

IEA Bioenergy Agreement: 2019-2021
Task 33: Gasification of Biomass and Waste
Second semi-annual Task meeting, 2020

Virtual meeting
18.-19.11. 2020

Minutes

Prepared by Dr. Jitka Hrbek, BOKU, Austria
and
Berend Vreugdenhil, TNO, NL

The list of attendees, for the Task Meeting includes:

Name	Country	Affiliation	email
Berend Vreugdenhil	Netherlands	ECN	vreugdenhil@tno.nl
Jitka Hrbek	Austria	BOKU	Jitka.hrbek@boku.ac.at
Christoph Pfeifer	Austria	BOKU	Christoph.pfeifer@boku.ac.at
Donatella Barisano	Italy	Enea	donatella.barisano@enea.it
Joakim Lundgren	Sweden	LTU	Joakim.lundgren@ltu.se
Thomas Kolb	Germany	KIT	Thomas.kolb@kit.edu
Mark Eberhard	Germany	KIT	Mark.eberhard@kit.edu
Patricia Thornley	UK	Aston University	p.thornley@aston.ac.uk
Robert Baldwin	USA	NREL	Robert.baldwin@nrel.gov

IEA Bioenergy Agreement: 2019-2021
Task 33: Gasification of Biomass and Waste

Second Semi-Annual Task Meeting, 2020

Virtual meeting

18.-19.11. 2020

The Agenda of the Task 33 meeting was as following:

18.11.2020 13:00 – 17:00 CET

- Welcome
- Overview of Task 33
- Minutes previous meeting
- Budget
- Update on TP1 Emerging gasifiers (Sweden / Joakim)
- Update on TP4 Status of gasification (Austria / Jitka)
- Update on ITP1 High temperature heat (Netherlands / Berend)
- Update on ITP2 Gasification in (bio) refineries (Austria / Jitka)
- Feedback ExCo – Recent strategy session
- Lay-out next triennium
- Workshop (Contribution of Harry Knoef)
- Next meetings / AOB

19.11.2020 13:00 – 17:00 CET

Country reports:

- Italy
- Germany
- Austria
- UK
- US
- Sweden
- Netherlands

Task 33 Meeting discussions

Meeting Minutes from the last online meeting in June approved.

1. Discussion regarding **budget** left, Berend prepared an overview (see table below)

Budget	Allocated	Spent	Left
Task funds	€ 199.942	€ 105.219	€ 94.723
TP1	€ 13.271	€ -	€ 13.271
TP4	€ 8.847	€ -	€ 8.847
ITP1	€ 17.694	€ 13.185	€ 4.509
CP1	€ 77.000	€ -	€ 77.000
Income			
IEA	€ 250.812	7 countries for 3 years	
Transfer Kevin	€ 33.926	Leftover previous triennium	
Transfer Jitka	€ 2.322	Closing account Austria	
Transfer Procec	€ 4.771	Previous ITP contribution	
ITP1 transfer	€ 8.847	Additional budget for ITP1	

At the moment slightly higher allocated funds, compared to income. Anyway, Task will spend less on travel, physical meetings and organizing of workshops.

2. Discussion regarding **Status report**, project leading by Austria (Jitka).

This time also nonmember countries should be included into the report.

Confirmations so far:

Spain – will contribute (Prof. Gomez-Barea, USE), confirmed already

France – will contribute (Madeleine Alphen, Club Pyrogazéification)

Canada – Christoph will contact

Jitka already prepared a text with an ask regarding contribution to the report and sent it to our members for further forward.

This time the Status report will be focusing on research in member countries and overall overview in non-member countries. Task members were asked to provide the information regarding research institutions as well as research areas related to gasification and include also description of 1-2 successful research projects in each country.

The template for research projects sent by Jitka to Task members.

The update of the database is essential for the Status report as well.

Each country should provide their contribution as well as update for the database till the end of 2020.

3. TP1 – **Emerging technologies for biomass and waste**

- molten bath gasification, reforming gasification, thermal plasma, cold plasma, super critical etc.
- this report can be used by IEA Bioenergy as unbiased information on the status of the technology
- Sweden leads (Joakim)

- Joakim sent the draft version to the group. Feedback awaiting till 11.12.2020
- TP1 also developed a good approach in evaluating emerging technologies, this could be applied to other technologies as well

4. ITP – **Bioenergy for high temperature heat in industry**

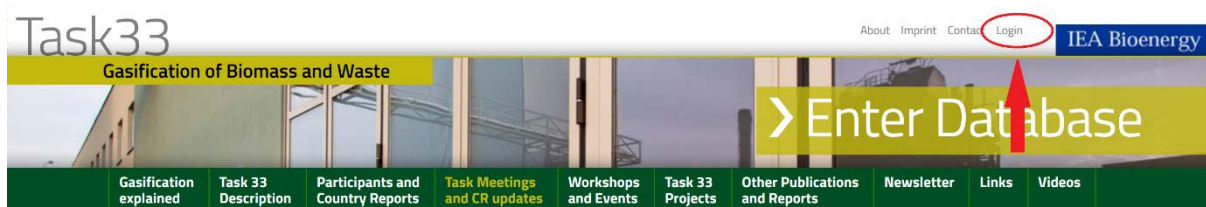
- Inter Task project together with T 32, 34, 36, 40
- Direct use of process heat or indirect through a heat carrying medium
- Several challenges ahead in integrating industries
- Proposed case study (T33 part): CFB gasifier using paper rejects for captive steam production at the ESKA plant in Groningen, the Netherlands
- Case studies are now available

5. CP (collaborative project with T 42) – **Gasification for the application in biorefineries**

- Project name changed to “Gasification applications in existing infrastructures for production of sustainable value-added products” to illustrate opportunities to apply thermal gasification
- The updated proposal was presented
- All issues regarding the project are clear now
- Each month online meeting to discuss the progress of the report
- Austria leads, NL, Sweden, Italy and Germany involved

6. Berend presented ExCo survey, details in member area

How to get to member area:



User: task33_member

Password: %task33_n8wb3r!

Berend's conclusions:

- Interaction between tasks can be promoted through ITPs
- Clustering of Task meetings to enable interaction
- BECCS considered highly relevant but not something to put into a separate task
- Always discussion on merging T33 and T34.
- With sufficient interest (at least 6 countries) the task will remain a separate task. However, it is good to keep in mind options to collaborate more in our value chains

7. Discussion on next Triennium

Berend suggested to restructure Task 33 to focus on the applications

Goals of the restructuring:

- Position gasification technology more prominent, better visibility for industry
- Driver for more interaction between participating countries
- Leverage for more industrial participation

Restructure within the Task 33 and division into subtasks:

- CHP
- SNG
- ABF (advanced bio fuels)
- Chemicals
- CC(U)S
- Hydrogen

Each subtask will be managed by 1 country; within the subtask we work on:

- new description for the website
- identifying industrial players and start to reach out for participation
- identifying R&D activities and needs, as well as demo's
- Include on our website a contact page where we place links to industrial practices and group them also by expertise (for instance biofuels, or CHP)

Discussions on sponsorship and involvement of industry on Task projects.

Berend will clear with Luc (technical coordinator) the rules for Task sponsorship.

8. Workshop

Topic definition: Gasification status – an overview

- Harry Knoef to present on the African situation
- Jitka to present on Task member countries and additional some non-participating countries
- Possible further speakers: China – Patricia and Christoph will contact possible speakers, India – Donatella contacts
- Date: February 2021

Actions: Berend will write invitation, discuss with Luc and EtaFlorence

To-do-list:

1. Flyer as Lessons learned – Joakim and Berend start and send the info to the group in Fall 2020, each country should then prepare a half page on this topic
2. Berend clears the rules for sponsorship with Luc

3. Each country should finalize the country report before the end of the year, following the instructions of Jitka

Country Reports Update

Austria, Jitka Hrbek, BOKU Vienna

Actual situation and potentials regarding renewable energy in Austria was presented as well as number of CHP gasification facilities. At the moment, there are over 140 small scale facilities in operation, together with el. output of 300 MW which produce over 2.200 GWh electricity and 4.02 GWh heat per year.

Energy consumption and potential of renewables in 2050 was presented as well.

Research on thermal gasification of biomass and waste takes place in Austria at the following institutions:

- BOKU Wien (University of Natural Resources and Life Sciences Vienna)
- TU Wien (Vienna University of Technology)
- BEST (Bioenergy and Sustainable Technologies)
- TU Graz (Graz University of Technology)
- MCI (Management Centre Innsbruck)
- GET (Güssing Energy Technology)

The research areas as well as actual projects were presented.

Austrian companies, which are active in area of thermal gasification were introduced.

Companies such as Aichernig Engineering GmbH, GET, Güssing Renewable Energy, GE Jenbacher, Glock Ökoenergie, Hargassner, Fröling, Syncraft, Gresco Power and Urbas were presented.

The presentation included the Syncraft mission to be CO₂ negative using biochar for CCS. Biochar is produced by Syncraft in excellent quality therefore it could be used for animal feed, as terra preta for soil enrichment, for water treatment as a part of filters and as a part of asphalt (green road). Adding of only 2% of biochar to asphalt by the production of 100 000 t of asphalt/year in Austria, 6000 t CO₂ can be stored. Taken to account the EU, it would be 9 mill. tons CO₂/year.

Other projects:

[Project Waste2Value](#)

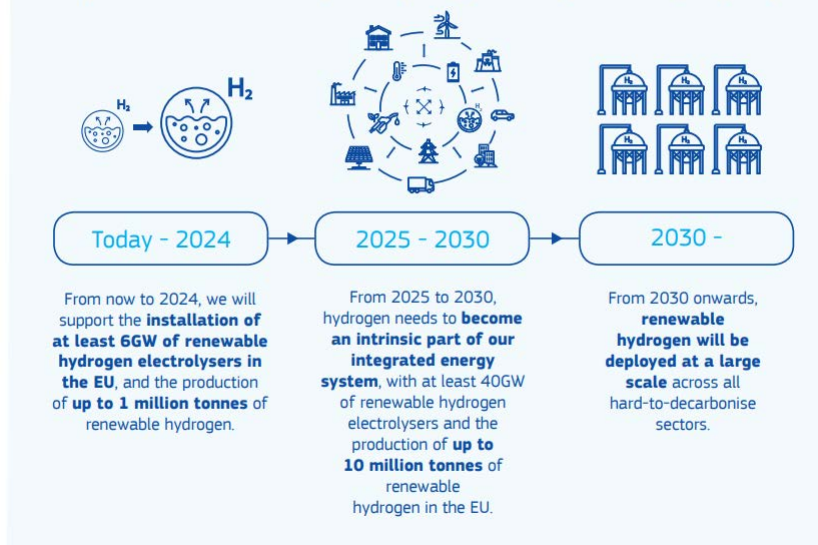
- at the moment there is a gasification facility under construction in Vienna. It will be a 1 MW dual fluidized bed demoplant, which will gasify waste materials (RDF). The facility will be coupled with 300 kW Fischer Tropsch synthesis pilot plant. Research laboratory with lab-scale synthesis test rigs for production of mixed alcohols, hydrogen separation etc. will be installed nearby.

Actually, the construction is undergoing, the first operational tests are planned for March/April.

Italy, Donatella Barisano, ENEA

According to “A climate-neutral Europe” act, a hydrogen eco-system was presented. Green hydrogen should be produced by electrolysis and by other pathways. Italian government established therefore a working group “Hydrogen”. One of the pathways for production of clean hydrogen should be gasification as well.

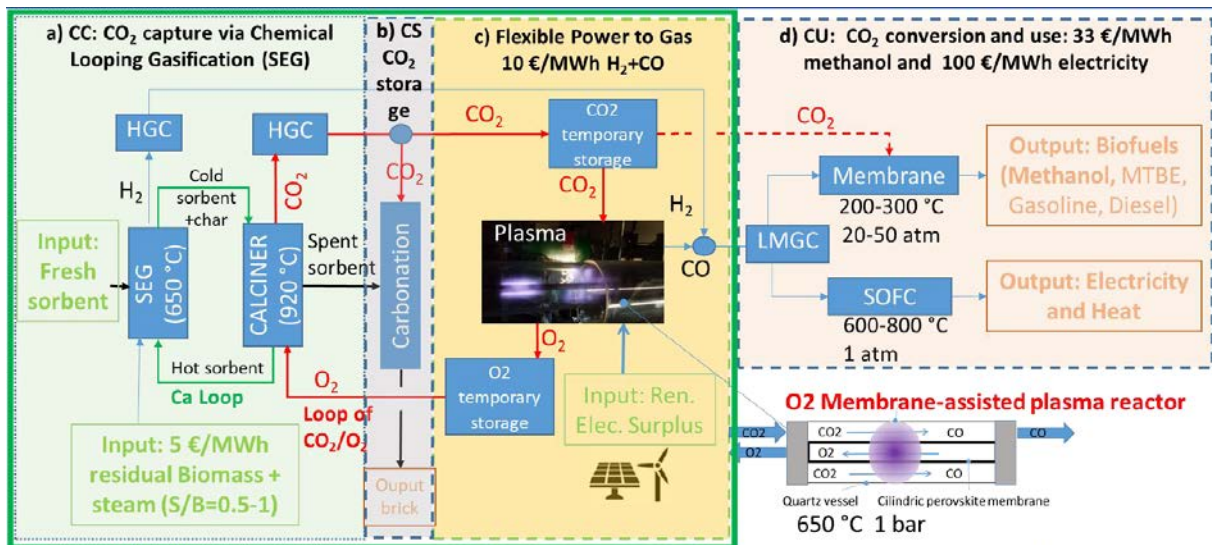
The path towards a European hydrogen eco-system step by step :



An Update on EU and national projects on gasification was presented.

GICO – Gasification Integrated with CO₂ capture and conversion

- Horizon 2020 project
- Development of small to medium scale residual biomass gasification plants integrated with CO₂ capture and conversion; outputs should be CHP and biofuels



GICO concept: a) Chemical Looping Gasification for production of pure H₂ and pure CO₂ from biogenic feedstock; b) Carbon Storage; c) Flexible Power to Gas based on CO₂ dissociation via O₂ membrane-assisted plasma reactor powered by renewable electricity surplus; d) methanol production via hydrogenation of CO and/or CO₂. Temporary storage of O₂ and CO₂ for fluctuation of renewable electricity. In case of no electricity excess, CO₂ can by-pass plasma and be sent to membrane.

Initiative by NextChem&Eni

- Eni and Maire Tecnimont sign agreement to introduce new technology that transforms non-recyclable waste into hydrogen and methanol (processes based on gasification are included)
- NextChem and US carbon recycling company, LanzaTech sign an agreement to license the "Waste to Ethanol" process line (syngas fermentation)
- by 2023 planned a startup of a plant for waste to methanol in Livorno (output capacity 110 ktons/year)

Netherlands, Berend Vreugdenhil, TNO

The NL is steering away from CHP from biomass, but biomass should be crucial by production of biofuels and biochemicals.

White paper from TNO on plastic waste introduced.

<http://publications.tno.nl/publication/34637387/hcNIhm/TNO-2020-circular-plastics.pdf>

Gasification status in the NL



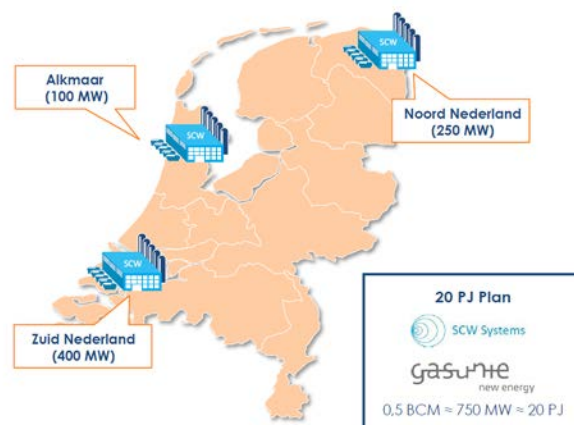
Synova (MILENA + OLGA)

Opportunities:

- plastic waste cracking and connecting to existing industrial infrastructure
- biomass gasification towards SNG
- waste to electricity

SCW Systems

- supercritical water gasification
- ambition 20 PJ



Status **Torrgas**

- 1 MW Demo DNV-GL (TRL 7)
- Scaleable to 100 MW
- 30 MW SNG Delfzijl in Basic Engineering fase
- 50 MW green hydrogen permitting, FEED fase
- Business model is the sale of licenses

Input streams (key is torrefaction)

- Woody residues
- Agricultural residues
- Grass streams
- Manure waste streams

Output possibilities

- SNG/LNG/CNG
- Hydrogen
- MeOH and DME
- Biokatalysis (syngas fermentation)
- Connect to the steel industry

G.I. Dynamics – Advanced Methanol Amsterdam

- RDF gasification using HTW technology
- Gidara acquired the HTW technology
- Goal is to convert 175 kton/year into 90 kton MeOH
- Connect the CO₂ to the OCAP

Stercore

- Manure to green gas & bio-based carbon factory
- NGO started a law suit Q1 2021 outcome expected, project is ready to start
 - o Input: 185 000 Mtons manure/digestate
 - o Output: 30 mill. m³ green natural gas, 75 000 Mtons biobased carbon

ENERKEM

- Rotterdam project is roughly 450 M euro for 230 kton
- The W2C consortium is currently evaluating drop-in biofuels rather than blend fuels

RWE

- Waste to Hydrogen in the planning in the south of the Netherlands
- Capacity will be 40 kton per year of hydrogen (1000 tpd of waste)
- Invest in the complete chain.
- Taking in waste, separating minerals, metals and drying
- Torrefaction of waste to a uniform pellet
- Siemens gasification technology (EF) to produce syngas
- Produce hydrogen and CO₂
- Process tested in Freiberg

Sweden, Joakim Lundgren, LTU

Commercial gasification projects – update

Cortus 6 MW WoodRoll® gasifier at the Höganäs steel plant

- Problems with particle build-up in the pyrolysis gas pipes
- Finely ground char particles form deposits in the pipes which complicates the combustion process
- Installation of a cyclone has reduced the amount of finely ground char, but further reduction is necessary

Cortus WoodRoll® in Mariposa (US)

- Biomass-to-electricity project in Mariposa
- Pacific Gas & Electric (PG&E) has approved Cortus and the Mariposa-project for delivery of 2,7 MW electricity
- Cortus can now participate in forthcoming auctions within the BioMAT-program

Cortus WoodRoll® & ENGIE in Bordeaux (Fr)

- Collaboration project (WoodHy) initiated 2019 on biomass-to-hydrogen
- An order from Engie Cofely worth 135 000 € to carry out an Advanced Feasibility Study of a plant for hydrogen and CO₂ production

MEVA CHP plant in Hortlax

- EF cyclone gasifier emanated from Luleå University of Technology
- Outputs 1.2 MWe and 2.4 MWth
- Small fraction fuels (sawdust, wood fibers and agricultural residues)
- Joint project with Andritz-Enviroburners - A complete gas burner test facility to enable complete engineering of industrial burner installations for process heat generation

Commercial projects under development

BioShare

- The company BioShare has recently been granted funding ($\approx 1,7$ M€, 2020-2024) to demonstrate integrated gasification and pyrolysis at a CHP-plant
- The reactor will be operated during three heating seasons to assess performance and gas quality with different feedstocks
- Also test different downstream units in pilot scale in separate projects with customers and other stakeholders

GoBiGas

- currently, plant is moth-balled and for sale
- Ongoing contract negotiations – Covid-19 situation delays the process

LTU Green Fuels plant

- still moth-balled to high costs,
- New regional funding secured for three years to keep the plant from being dismantled and to find new projects

Phoenix Biopower

The Biomass-fired TopCycle (BTC) - high-pressure steam treatment and entrained flow gasification, gas turbine for power generation, aiming at electrical efficiency of up to 60 %

- Funding for a pre-study on a pilot plant together with Tekniska Verken in Linköping

Research activities

- Swedish Gasification Centre (SFC): 2011-2021, budget 54 M€
- Swedish Knowledge Centre for Renewable Transportation Fuels (f3): New phase 2018-2021, budget 3.3 M€
- Swedish Energy Agency's biofuel program: On-going 2017-21. Both thermal and biochemical conversion, budget 18 M€

SFC (Swedish Gasification Centre)

- Strengthen and coordinate Swedish gasification R&D and foster a new generation of gasification competence in Swedish academy and industry

- In total, 19 companies, 8 universities and one research institute

- Plan for a renewed research program with broadened scope and increased industrial relevance

- New focus areas:

Gasification in paper- and pulp industries

Gasification in petrochemical industries

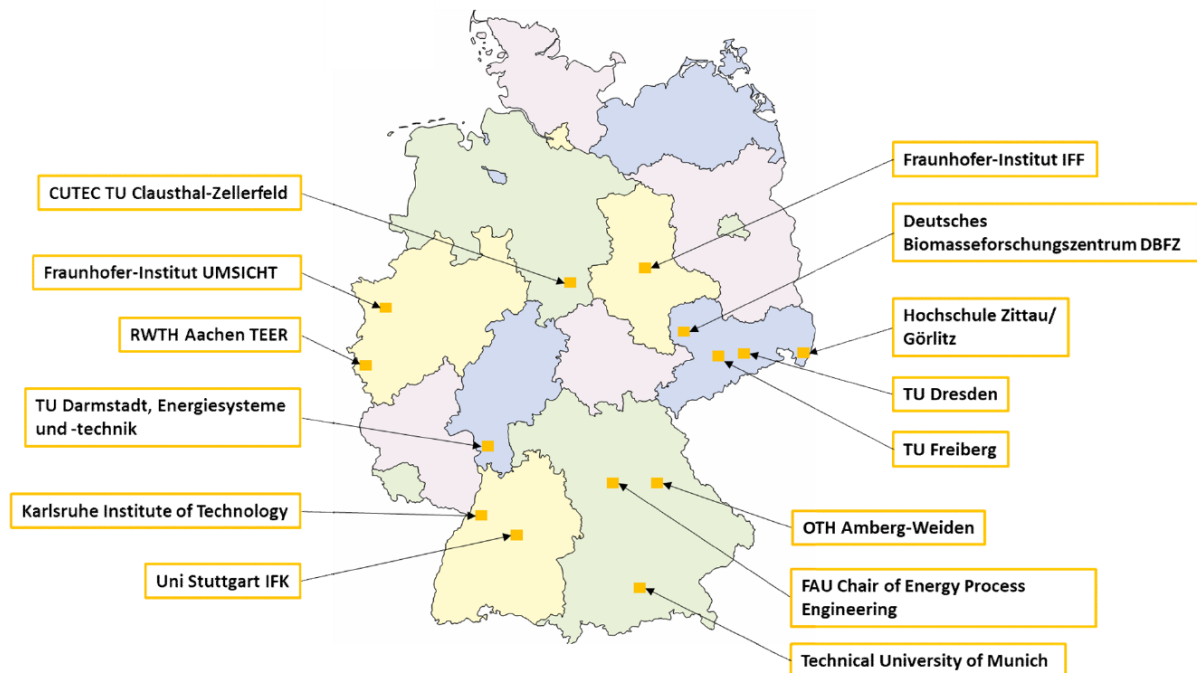
Gasification in steel industries

Policy issues influencing gasification technologies

1. The reduction obligation for transport fuels forces fuel distributors to blend in pre-determined shares of renewable fuels into fossil diesel and gasoline or pay fairly large fines
2. The reduction obligation in itself is good, but in the current form, it fails to promote domestically produced biofuels
3. Sweden has now instead become a very large importer of HVO, which is, in the long term hardly sustainable. SFC has published a position paper in the matter, see www.sfc-sweden.se
4. In the Budget Bill for 2021, the Government has proposed gradually increasing reduction quotas for 2021-2030 (28% CO₂-reduction for gasoline, and 66% for diesel in 2030)
5. The government will also introduce a reduction obligation for aviation fuels
6. The proposal from the biogas market investigation to give a premium to biogas/biomethane only produced via anaerobic digestion, does not seem to be realized
7. The Government has now commissioned the Swedish Energy Agency to investigate the need for additional policy instruments to promote domestic production of biofuels with new technologies

Germany, Mark Eberhard, KIT

Research in field of biomass and waste gasification



German Biomass Research Center,

Deutsches Biomasseforschungszentrum – DBFZ

- 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:
 - o 100kW Heatpipe Reformer
 - o Plasma gasifier
 - o Allothermic fluidised bed gasifier (5 kW, 5bar) for biomass / coal
 - o Scrubber for purification of e.g. syngas from the gasification

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:
 - o Since 2009: dust-fired combustion chamber, two fluidized bed reactors, CO₂ separation processes
 - o Since 2015: High Temperature Winkler (HTW) gasifier 0.5 MW_{th} + 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

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

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)

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

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

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 electrochemical 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
 - 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

reFuels – Think fuels new

- Provide, test and evaluate reFuels produced by KIT's syngas platform
- Find practicable solution to realize CO₂ 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

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 CO₂

Engine and fleet test with blends

Fuel and combustion properties

Emission behaviour

Dynamic behaviour

Component approval

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.

United Kingdom, Patricia Thornley, Aston University

UK Government Response to Committee on Climate Change published November 2020

- Commitment to develop a biomass strategy for the UK
- Will be cross-governmental effort led by department for Business, Energy and Industrial Strategy
- To be developed 2020-2022

Academic BECCS-hydrogen demonstrator

- Proposal submitted, decision early 2021
- UK Government issued call for demonstration innovation projects that are industry-led including BECCS
- (<https://www.gov.uk/government/publications/direct-air-capture-and-other-greenhouse-gas-removal-technologies-competition>)

KEW plant

- Have been commissioning plant with tests on waste wood, RDF and other feedstocks)
- Update given at Supergen Bioenergy hub annual assembly 17 November 2020 – available online by end November at www.supergen-bioenergy.net
- Useful analysis of costs and GHG balance for bio-hydrogen:
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/873885/kew-zero-carbon-bulk-hydrogen-supply.pdf

Advanced Biofuel Solutions Ltd (ABSL) Swindon site

- Commercial demo
- 20-25 GWh/yr of bioSNG
- Cost of £38M
- Construction complete
- Cold commissioning at moment. Lots of snags but resolving them. e.g. conveyors and handling online.
- Hot commissioning in January 2021
- Planning to be processing waste Feb / March 2021
- Update: <https://www.linkedin.com/company/advanced-biofuel-solutions-ltd/>

Project Bright

- Some similar technologies to ABSL Swindon plant
- Larger scale – 320GWh/yr bio-SNG
- Located near center of HyNet project – CCS infrastructure should be available ~2025

CoGen (Hooton/Cheshire)

- 270ktpa municipal solid waste
- 24 MWe
- Kobelco gasifier
- Now cold commissioning
- Other four sites (Dartmoor, Welland, Birmingham, Ince) using Nexterra / Outotec gasifiers with waste wood, still in operation

- Energy Works Hull offline as of Sept 2020 after fire, was operating – 28MWe/10MWth
- Amey Milton Keynes site still in operation
- Viridor Glasgow site opened August 2020 (200ktpa / 15MWe Energos gasifier)
- Hoddesdon (90ktpa RDF / 10MWe) started operating January 2020 (EPC and operation through Bouygues Energy and Services).
- Barr Killoch Energy Recovery Park Planned - 85ktpa RDF, 25MWth / 12MWe (East Ayrshire)
Looks like dual gasifier units direct coupled to steam generator.

USA, Robert Baldwin, NREL

Fulcrum Bioenergy/Sierra Biofuels:

- MSW feedstock/TRI indirectly heated fluid bed steam reforming gasifier
- 350,000 tons per year raw MSW -> 175,000 tons per year prepared MSW
- 20 TPH throughput

- MRF operational since 2016; at landfill 10 miles from biorefinery
- Gasification/FT under construction, start up in Q1 2021
- Johnson Matthey DAVY™/BP fixed-bed FT
- Recently pivoted from jet fuel to FT wax
- Off-take with Marathon Oil Co., Wax to be refined in Marathon's Martinez CA refinery
Uncertain whereas Martinez, CA is being converted to renewable diesel facility
- Other offtakers include United and Cathay Pacific, BP Air, World Fuels
- FT jet fuel capability to be added in Phase II
- Plant is "full scale", 3x scale up planned with parallel trains
12 new projects currently planned/underway
- More information: <http://fulcrum-bioenergy.com/facilities/>

Red Rock Bio

- Gasification to Fischer-Tropsch
- Technology providers
- Providers Gasification: TCG Global steam reforming
 FT technology: Velocys and Emerging Fuels Technology
 Parallel FT trains
 Hydroprocessing: Haldor Topsoe
- Feedstock: forest residue (136,000 tons per year)
- Products: cellulosic renewable jet, diesel, and naphtha fuels
- Offtakes: Southwest Airlines, FedEx Express
- First commercial project status
- Site: Lakeview, OR
- Capacity: 15 MGY
- Anticipated construction completion: Q1 2021

Other commercialization activities

Aries Clean Energy

- Downdraft gasifier for biochar and syngas-to-power applications
- Fluid bed gasifier for production of syngas
- Projects:
 - 1) Linden, NJ; fluidized bed gasification of bio-solids (Linden Roselle Sewerage Authority)
Processing 430 TPD biosolids; 22 TPD biochar and power
Construction underway; operational in Q1 2021
 - 2) Holloway Bioenergy; Lost Hills, CA
Aries down-draft gasifier; Ag wastes from California's Central Valley
165 TPD ag waste feedstock producing 86MWe/D and 5,000 TPY biochar
Operational Q3 2021
 - 3) Lebanon, TN
Aries down-draft gasifier; wood wastes and bio-solids diverted from landfill
420KWe/D and biochar
Operational since 2017

Sierra Energy

- DoD project (Ft. Hunter Liggett, CA; Army base)
- Gasifier: FastOxtechnology; blast furnace design (~2,200 °C)
- 'Commercial' project underway to produce FT liquids and power
 - Basically a waste minimization project
 - 20 MTD military waste + woody biomass
 - 500 KWhe electricity
 - 1 BBL/D FT diesel fuel

Frontline BioEnergy

- Pressurized fluid bed (10 Bar)
- Air or oxygen with steam (TarFreeGas®; PMFreeGas®)
- Projects:
 - San Joaquin Renewables; San Joaquin, CA
 - RNG from Ag wastes
 - 15 million gallon-equivalents of RNG
 - Engineering in progress; approvals for injection in existing pipelines received

SunGas Renewables

- Spinoff from GTI
- Pressurized fluid bed technology
- Incorporates catalytic tar reforming technology from Andritz and Haldor-Topsoe
- Several FT projects 'under discussion'
- First commercial deployment planned for Gulf coast USA to produce hydrogen or chemical precursors

Aemetis/Lanzatech

- 60 MM GPY cellulosic ethanol from agricultural wastes
- InEnTec gasification technology to be used

Research activities

West Biofuels (DOE project)

- Producing FT wax for FCC co-processing
- Joint project with NREL

Feedstock Conversion Interface Consortium

- DOE National Lab consortium
- Focuses on feedstock handling and delivery to throat of reactor
- Extensive interaction with Red Rock Biofuels; gasifier modeling

Enerkem/National Renewable Energy Laboratory (NREL)

- High-octane gasoline (triptanes) from syngas: renewable F1 racing fuel
 - o Novel catalyst developed (bio-methanol →DME →hydrocarbons); not MTG
 - o Scale-up; ExxonMobil

Ohio State University (DOE project)

- “Biomass Gasification for Chemicals Production using Chemical Looping”
- Methanol production

North Carolina State University (DOE project)

- Chemical looping technology
- Combining gasification, air separation and syngas cleaning/conditioning into a single circulating fluidized bed reactor

Research highlights

Lanzatech

- Syngas fermentation to ethanol and other products (largely oxygenates)
- Clean syngas a priority
 - o Small levels of contaminants fatal to fermentation organisms (ex. ppb HCN)
- 10 M GPY ATJ (LanzaJet) plant planned for LT's Freedom Pines site in Soperton, GA
 - o Ethanol from Aemetis (InEnTecgasification of ag wastes); DOE sponsorship

Gas Technology Institute

- Decontamination of Non-recyclable MSW and Preprocessing for Conversion to Diesel
- GTI U-Gas® technology development
- DOE project

END