



**IEA Bioenergy**  
Technology Collaboration Programme



# Country Report Germany

## Task 33 Thermal Gasification of Biomass

### Update

Thomas Kolb, Mark Eberhard

KIT - The Research University in the Helmholtz Association

ENGLER-BUNTE-INSTITUT Fuel Technology, EBI ceb  
Institute for TECHNICAL CHEMISTRY, Gasification Technology, ITC vgt

Onlineworkshop, 19.11.2020

*The IEA Bioenergy Technology Collaboration Programme (TCP) is organised under the auspices of the International Energy Agency (IEA) but is functionally and legally autonomous. Views, findings and publications of the IEA Bioenergy TCP do not necessarily represent the views or policies of the IEA Secretariat or its individual member countries.*

**Technology Collaboration Programme**  
by **iea**

## Folie 1

---

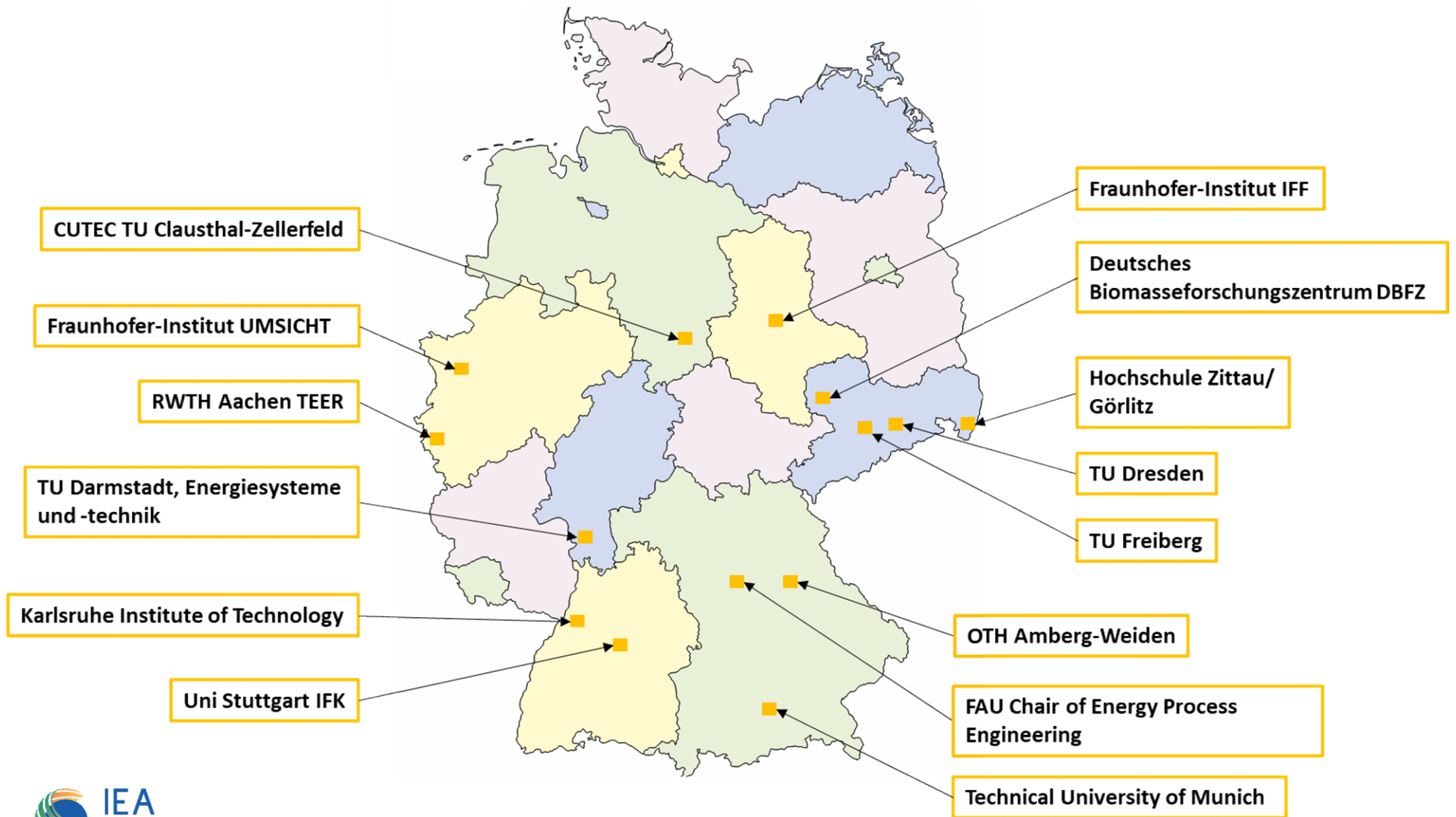
### EC1

To replace photograph (while maintaining the shape): right click on image> choose FORMAT SHAPE > choose FILL > choose PICTURE OR TEXTURE > choose CHOOSE PICTURE in FROM FILE field > navigate to and choose an image to replace background > OK > this new image will now have been skewed to match the shape of the old image so, in order to correct the original shape, choose FORMAT PICTURE in the ribbon bar > under ADJUST, click the drop-down menu of the CROP button and choose CROP TO FIT > you can then resize the iage using the handles to fill the space better while holding down the SHIFT key in order to maintain the original shape

Eleonora Chelazzi; 02.03.2020

# Research Special

## Germany Research Institutes/Centers dealing with biomass/waste gasification





## German Biomass Research Center, Deutsches Biomasseforschungszentrum - DBFZ

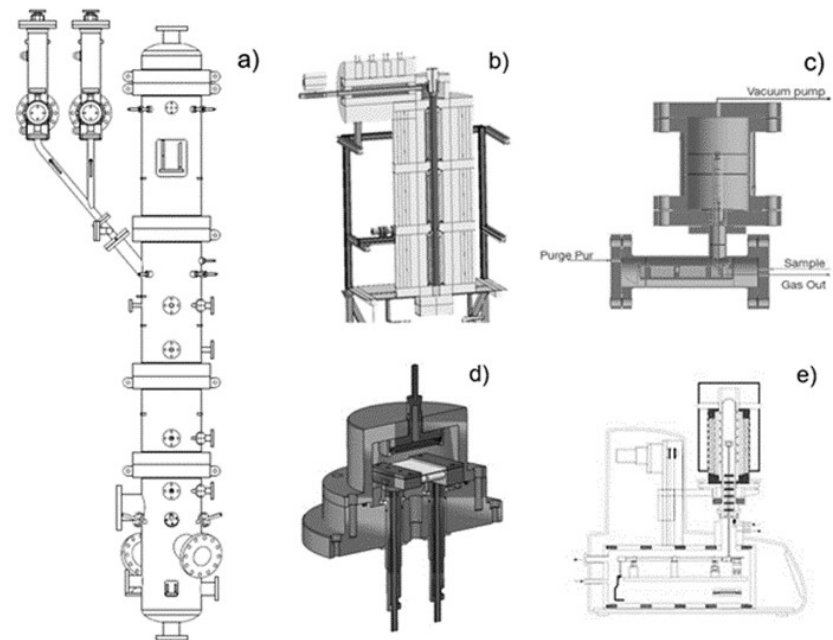
- DBFZ was founded in 2008 with the aim of establishing a central research institution for all relevant fields of bioenergy research and to network the results of the very complex German research landscape in this sector.
- Shareholder: Federal Ministry of Food and Agriculture (BMEL)
- "Smart Bioenergy" concept - research with a systemic view
- all conversion pathways
  - biochemical and thermochemical conversion,
  - biorefinery technology and bioenergy systems
- Test Facilities:
  - biogas research plant
  - engine test facility
  - hydrothermal, gasification and methanization reactors

# Technical University of Munich - Chair of Energy Systems

- air- and oxygen-blown entrained flow gasification of raw and pretreated solid fuels, mainly biomass and waste fractions
- pretreatment includes torrefaction, hydrothermal carbonization and pyrolysis
- reaction kinetics and particle development during gasification, gas characterization of synthesis gas, flame stability and gas cleaning processes

- Test Facilities:

- a) PiTER 1800 °C 50bar
- b) BabiTER
- c) Thermogravimetric Analyzers (pressure)
- d) Wire Mesh Reactor
- e) Thermogravimetric Analyzers
  - BOOSTER (Pilot Scale EFG)
  - Gas Cleaning Unit
  - Fuel Analysis Lab



# Friedrich-Alexander Universität Erlangen-Nürnberg, Chair of Energy Process Engineering

- combustion and gasification of biomass and coal in fluidized bed systems
- focus on allothermal heat pipe based gasification.
- ash melting behavior
- pyrolysis and gasification kinetics
- integration of innovative storage technologies for electricity and heat generation in decentralized combined heat and power (CHP)
- Test Facilities:
  - 100kW Heatpipe Reformer
  - Plasma gasifier
  - Allothermic fluidised bed gasifier (5 kW, 5bar) for biomass / coal
  - Scrubber for purification of e.g. syngas from the gasification



Plasma-gasifier "Xishi"

<https://www.evt.tf.fau.eu/>

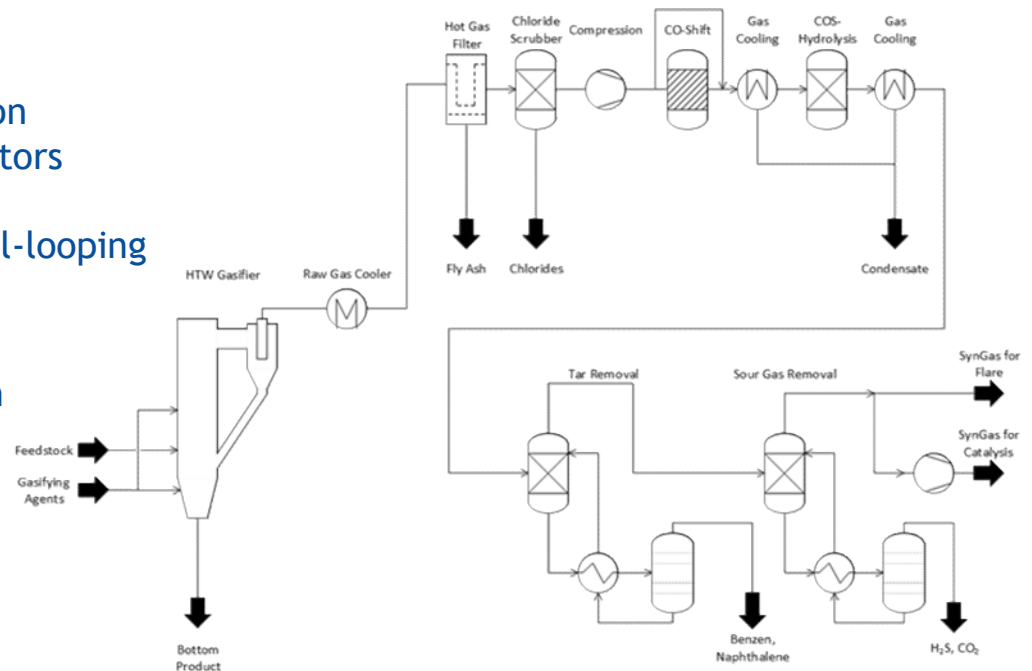
[www.ieabioenergy.com](http://www.ieabioenergy.com)

# Technical University of Darmstadt - Institute for Energy Systems and Technology (EST)

- energy supply based on thermal conversion processes.
- Focused on processes based on fluidized bed technology
- modelling and simulation of multiphase flows

- **Test Facilities:**

- Since 2009: dust-fired combustion chamber, two fluidized bed reactors → CO<sub>2</sub> separation processes (Carbonate-looping and chemical-looping process)
- Since 2015: High Temperature Winkler (HTW) gasifier 0.5 MW<sub>th</sub> + gas treatment plant



# University of Stuttgart - Institute of Combustion and Power Plant

## Technology (IFK)

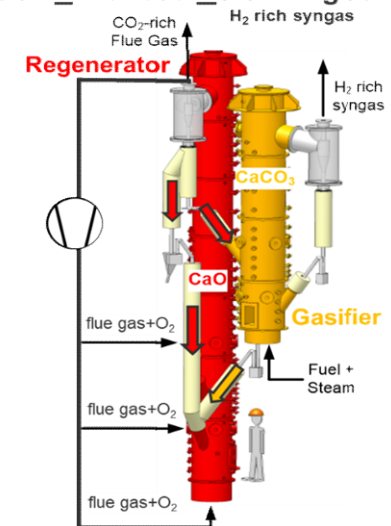
- thermal utilization of gaseous, liquid and solid fuels
- combustion and gasification systems (fixed bed, pulverized fuel, fluidized bed systems and gaseous and liquid fuel boilers)
- experimental facilities with capacities ranging from 5 kW up to 500 kW
- sorption enhanced gasification/reforming (SEG), air gasification, oxygen/steam gasification, and multi stage gasification

- Test Facilities:

- MAGNUS 200 kW SEG demonstration facility TRL 6
- laboratory for fuel, ash and sorbent characterization
- liquid and gas sample analysis
- mills, crushers and other equipment for fuel and sample preparation
- online gas analyzers

### MAGNUS – 200 kW pilot plant for Sorption Enhanced Reforming at IFK

- Gasifier  
bubbling bed reactor  
diameter: 330 mm  
height: 6 m
  - Regenerator  
circulating fluidized bed  
diameter: 210 mm  
height: 10 m
  - Gas analyses  
Gasifier  
H<sub>2</sub>, O<sub>2</sub>, CO, CO<sub>2</sub>, CH<sub>4</sub>, C2-C4, tar  
Regenerator  
CO, O<sub>2</sub>, CO<sub>2</sub>, SO<sub>2</sub>, NO<sub>x</sub>
  - no electrical heating
  - gravimetric fuel dosing
  - fuels: wood pellets, waste, residues
- TRL 6 SEG pilot plant





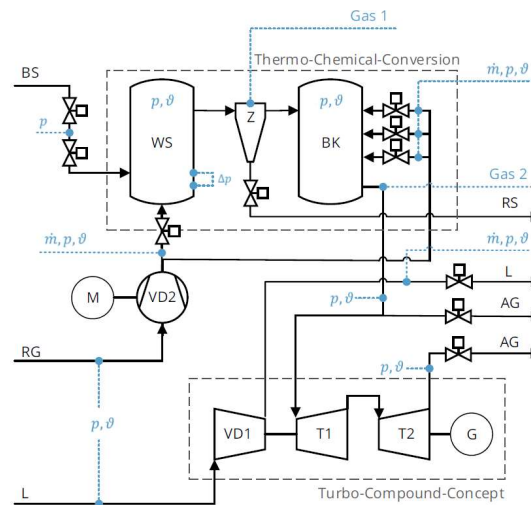
# TU Bergakademie Freiberg - Institute of Energy Process Engineering and Chemical Engineering (IEC)

- transformation from a linear to circular carbon economy for sectors ranging from energy, chemical, waste, metallurgy to processing industries
- experimental process evaluation, CFD simulation, flow-sheet simulation, mineral phase simulation, reactive fluid dynamics to thermodynamic process chains analysis
- first-of-its kind project based on proprietary gasification technology for large-scale green hydrogen production from waste wood to support the National Hydrogen Strategy
- low carbon transition in the mobility sector with synthetic fuels
  - electricity-based liquid fuels (“E-Fuels”)
  - biogenic waste-based fuels (“W-Fuels”)
  - electricity-based renewable hydrogen (“WE-Fuels”)
- Test Facilities:
  - FlexiSlag (BGL) Pilot Plant 10MW
  - FlexiEntrained (GSP) Pilot Plant 5 MWth, 0.6 and 2.6 MPa
  - FlexiCOORVED fluidized-bed gasifier, ambient pressure, 40 and 60 kW



# TU Dresden - Institute of Process Engineering and Environmental Technology

- For experimental investigations with focus on gasification, several laboratory scale facilities are available for fuel characterisation and determination of reaction kinetic data.
- Laboratory facilities:
  - fuel properties according to the fuel specific EN and DIN standards
  - thermogravimetric analyzers (TGA)
- Test Facilities:
  - semibatch-reactors (grate and fluidized bed system)
  - TC<sup>2</sup> process: pressurized fluidized bed gasification plus turbo-compound-concept  
100 - 1000kW thermal input, power production
  - 300 kW<sub>th</sub> circulating fluidized bed combustion test facility



TC<sup>2</sup> process



## RWTH Aachen University - Unit of Technology of Fuels (TEER)

- activities range from conceptual studies to process assessment and development on a laboratory scale as well as on an industrial scale
  - gasification process for problematic polymer waste, expanded polystyrene (EPS)
  - characterisation and minimisation of tars as well as volatile hydrocarbons (VOC) in syngas
  - optimisation of measurement methods
    - tars, (poly-) aromatic hydrocarbons (PAH, BTX) and particles as well as fibres
    - continuous measurement of syngas and flue gas composition
    - discontinuous gas sampling setups
  - **Laboratory facilities:**
    - fuel basic properties
    - Fuel special parameters (e. g. ash softening behaviour, BET surface)
- Test Facilities:**
- pyrolysis, gasification and combustion tests on a semi-industrial scale

# OTH Amberg-Weiden - Institute of Energy Technology (IfE)

## Center of Excellence for Cogeneration Technologies (CoECogen)

- cogeneration technologies, engine powered CHP units, fuel cells, steam processes
- research for practical applications
- Hydrogen produced from biomass and biowaste
- admixing of hydrogen to natural gas
- Laboratory facilities:
  - 6 test benches for CHP systems
    - 4 for small CHP systems with an electrical nominal power of up to 25 kWel
    - 2 for medium sized CHP systems up to 600 kWel
    - EnergyLab with Elektrolyzer, CHP, Waste water treatment, sewage sludge treatment, PV, Windpark
  - measurement equipment
    - exhaust measurement systems,
    - power analysers
    - systems for combustion analysis



Test bench

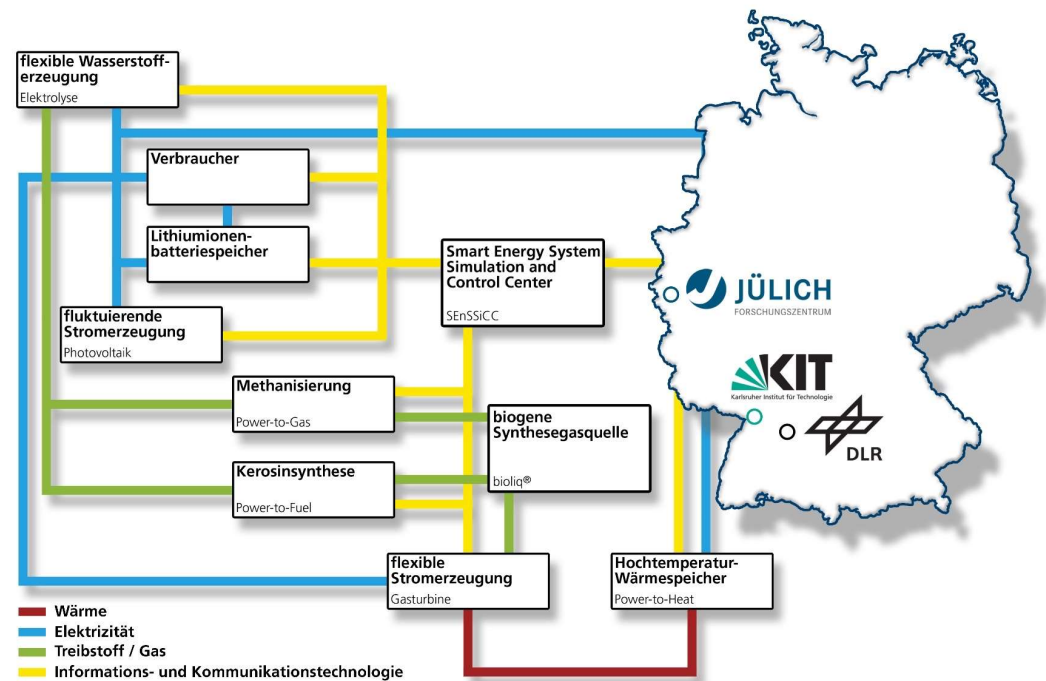
[www.ieabioenergy.com](http://www.ieabioenergy.com)

# The Karlsruhe Institute of Technology (KIT)

## Energy Lab 2.0



- Large scale infrastructure for future energy systems based on RE
- Demonstration of sector coupling technologies
- Power-, heat- and gasgrid with thermal, chemical and electro-chemical storage
- ICT based coupling of energy grids, real time data from dynamic experiments, data security, data protection
- Combining MW-scale experiment with multi-scale simulation and Big Data



# The Karlsruhe Institute of Technology (KIT)

- experimental from lab to pilot scale
- Test Facilities:
  - SANDRA, pressurized syngas fermentation
  - VERENA, hydrothermal gasification 100kg/h
  - REGA, atmospheric entrained flow gasifier 60kW
  - Fuel Lab EBI ceb
  - Energy Lab 2.0
    - Smart Energy System Simulation and Control Center - SEnSSiCC
    - Elektrolyzer, Methanation, Jet fuel synthesis
    - Gas turbine, LivingLabs, Photovoltaik
    - Battery storage, FuelCells...
  - bioliq pilot plant
    - Pyrolysis, HP Entrained Flow Gasifier
    - HPHT Gas Cleaning, Fuel Synthesis

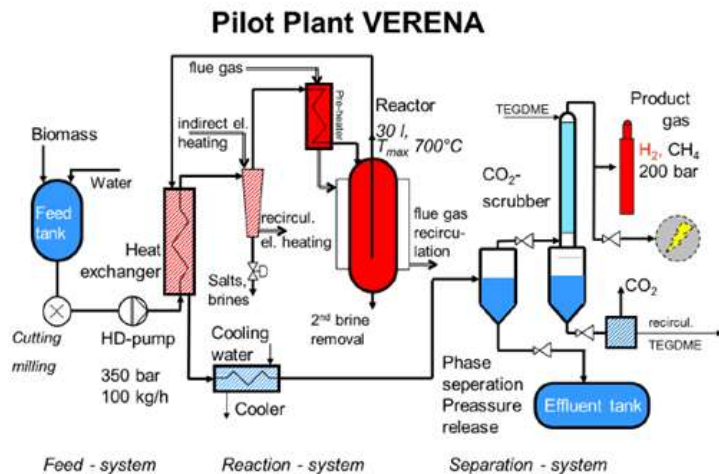


# The Karlsruhe Institute of Technology (KIT)

## Test facilities

### VERENA

- hydrothermal gasification 100kg/h
- biomass with up to 20 % dry matter
- pressure up to 300 bar
- temperature up to 670 °C



### SANDRA

- pressurized syngas fermentation
- pressure up to 7 bar
- working volume of 2.5 L
- H<sub>2</sub>/CO<sub>2</sub>- and H<sub>2</sub>/CO/CO<sub>2</sub>-fermentation
- semi-batch operation (continuous gas supply)



# reFuels - Think fuels new

- Provide, test and evaluate reFuels produced by KIT's syngas platform
- Find practicable solution to realize CO<sub>2</sub> reduction by at least 20% by 2030 with drop-in components which are available or can be introduced on short term.
- Assure compatibility to EN228 and EN590 gasoline and diesel standards to serve the whole fleet
- Evaluation of scenarios differing by resource, technology, and products and their integration into the energy system
- Development of a demonstration plant design for refinery integration

EnergyLab2.0





# reFuels - fuel pathways

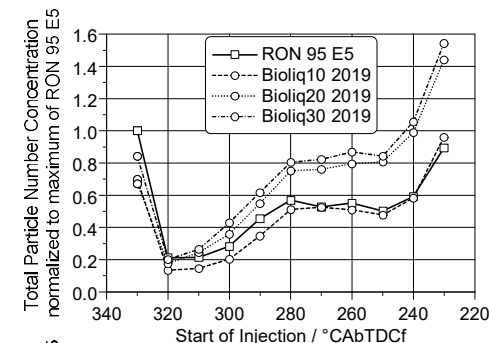
- Gasoline from BIOLIQ's methanol-to-gasoline process utilizing biomass as feedstock
  - Drop in aromat-rich distillate (IKFT)
  - Upgraded heavy gasoline fraction (EBI)
  
- Improved Fischer-Tropsch diesel from INERATEC's micro-structured reactors from renewable hydrogen and CO<sub>2</sub>
  
- Engine and fleet test with blends
  - Fuel and combustion properties
  - Emission behaviour
  - Dynamic behaviour
  - Component approval



IKFT, ITC)



IMVT



IFKM

# reFuels – Think fuels new

## Synthesis of gasoline fuel

- In 2019 and 2020 the bioliq HP Entrained Flow Gasifier provided ~500h of syngas supply in 4 campaigns to the following process steps.
- First batch of 800 L fuel distillate from bioliq Methanol/DME-to-gasoline process produced and blended to 30% gasoline standard fuel by Haltermann-Carless company
- Evaluation of emissions and performance on test engines and cars by KIT, Porsche, Mahle and Bosch
- Results will be considered to formulate a optimized second batch of 800 L.
- Hydrotreating of heavy fraction rich in aromatics has been successfully verified in lab scale for screening of catalysts and process conditions
- Larger scale testing with VTS company in the order of 100 L started.



Bildquellen KIT IFKM / Amadeus Bramsiepe, KIT



# Project Partners



AUDI AG, BorgWarner Inc. Ludwigsburg, Caterpillar Energy Solutions GmbH (MWM), Daimler AG, Eberspächer GmbH & Co. KG, Freudenberg Sealing Technologies GmbH & Co. KG, Ineratec, KS Kolbenschmidt GmbH, Mahle GmbH, Mann + Hummel GmbH, Dr. Ing. h.c. F. Porsche AG, Robert Bosch GmbH, Rolls-Royce Powersystems AG (MTU) Schaeffler, Deutsche Bahn and ENBW AG and MiRO GmbH & Co. KG with support of Mineralölwirtschaftsverband (MWW).