IEA Bioenergy Agreement: 2019-2021
Task 33: Gasification of Biomass and Waste
First semi-annual Task meeting, 2021
Virtual meeting
2.-3. June 2021

Minutes

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

The list of attendees, for the Task Meeting includes:

Name	Country	Affiliation	email
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IEA Bioenergy Agreement: 2019-2021

Task 33: Gasification of Biomass and Waste

First Semi-Annual Task Meeting, 2021

Virtual meeting

2—3. June 2021

The Agenda of the Task 33 meeting was as following:

2. June 2021 13:00 – 17:00 CET

- Welcome
- Feedback ExCo – Luc
- Overview of the Task 33
    - Minutes previous meeting
    - Budget
    - Update on CP 1 (Jitka)
- Layout next triennium
- End of triennium workshop
- Next meetings /AOB

3. June 2021 13:00 – 17:00 CET

Country reports:

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

Task 33 Meeting discussions

Meeting Minutes from the last online meeting approved.

FEEDBACK EXCO (by Luc)

ExCo87 had two parts:

(1) internal workshop on the next triennium.
- Draft Task proposals were presented. Based on this ExCo members indicated which Tasks they intend to join in the next triennium (see overview I shared with you earlier). Final Task proposals to be prepared by ExCo88 (Pearse expects them by 30 August), where countries will make commitments.
- 4 concrete Intertask ideas were brought forward: Synergies of green hydrogen and bioenergy deployment; Deployment of BECCUS value chains; Lessons Learned Biofuels; High value products from low value inputs. These are expected to develop a proposal by ExCo88.

(2) Formal ExCo meeting
- A new secretary was elected as Pearse will retire in 2022. Andrea Rossi was elected as new Secretary from January 2022. He has background in FAO and GBEP and in recent years he helps IEA in the secretariat of the Biofuture Platform.
- There was a discussion on the carbon footprint of IEA Bioenergy (ExCo & Tasks) and how to deal with this. The suggestion is to work towards a balance of physical and (in-between) online meetings. Max 2 physical meetings per year, preferably connected with another event (workshop/conference) so people don't travel a long way just for one meeting. Online participation should be possible (hybrid meetings), but when there is a physical meeting people should be encouraged to join physically (in person interactions are always better). We will install a monitoring system to keep track of travel involved in ExCo & Task meetings.
- New project starting in June (from excess budget of the Secretary Fund): 'Bioenergy Review Update' (=overhaul of the 2009 bioenergy report 'Bioenergy – a sustainable and reliable energy source: A review of status and prospects'). The project will reach out to the Tasks for input/feedback on specific points.
- ExCo also intends to allocate funds from the excess budget of the Secretary Fund to extra work on communications, to reach outside the bioenergy bubble and provide a countervoice against anti-biomass media campaigns.

End of triennium conference will be held online 29.11.-9.12.2021.

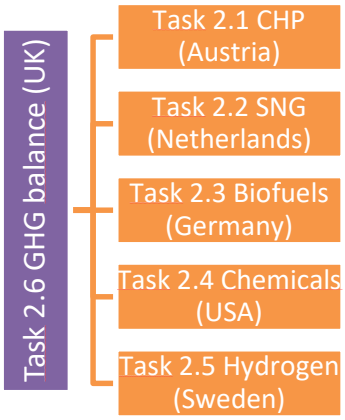
NEXT TRIENNIUM activities

Task 33 will be restructured with focus on applications of product gas.

The aim:

- Gasification technology should be presented more prominent, better visible for industry
- Driver for more interaction between participating countries
- Leverage for more industrial participation

Each topic should be led by one country. Following topics were chosen.



Each task organizer is responsible for the following items:

- Provide a process description, e.g so what is SNG, what are the common routes and provide a simple flowsheet, with the general outputs (SNG and CO2)
- Identify the commercial activities in the field (this is a team effort) with preferably a company list (linking to websites). That we will become a major point of information for relevant stakeholders also boosting the attractiveness of the task website.
- Identify threats and opportunities and R&D topics. This could be done best by organizing workshops/surveys (or similar) to get the market perspective on this.
- Use the above mentioned work for a suggestion on an implementing strategy.

Task 2.6 is an overarching task, since CCS plays an important role in all these processes.

The possible collaboration on the subtask can be seen here:

T2.1 CHP (Austria)	T2.2 SNG (Netherlands)	T2.3 Biofuels (Sweden)	T2.4 Chemicals (US)	T2.5 Hydrogen (Germany)	T2.6 CO_2 balances (UK)
• FEE??	• EBA connection	• ITP on biofuels led by Task39	• ITP on high value products led by Task 36	• ITP on hydrogen led by Task 44 • IEA Hydrogen is looking into biogenic based hydrogen	• ITP on CCUS led by Task40

Next meeting October/November 2021. Online/offline tbd.

Country Reports Update

Austria, Jitka Hrbek, BOKU Vienna

Renewable energy in 2017 and potentials for 2030 and 2050 in Austria were presented.
New publication "Holzgas" by Austrian Biomass association was presented as well as a list of producers/designers of CHP facilities in Austria. At the moment there are more than 140 operational CHP facilities.

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 CO_2 negative using biochar for CCS. Biochar ist 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 CO_2 can be stored. Taken to account the EU, it would be 9 mill. tons CO_2/year.
SynCraft and INNIO Jenbacher intensify collaboration for the energetic use of biomass.

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 finished, the first operational tests are planned for Fall 2021.

India, Mohana Rao, Indian Oil Corporation Ltd.

- **Biomass feedstock availability**- agro residues, agro industrial waste, MSW
- **Gasification technology** – fixed bed, for CHP, output few kW to few MW
- **Key drivers** – to reduce dependence on energy imports, low carbon pathways, policy and incentive system

Brief history of gasification and financial assistance for gasification and cogeneration in India were presented.

Recent developments outside CHP

Mangalore Refinery and Petrochemicals Limited (MRPL) has awarded LanzaTech the contract to commence the basic engineering for an integrated processing facility to convert locally available agricultural residues to approximately 16ktons/year (5.3MGal/year) of fuel grade ethanol

•To convert the solid biomass waste to gases, LanzaTech will deploy commercially proven gasification technology from Ankur Scientific, a waste to energy company that specializes in distributed production

•The resulting carbon rich gas will then be converted to ethanol using LanzaTech's gas fermentation platform

•The integrated technology will have the flexibility to process a wide range of biomass feedstocks enabling rapid replication at other locations

Indian Oil Corporation Ltd. – initiatives on gasification

Biomass gasification pilot plant

- Setup 10kg/h fixed bed downdraft biomass gasification pilot plant to study gasification characteristics of different biomass feedstock
- Gasification plant operated with both wood chips and biomass briquettes (generated from agroresidue) using air as oxidant
- Experiments conducted at different equivalence ratios from 0.28 to 0.34
- CO/H2ratio of generated syngas/producer gas: 1.2–1.35
- Gasyield:1.9-2.2Nm3/kg biomass

Two stage gasification system

- Gasification of biomass, MSW and oil sludge
    - 1st stage – induction based fixed bed batch reactor
    - 2nd stage – plasma reactor for cracking the tars
- Syngas samples collected and analysed offline (GC)
- CO/H2 ratio of generated gas 1,36-2,31
- Heavier hydrocarbons (vol%) 1,4-4,0

Oxy-steam biomass gasification for hydrogen production

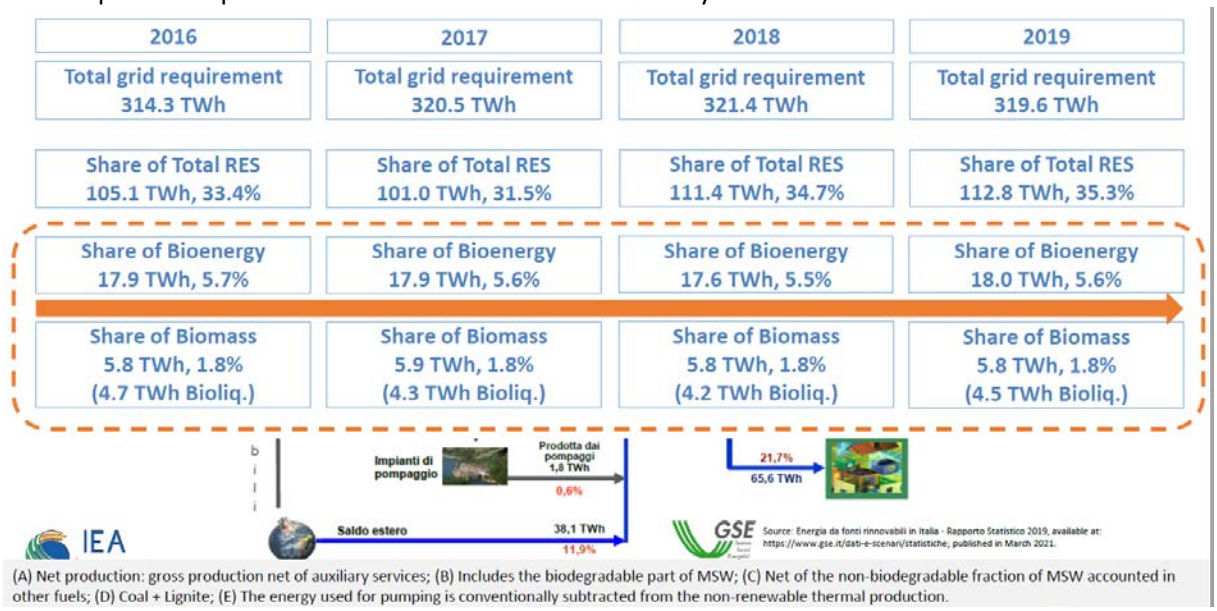
- Together with Indian Institute of Science (IISc)
- Developed technology demonstrated at 2kg/h hydrogen
- Vacuum pressure swing adsorption considered for production of fuel cell grade hydrogen
- Currently optimization of operating conditions and generation of scale up data is undergoing
- 240-250 kg/d hydrogen production demo plant will be set up

Other IOCL initiatives

- High ash coal gasification
- Multi-feed 1-2 kg/h set up for research
- Feedstock variations research
- Developed Indian coals characterization data
- Gasification kinetics
- Developed a novel concept on integrated gasification for optimal use of available gasifier designs by segregation of feedstock according to reactivity and ash content

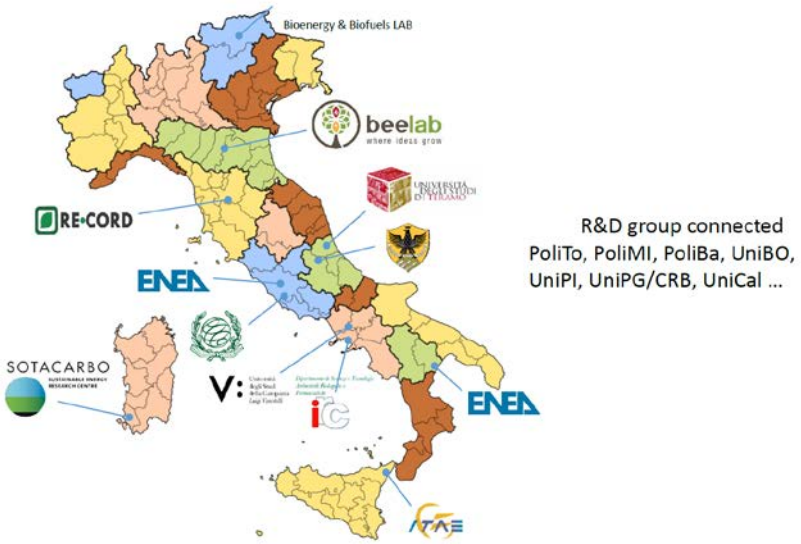
Italy, Donatella Barisano, ENEA

National electricity balance from 2016 to 2019 as well as share of individual RES to gross final consumption was presented. The Italian National Recovery and Resilience Plan was introduced.

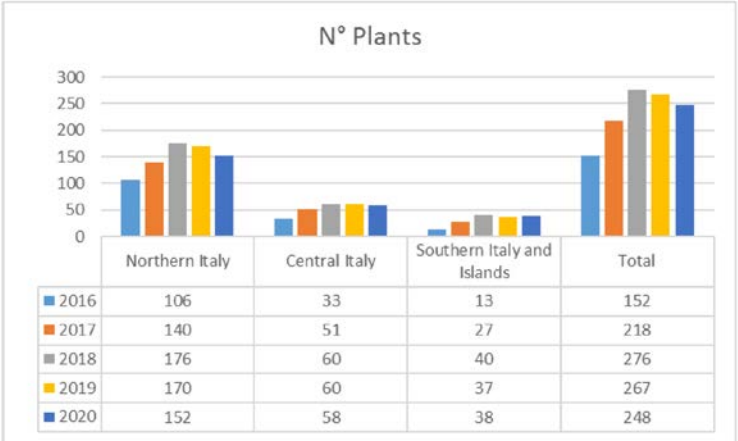


(A) Net production: gross production net of auxiliary services; (B) Includes the biodegradable part of MSW; (C) Net of the non-biodegradable fraction of MSW accounted in other fuels; (D) Coal + Lignite; (E) The energy used for pumping is conventionally subtracted from the non-renewable thermal production.

Gasification - Italian R&D organizations



The CHP plants are in Italy mostly situated in the northern part of the country. At the moment there are nearly 250 operational facilities in Italy, tendency slightly decreasing. In 2018, there were 276 units in operation.

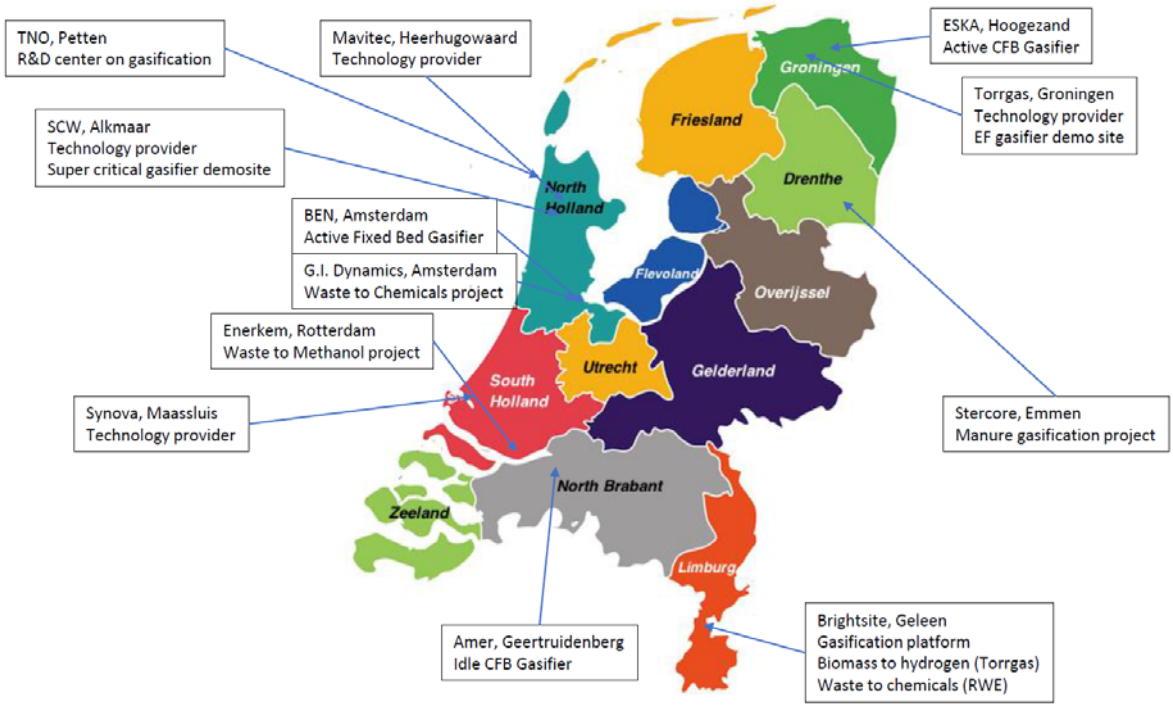


	Northern Italy	Central Italy	Southern Italy and Islands	Total
2016	106	33	13	152
2017	140	51	27	218
2018	176	60	40	276
2019	170	60	37	267
2020	152	58	38	248

Netherlands, Berend Vreugdenhil, TNO

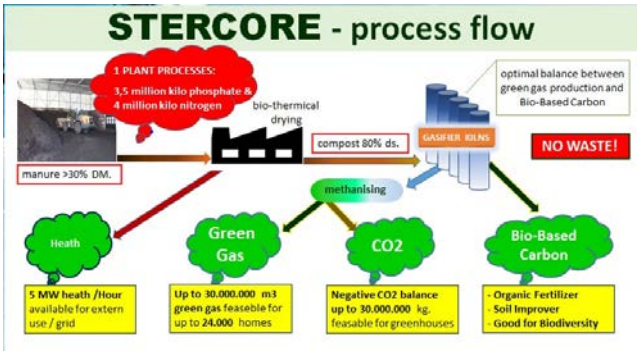
- The NL is steering away from CHP from biomass, but biomass should be crucial by production of biofuels and biochemicals.
- Circularity will depend on gasification based technologies
- Hydrogen production from renewables is pushed a lot, provides opportunities for gasification

Gasification status in the NL



Stercore

- Manure to green gas & bio-based carbon factory
  - Economic due diligence finished
  - Technical due diligence finished
  - Technical detailed design and building design finished together with Emmtec Engineering as EPC
  - Off-take agreement for Bio-LNG with UK/NL oil major agreed upon as a fuel guarantee not depending on the SDE++ scheme
  - Court-ruling expected to be finalized in September



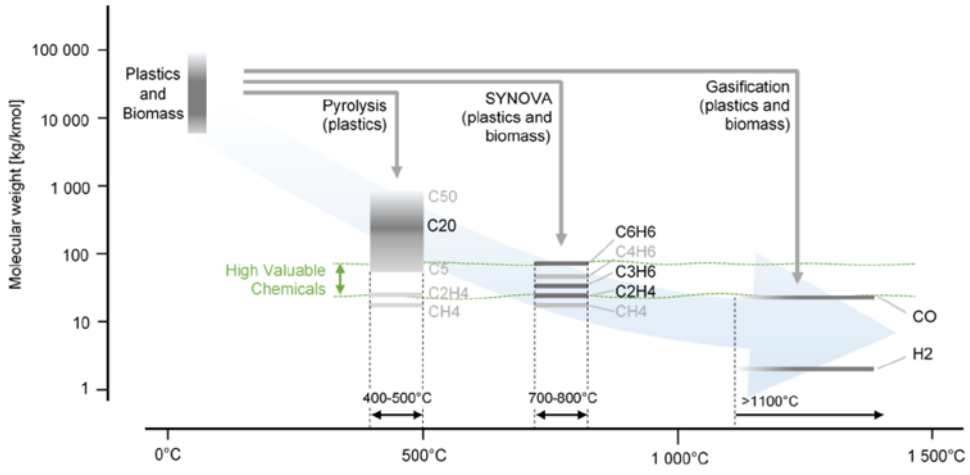
Status **Torrgas**

•1 MW Demo DNV-GL (TRL 7)
•Scaleable to100 MW
•30 MW SNG Delfzijl nearing financial close
•50 MW green hydrogen, working on funding
•currently started 3. global MeOH project

Synova (MILENA + OLGA)

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

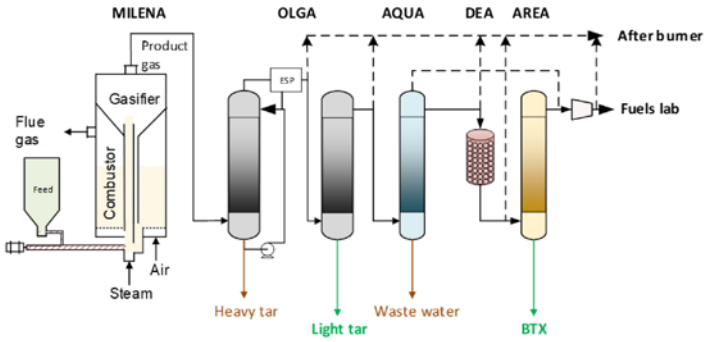
Synova's solution: medium temperature = direct chemicals



ENERKEM

- TRL 9, more than 25.000 OH
- Feedstock: pure plastics, RDF, Biomass, construction and demolition, industrial, commercial waste
- Rotterdam, NL: project undergoing a review

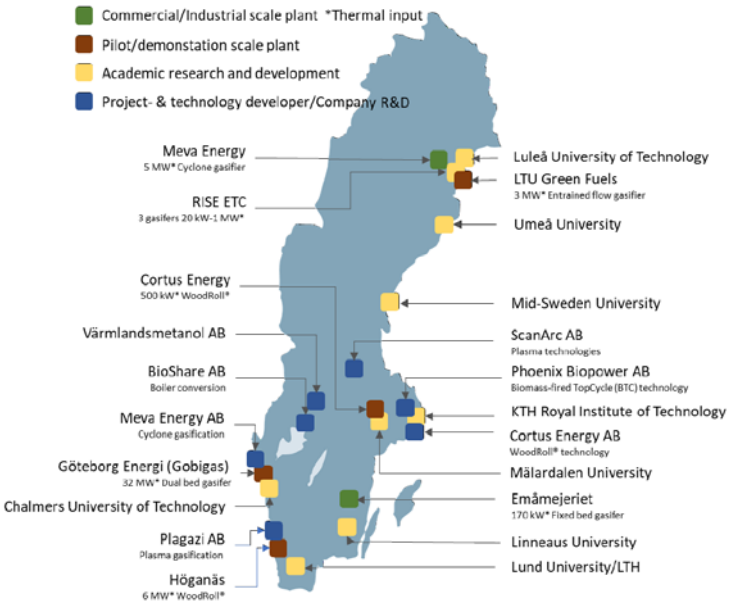
TNO lab infrastructure update



- Possibility to recover light tar components as products, roughly 200 gram/h (mostly naphthalene)
- Water scrubbing system, capable of dosing acid/caustic for additional impurities capturing
- DEA: conversion of olefins to aromatics to boost the yield of the BTX scrubber
- AREA: capturing 150 –300 gram/h of BTX

No updates so far from
G.I. Dynamics, HoSt, SCW, BEN, Mavitec, ESKA

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 now seem fixed
- the different processes of the reconstructed plant are currently being tested
- 7 days of continuous syngas production with the integrated process is the next milestone

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 has decided to await the development of Covid-19 and the implementation of Milestone 3 before starting any further activities

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 CO_2 production
- no futher activity until milestone 3 is Höganäs fullfilled

MEVA CHP plant in Hortlax
- EF cyclone gasifier emanated from Luleå University of Technology
- Outputs 1.2 MWel 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
- News soon be released

Plagazi AB
- PlagaziAB has a concept for transforming waste into hydrogen through plasma gasification.
- Neue EnergienPremnitzand Plagazihave completed the Basic Engineering phase of a project to build the first Plagaziplant in Europe. Planned start Q2, 2023.
- Plagazihas also signed a partnership with the Dutch engineering company DordtechCircular Energy Solutions.

GoBiGas plant will be dismantled

LTU Green Fuels plant
- New regional funding secured for three years to keep the plant from being dismantled and to find new projects

Pilot BL gasification	Pilot methanol + DME	Field testing
3 MW, 20 t DS/d	4 t/d methanol/DME	Volvo Trucks DME 8 trucks, >1 500 000 km
>28 000 h since 2005	>12 000 h since 2011	
Recovery of cooking chemicals without difficulties		DME and methanol in industrial applications
Opportunities for exp. campaigns 24/7, high availability		

Large industrial transformation in Norrbotten

- SSAB in Luleå produces 2 million tons per year of steel. 2026 the first fossil-free steel will be produced and 2040, SSAB will be fossil free = >0.1 billion kg of H2= >5 TWh of electricity
- LKAB mines one of the world's richest iron ore deposits (27.2 million tons per year). They are now making the biggest industry investment ever in Sweden through the shift from iron ore pellets to CO2-free sponge iron
- Assuming that all iron ore pellets are converted into sponge iron via a H2-only DRI process = 1 billion kg of H2= 53 TWh of electricity
- The company H2 Green Steel have started developing a completely new steel mill in Boden. The annual production at full capacity in 2030 will be 5 million tons steel. Making the same assumptions as for the SSAB, H2demand leads to an annual electricity need of 13.9 TWh.
- Large increase in renewable power production within the next 10-20 years will be needed.

LTU Green Fuels plant – CH_2ESS

- CH_2ESS -Centre for Hydrogen use in industry and the Energy System Sweden.
- An extensive research and education investment in close collaboration with leading basic industries and energy companies.
- The focus is on hydrogen in industrial processes and energy systems.
- The core is LTU Green Fuels –great opportunities for combining electrolysis and biomass gasification
- Open for collaborations and new partners.
- MoU's with GTI and NTNU H2-team

Ongoing Swedish gasification-related R&D programs

- 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€

Policy issues influencing gasification technologies

- The reduction obligation for transport fuels forces fuel distributors to blend in renewable fuels into fossil diesel and gasoline to reach pre-determined CO2-reduction levels or pay large fines
- In the Budget Bill for 2021, the Government has proposed gradually increasing reduction quotas for 2021-2030 (6 % CO2-reduction for gasoline, and 26% for diesel in 2021; 28%CO2-reduction for gasoline, and 66%for diesel in 2030)
- The reduction obligation is good, but in the current form, it fails to promote domestically produced biofuels
- Sweden has 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

The Government commissioned the Swedish Energy Agency to investigate the need for additional policy instruments to promote domestic production of biofuels with new technologies

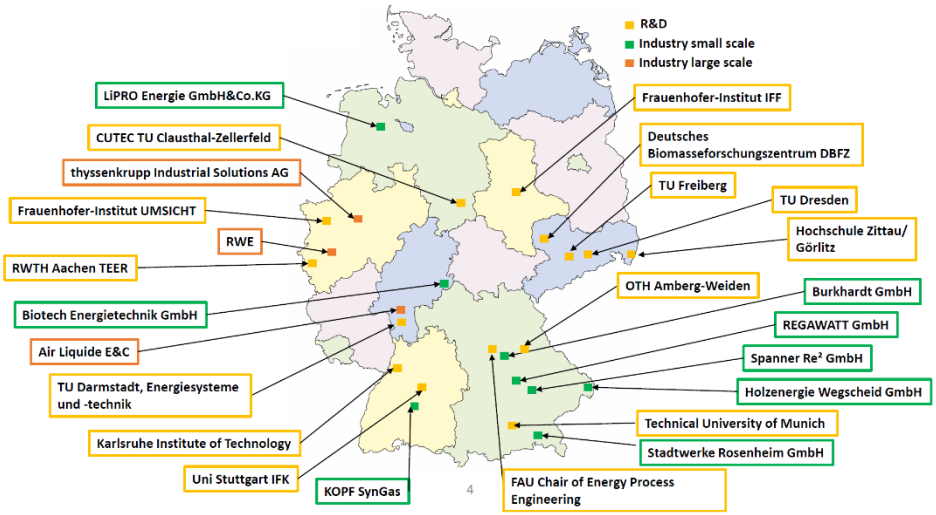
Preliminary proposal from the Agency

- Investment support combined with instruments that increase the willingness to pay for the product.
- A targeted quota in the reduction obligation for raw materials based on lignocellulose.

Germany, Mark Eberhard, KIT

New Climate protection act in 2021
-significantly stricter climate protection targets.
-65 % fewer greenhouse gases by 2030 than it did in 1990, compared with only 55 percent previously.
-CO_2 emissions are to fall by as much as 88 percent by 2040.

Gasification activities in Germany



CHP plants small scale
Market continues to cool down
-As the number of equipment manufacturers remains constant, a turnaround can be achieved in the short term by improving the regulatory framework

Industrial activities

Sülzle Kopf
- FB gasification for sewage sludge with CHP via gas engine
- plant in Koblenz: 440 kWel./525 kWth.
- load change between 500-600 kg/h
- stable gas quality

RWE Phosphorus from sewge sludge
-Pilot plant in Niederaußem
-Atmospheric entrained flow gasifier
-Three-component fuel mixing, refractory lining, dip quench, liquid ash discharge
-Fuels: Sewage Sludge, Sewage Sludge Ash, Lignite (ca. 130 kg/h, max 800 kWth)
-Temperature ~1,500°C
-Objective: Prove recovery of phosphorus from sewage sludge / sewage sludge ash
-Erection in 2020, Start-Up June 2021
-Funding provided by State of North Rhine Westphalia (Ministry of Economics);
Total project budget (incl. cost for plant operation): 6.7 Mio. €

-Partners: Fraunhofer UMSICHT, Ruhr Universität Bochum
-Waste gasification

Blue Energy CHP
Wood gas cogeneration plant to be converted into an advanced bio-energy park
Future Products:
-Heat and Power
-Bio-oil
-Hydrogen

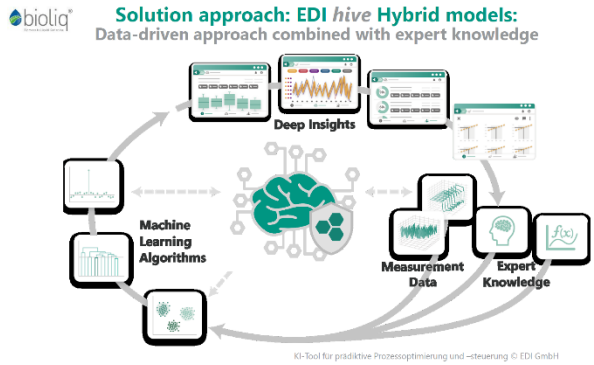
Plant on hold due to lack of approval from licensing authority
-Wood oil was initially classified by the authorities as waste and wanted to approve the plant only according to waste law
-Currently: Submission of new permit application
-hope for start up again in the middle of 2022

BioTfuel

- Bionext and its partners have reached a major milestone in the development of low-carbon BioJet Fuels with the production of Fischer-Tropsch-synthesis products from wood waste biomass.
- Stable and continuous gasification of various woody biomasses pre-treated by torrefactionwere achieved over several weeks on the pre-industrial units allowing bio-based Synthesis gas (syngas) to be converted into Fischer-Tropschproducts.
- Press Release ThyssenKrupp Industrial Solutions 12.04.2021

Bioliq
Technical detailscampaignApril/May 2021

- Test series: Lambda variation from maximum to minimum reactor temperature to determine scale-up factors.
- Wood pyrolysis oil+ wood coke
- Test series: measurements with high speed camera to detect the influence of operating conditions on flame structures and flame stability



- Use case: predictive control of synthetic fuel production plants

United Kingdom, Paula Blanco-Sanchez, Aston University

- Commitment to develop a biomass strategy for the UK

- Will be cross-governmental effort led by department for Business, Energy and Industrial Strategy (BEIS)
- To be developed 2020-2022

UK Greenhouse Gas Removal Demonstrator (GGR-D) programme
The £31.5 million Greenhouse Gas Removal (GGR) programme is part of the second wave of the government's Strategic Priorities Fund (SPF), which invests in high quality multi and interdisciplinary research.
•5 projects with nature based solutions (peatlands, enhanced rock weathering, biochar, large-scale tree planting, rapid scale-up of perennial bioenergy crops)
•Coordinating GGR hub addressing cross-cutting aspects
https://www.ukri.org/news/uk-invests-over-30m-in-large-scale-greenhouse-gas-removal/

Academic research activities
Project: Feasibility of Afforestation and BECCS for GHG removal

- InvestigatethefeasibilityofdifferentBECCSsupplychainstounderstandthepotentialUKcontributionbyevaluatingthepotentialforcarboncaptureandGHGemissionsremoval.

Advanced Biofuel Solutions Ltd (ABSL) Swindon site

- Commercial demo
- 20-25 GWh/yr of bioSNG
- Cost of £38M
- Construction complete
- Continued commissioning
- Update: https://www.linkedin.com/company/advanced-biofuel-solutions-ltd/

Other sites

- Energy Works Hull (28MWe) back in operation
- Levenseat(Outotec) operational
- Ince Bio Power facility exploring option for CCS.
- Hooton Bio Power (Kobelco gasifier) still in commissioning (contractor is BWSC)
- Riverridge/ Full Circle gasifier (nr Belfast) operational.

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 throughoput
- Gasification/FT under construction, start up in Q1 2021 – shift to Q3 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 (instead of 136,000 tons/y now planed 166,000 dry tons/y)
- 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: Q4 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 ºC)
- `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 projects in advanced stages of engineering (RNG, Liquid biofuels, Advanced power cycle, hydrogen)

Gas Technology Institute

- DOE project for decontamination and preprocessing of non-recyclable MSW
- DOE/EPRI project for net-zero emission application of U-GAS for biomass/coal blended feedstock

Aemetis/Lanzatech

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

Closing thoughts

- DOE: Liquid transportation biofuels coming back on the table
- New administration focused on implications of renewable energy
- DOE has issued a roadmap to stand up 4-5 operating biofuels demonstration plants (each at approx. 1M GPY) by 2030

END