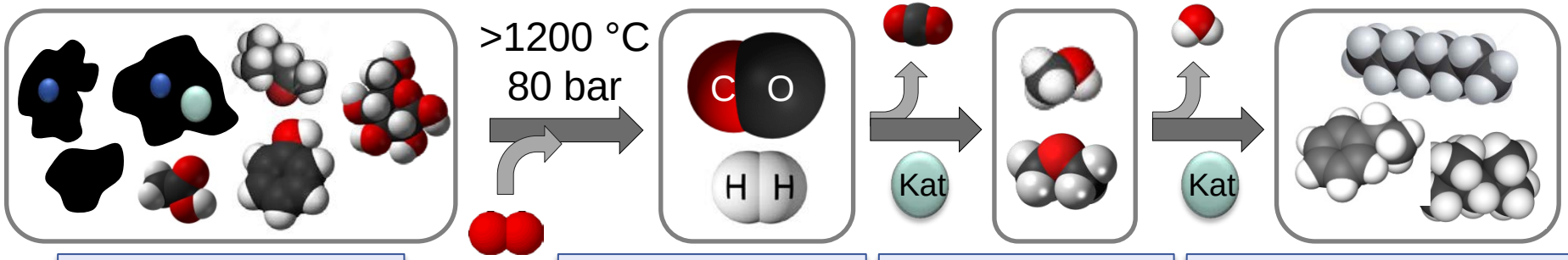
De-centralized pre-treatment by fast pyrolysis



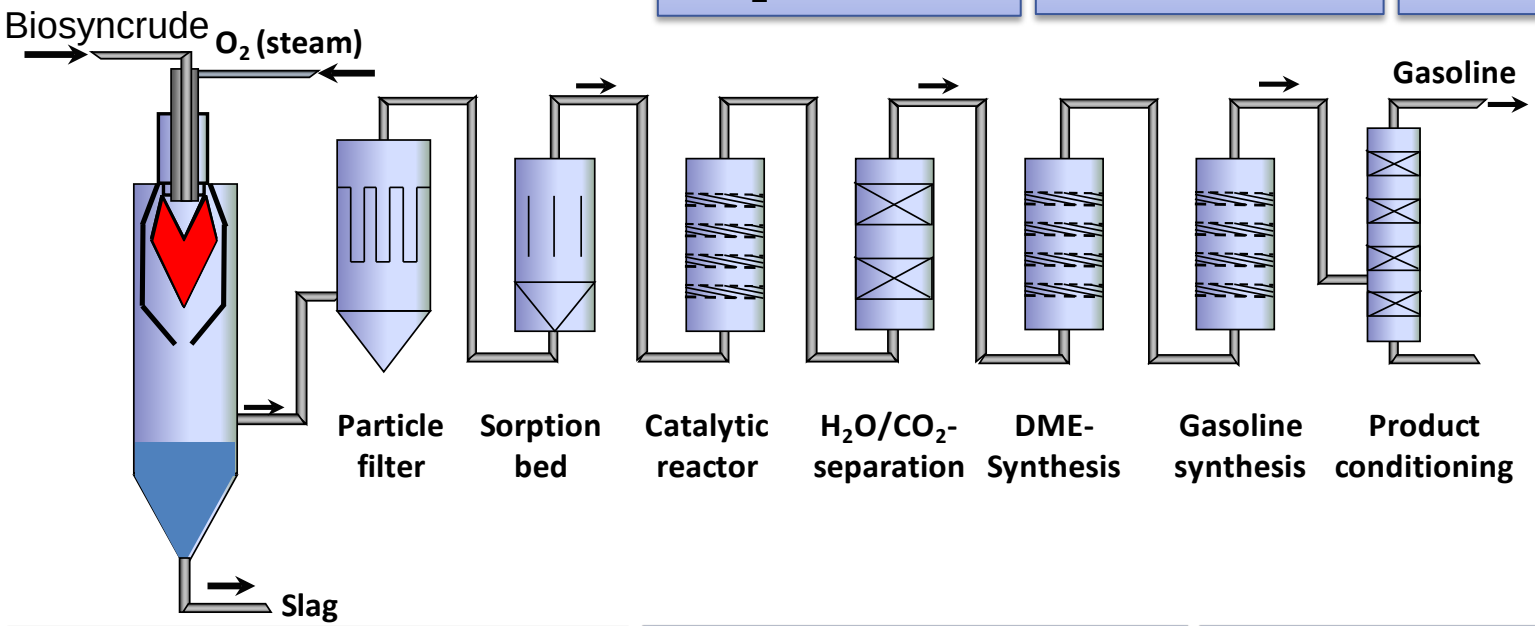




Central conversion technology



Biosyncrude | Syngas (1:1) CO_2, impurities | Methanol Dimethylether | Hydrocarbons



Gasoline
Diesel
Kerosene
Ethylene
Propylene
Methane
Hydrogen
Advanced biofuels!?

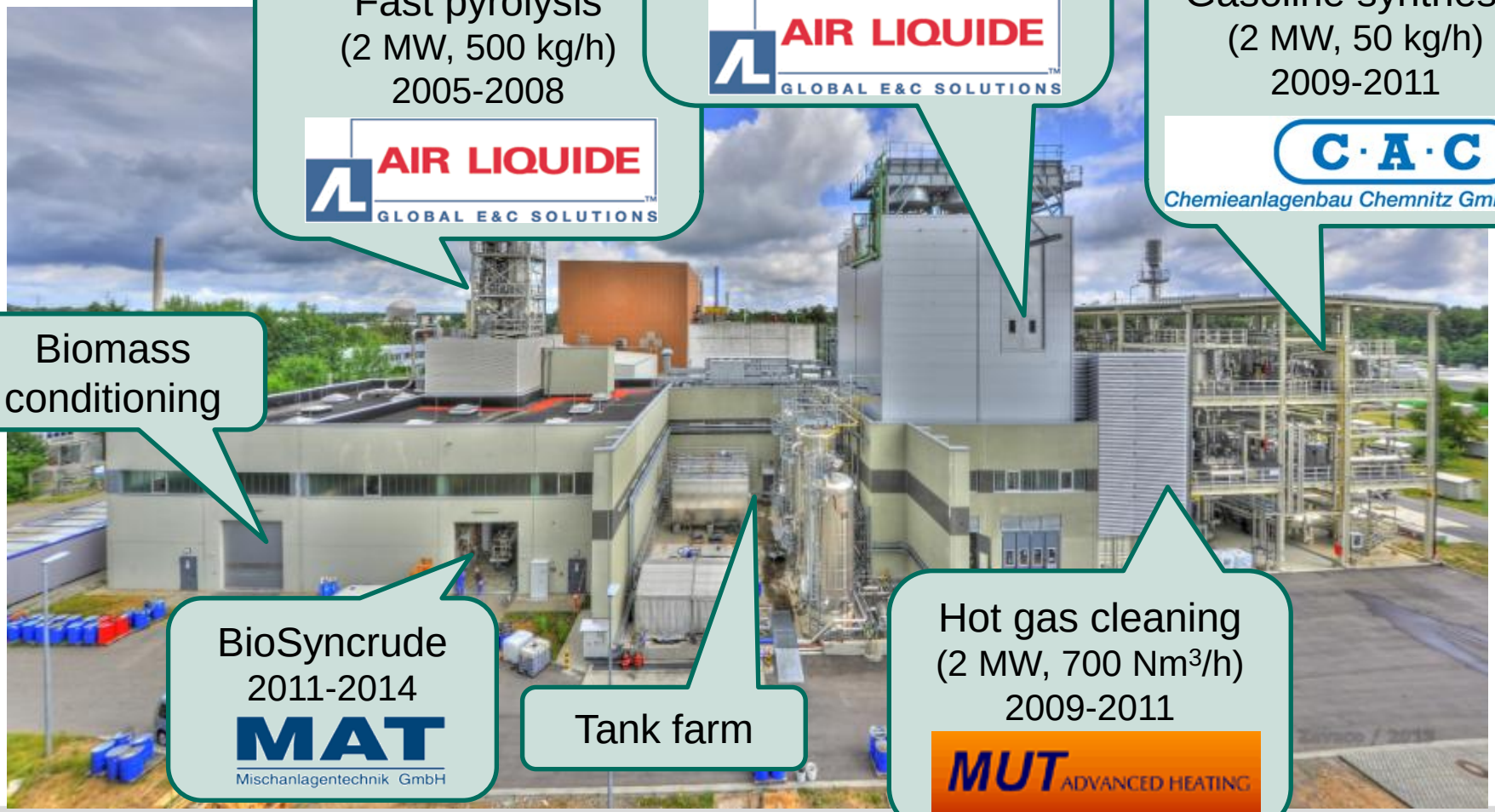
Entrained flow gasification | Hot gas cleaning | Fuel synthesis

bioliq® pilot plant

Gefördert durch:
Bundesministerium für Ernährung und Landwirtschaft
aufgrund eines Beschlusses des Deutschen Bundestages

FNR Fachagentur Nachwachsende Rohstoffe e.V.

KIT Karlsruhe Institute of Technology



Fast pyrolysis
(2 MW, 500 kg/h)
2005-2008
AIR LIQUIDE GLOBAL E&C SOLUTIONS

Entrained Flow Gasification
(5 MW, 1 t/h)
2008-2013
AIR LIQUIDE GLOBAL E&C SOLUTIONS

Gasoline synthesis
(2 MW, 50 kg/h)
2009-2011
C·A·C Chemieanlagenbau Chemnitz GmbH

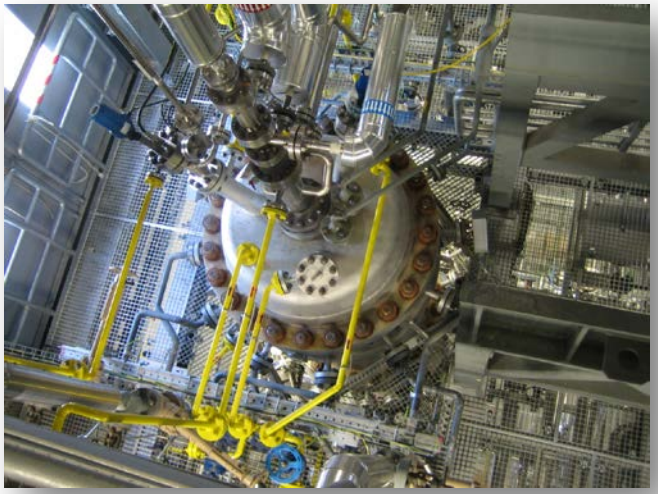
Biomass conditioning

BioSyncrude
2011-2014
MAT Mischanlagentechnik GmbH

Tank farm

Hot gas cleaning
(2 MW, 700 Nm^3/h)
2009-2011
MUT ADVANCED HEATING

bioliq® impressions

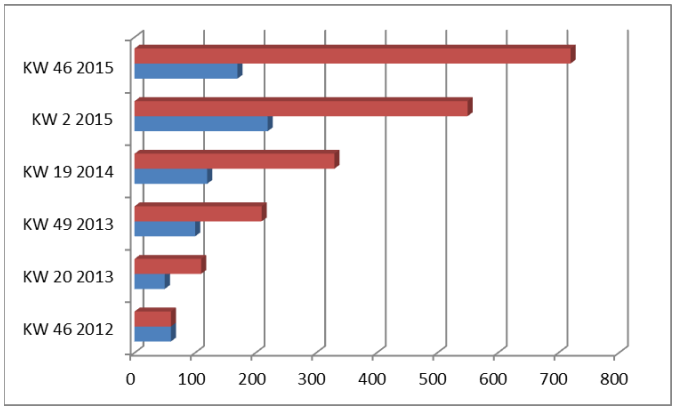


12 km piping, 50 km wiring,
250 motors, 1500 t steel,
40 pumps,

100.000 engineering hours,
> 40 operators and engineers,
1st full operation in 2014

bioliq® - fast pyrolysis

- Stable operation since 2015
  - greater amounts of slurry can now be produced
- Typical products
  - Organic condensate with remaining solids, can directly be used in the bioliq gasifier
  - Suspension of aqueous condensate & straw char, has still to be qualified as a fuel for the entrained flow gasifier
- > 130 t wheat straw processed
- Optimization topics
  - Feedstock entry
  - Heat carrier loop



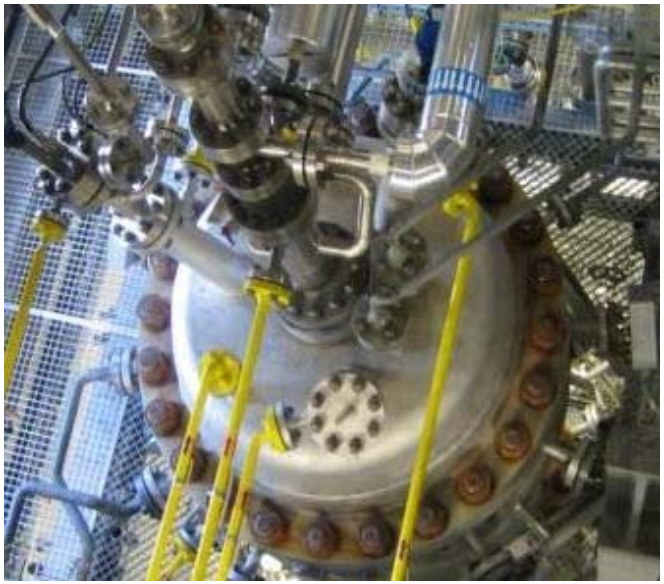
operational hours,
single and accumulated

bioliq® - biosyncrude and tank farm

- Interface between pyrolysis and gasifier
  - Interdisciplinary working group to optimize fuel properties and specifications
- Expansion of mixing station and tank farm completed
  - 10 product tanks with 240 m^3 storage volume
- Optimization topics
  - use of all pyrolysis products for entrained flow gasification

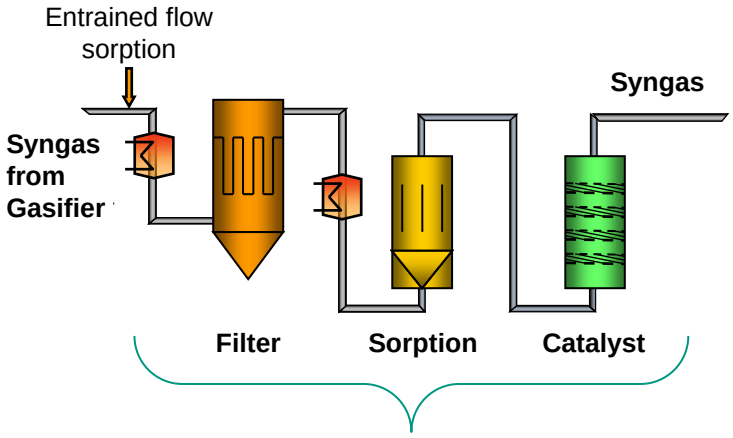
bioliq® - entrained flow gasifier

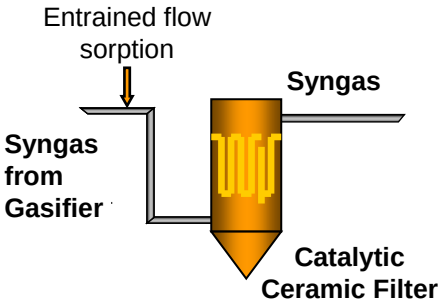
- Since 2013 about 420 tons of slurry were processed at approximately 560 hours of operation with slurry
- Slurries used
  - organic condensate of bioliq® fast pyrolysis
  - wood based pyrolysis oils
  - ethylene glycol as model fuel
  - with different types of solids (wood- / straw char, ashes, glass)
- Optimization topics
  - Calcite layers at different positions
  - Slag discharge



bioliq® - hot gas cleaning

- Proof of the required purity specifications with fixed bed adsorption at 700°C / 400°C in 40 bar campaigns 2014
- Construction and commissioning of a dry entrained flow adsorption
- Construction and commissioning of a online-gas-analysis for S-, Cl- and N-species, for clean and raw gas side
- Optimization topics
  - Long term operation behavior





MUT ADVANCED HEATING

bioliq® - synthesis

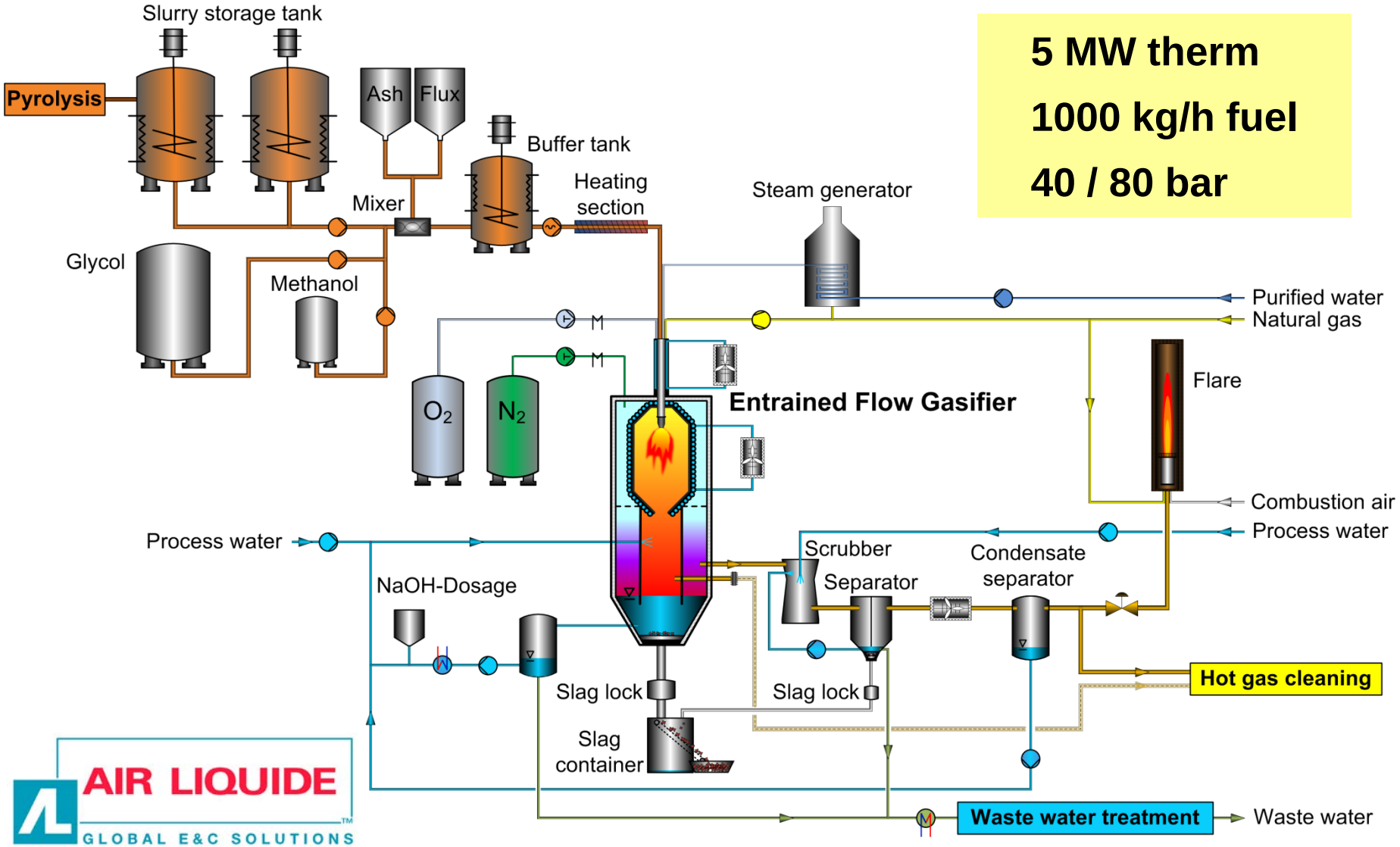
- Completion / takeover of the synthesis plant after test operation in 2013
- Commissioning of synthesis plant and first generation of gasoline samples in 2014
- Process and product analysis ready for operation
- Further sampling positions for gasoline and syngas installed
- Development
  - cooperation with engines and technical institutions established
  - mini-plant for scale-up of process and of catalysts
  - provision of gasoline samples on a scale > 200 kg from 2017 onwards

C·A·C Chemieanlagenbau Chemnitz GmbH

R&D Implementation

- Use of the pilot plant for demonstration and as research platform
- Program oriented funding of Helmholtz Association
  - Pilot plant operation and R&D themes addressed in ENERGY program topics Renewable Energy, Storage and cross-linked Infrastructure, Energy Materials and Resources
- bioliq PhD network at KIT
  - Actually 25 students working on fundamental, bioliq technology related aspects at 5 institutes of KIT
- HVIGasTech
  - 8 partner institutions with 12 PhD students for modeling gasification of solid/liquid fuel in the bioliq entrained flow gasifier
    www.hvigastech.org

bioliq® - High Pressure Entrained Flow Gasifier



5 MW therm

1000 kg/h fuel

40 / 80 bar

AIR LIQUIDE GLOBAL E&C SOLUTIONS

bioliq® gasifier - Main Features

- Operation Pressure
  - 40 bar(a) or 80 bar(a)
- Load range
  - 700 kg/h – 1000 kg/h Slurry (3.5 – 5 MW_{th})
  - Auxiliary NG feeding of up to 1MW
- Feedstock – Slurry
  - LHV 13 – 25 MJ/kg
  - max. 40 wt% solids with max. particle size of 1 mm
  - Viscosity of up to 1 Pas at 70 °C
- Especially equipped/prepared for research
  - Two reactor sizes (cooling screens) and two burners
  - Two possible quench configurations (dip tube or open quench)
  - Optical access to reaction chamber
  - Extensively equipped with instrumentation (p, T, V, composition, etc.),
  - Sampling possibilities

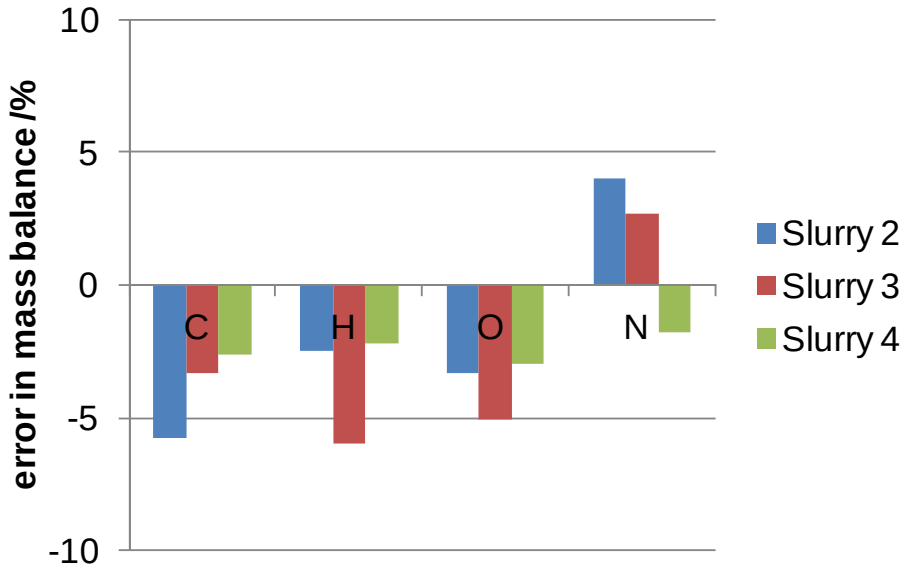
Mass Balance by Main Elements

- Typical syngas composition (dry in vol%)

H_2	CO	CO_2	N_2	CH_4
28-33	28-37	18-27	12-18	<0,1-0,3

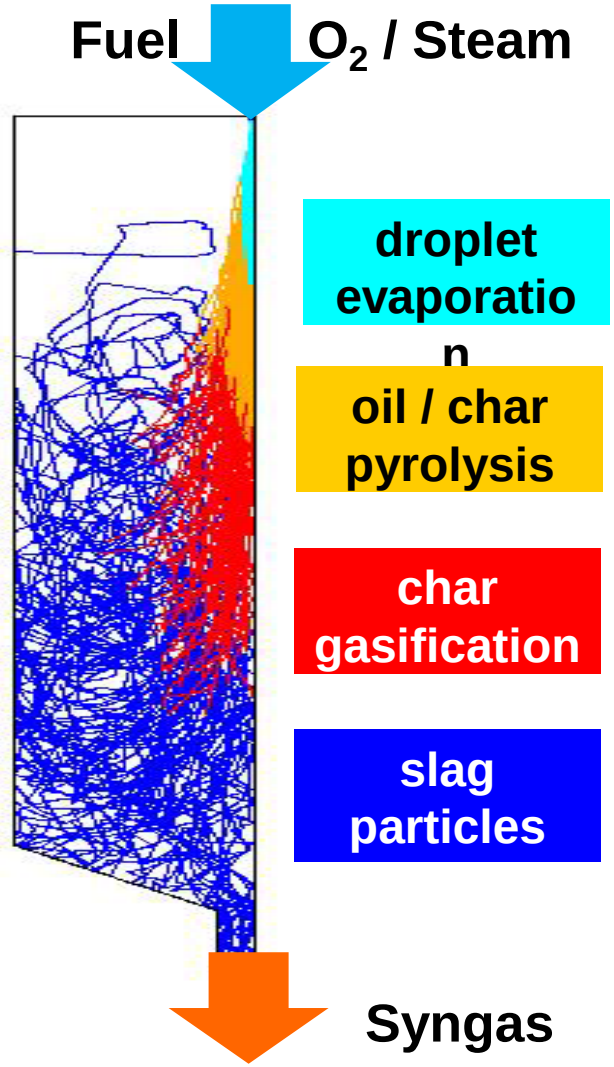
  - rel. high N_2 concentration due to purging several accesses to pilot reactor

- Mass balance performed for main elements
  - July and Dec. 2015 campaigns
  - averaged values for three different slurries
  - indicating good overall balance



Source: M. Müller-Hagedorn et al, 8th International Freiberg Conference June, 13th, 2016

Challenges of entrained flow gasification



reacting 3-phase-system

at high temperature and high pressure

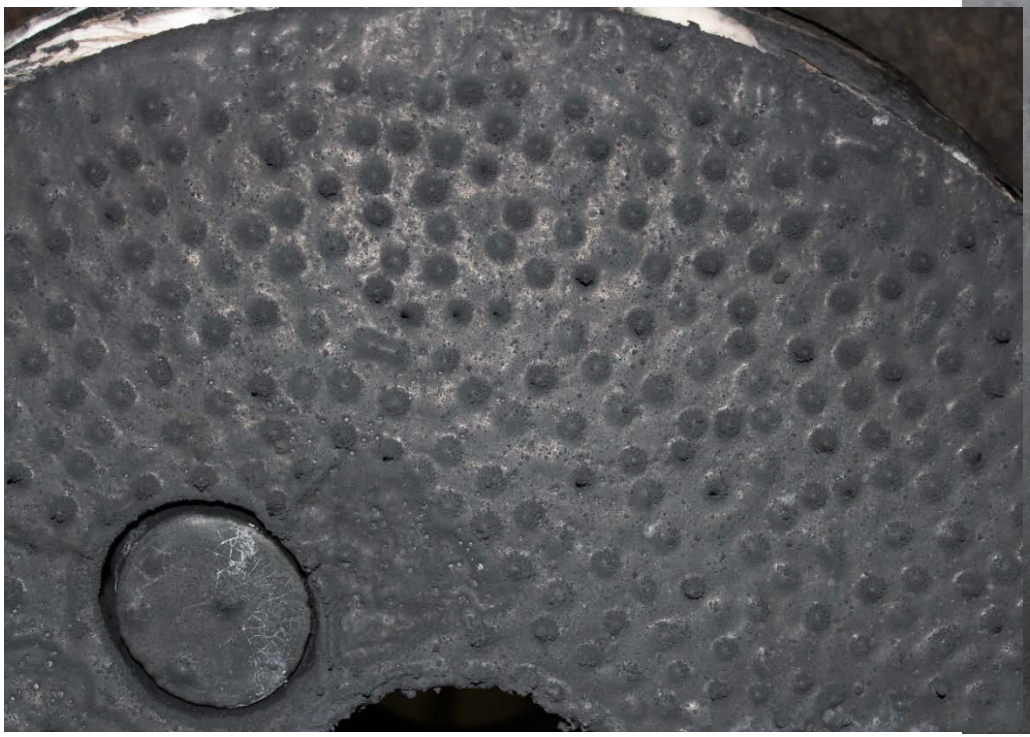
➔ **Atomization**

➔ **Slag**

Source: M. Mancini

Slag distribution inside the reactor

- Validation of design of reactor and burner
  - all walls have to be covered completely with slag
  - reactor walls
  - reactor top



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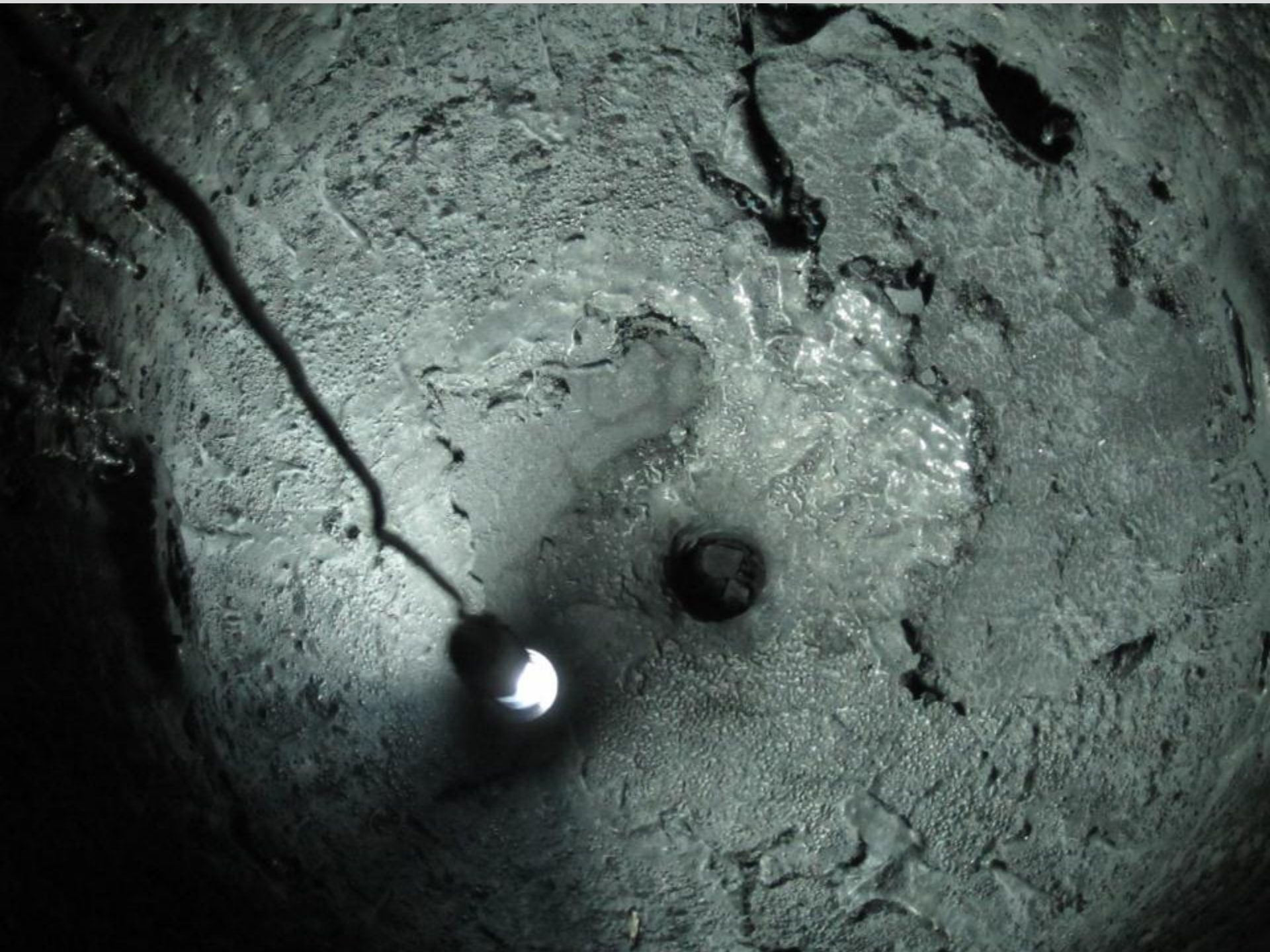
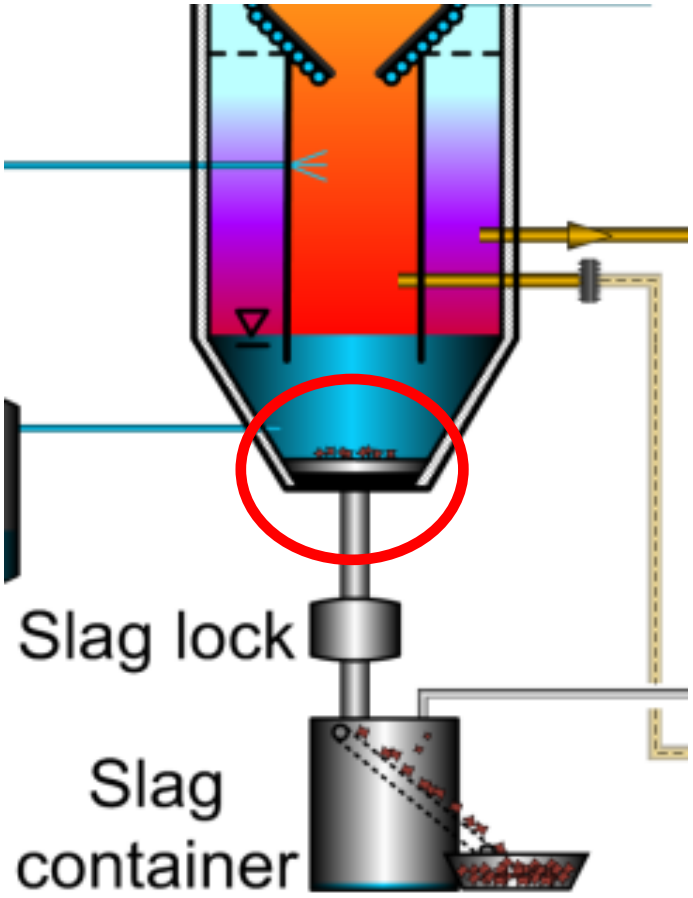


Slag Discharge

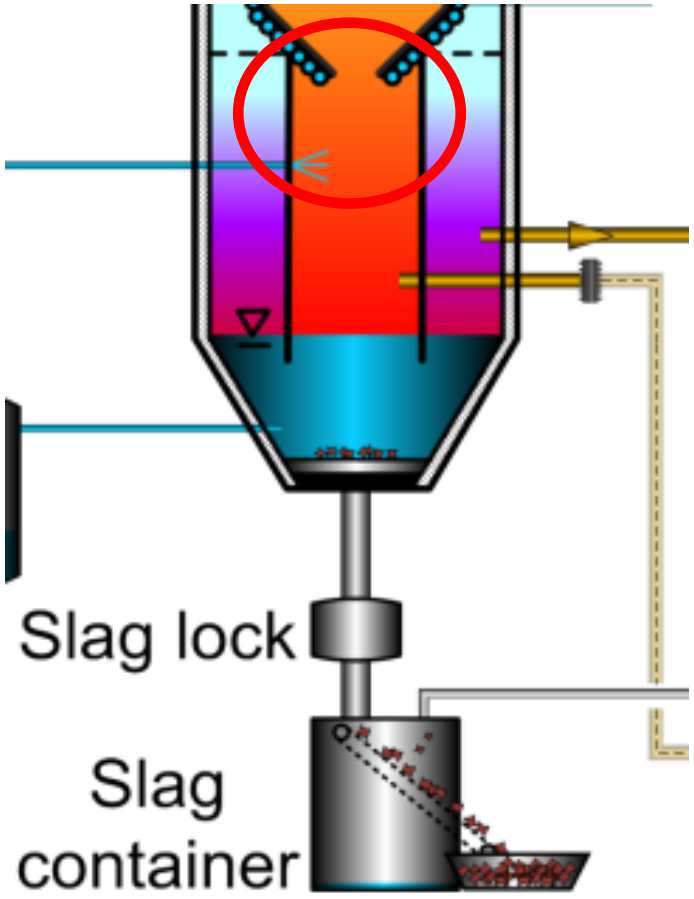


Challenge:

frequently clogging at quench cone

by slag lumps

Slag Discharge



Slag Lumps

Influence of slag viscosity and
flow temperature by variation of:

- additives (flux)
- reactor temperature (syngas temperature)

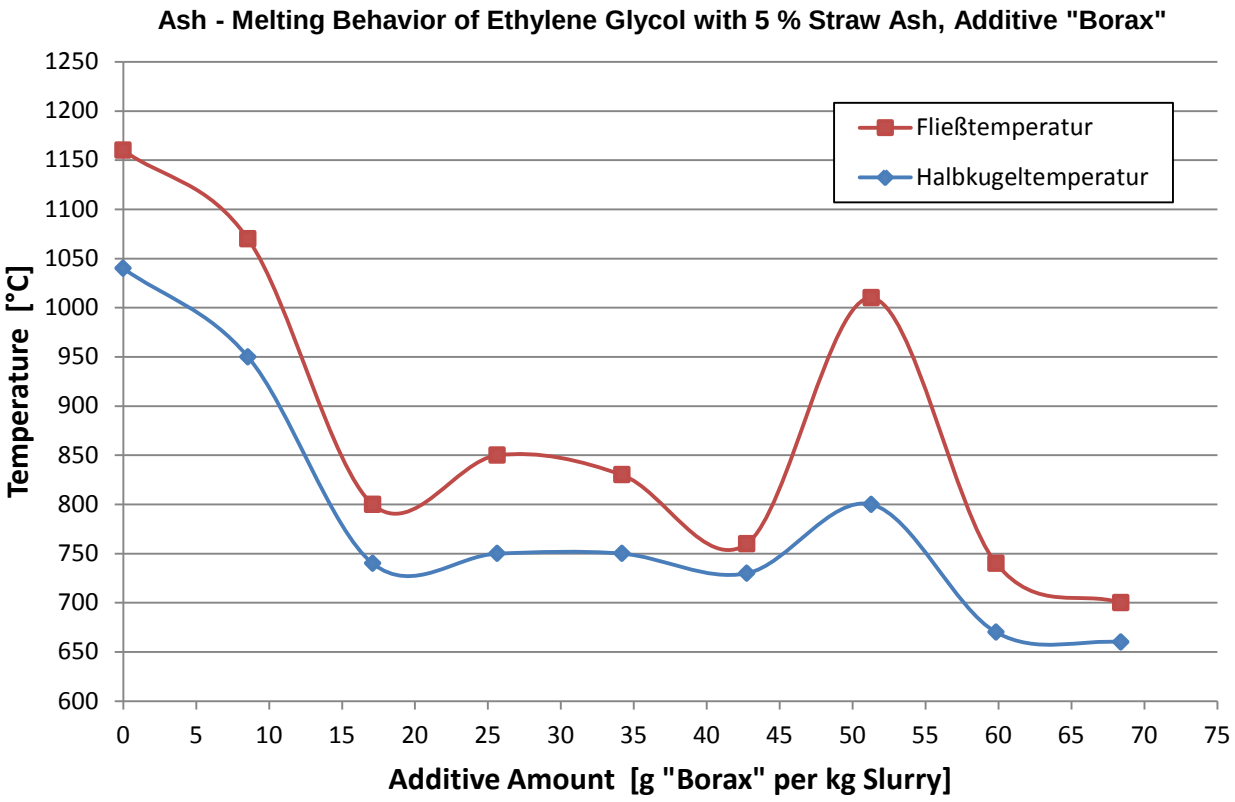
Influence of thermal conditions at
reactor bottom /outlet by variation of:

- slag amount
- syngas-flow / -temperature
- quench cooling

bioliq® gasifier - Additives Dosage

Reduction of slag flow temperature by additives

- ➔ reduced reactor temperature needed
- ➔ increase of Cold Gas Efficiency



bioliq® gasifier - Additives Dosage

Characteristics:

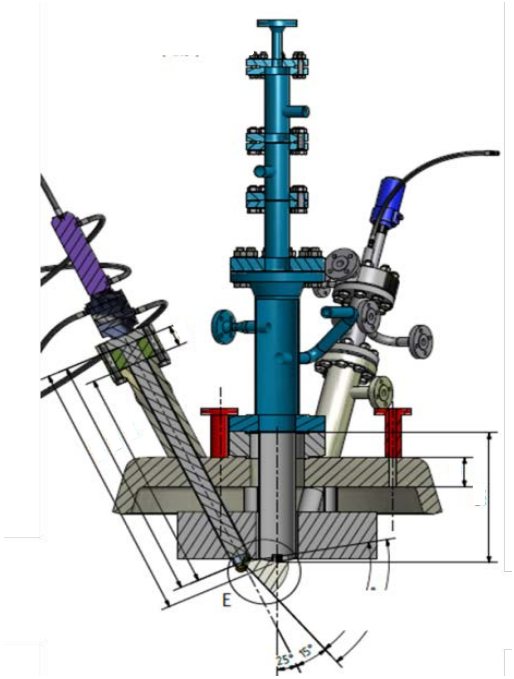
- Big Bag – station
- atmospheric, N_2 - purged
- max. 2 x 50 kg/h additives

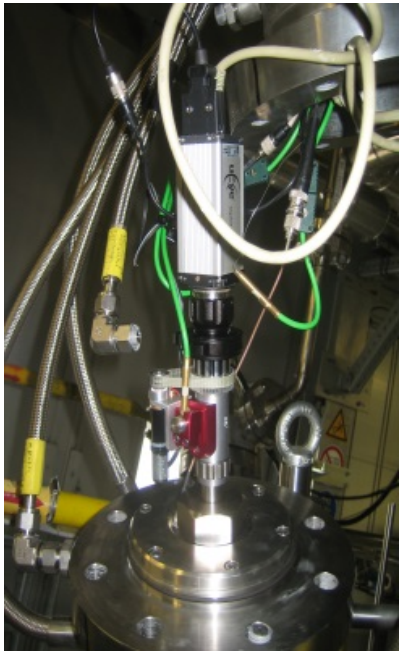
bioliq® gasifier - Additives Dosage

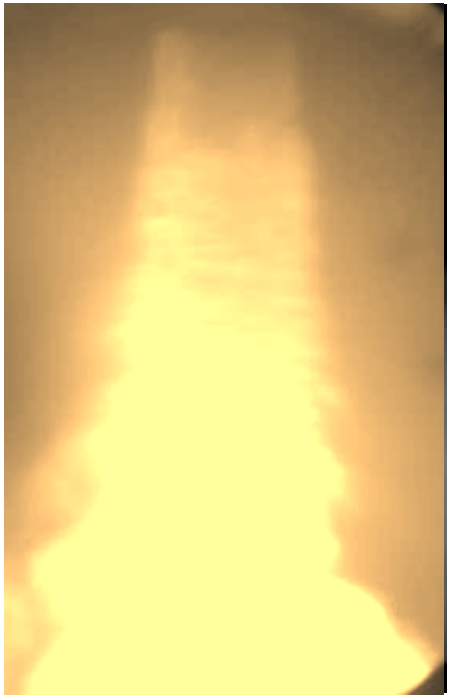
bioliq® - High Pressure Optical Borescope

camera based systems for analysis of atomization

- High Dynamic Range Camera
- High Speed Camera







gasifier flame at 40 bar

cooperation: KIT Institute for Applied Computer Science, IAI

bioliq®



one day at bioliq



Source: L. Tkotz

Thanks to…

- Funding Agencies and institutions
- partners from industry and academia
- the teams from KIT
- …and to the audience

L. Tkotz

www.bioliq.de

contact:
Dr.-Ing. Bernd Zimmerlin
Karlsruher Institut für Technologie
Institute for Technical Chemistry
phone: +49 721 608 24116
mail: bernd.zimmerlin@kit.edu