IEA Bioenergy Agreement: 2019-2021
Task 33: Gasification of Biomass and Waste
Second semi-annual Task meeting, 2021
Hybrid meeting in Trisaia, Italy and virtual

1.-3. December 2021

Minutes

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

The list of attendees on 1. December 2021:

Name	Country	Affiliation	email
Berend Vreugdenhil	The Netherlands	TNO	Berend. vreugdenhil@tno.nl
Jitka Hrbek	Austria	BOKU	Jitka.hrbek@boku.ac.at
Luc Pelkmans	Belgium	IEA Bioenergy	Luc.pelkmans@caprea.be
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
Mirjam Roeder	UK	Aston University	m.roeder@aton.ac.uk
Robert Baldwin	USA	NREL	Robert.baldwin@nrel.gov
Rajesh Badhe	India	Indian Oil	badher@indianoil.in
Mohan Rao Dharamchela	India	Indian Oil	mohanrd@indianoil.in
Benjamin Berger	Belgium	ECAM	brg@ecam.be
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IEA Bioenergy Agreement: 2019-2021

Task 33: Gasification of Biomass and Waste

Second Semi-Annual Task Meeting, 2021

Hybrid meeting in Trisaia, Italy and virtual

1.—3. December 2021

The Agenda of the Task 33 meeting was as following:

Item	Time	Who
Welcome	9:00 – 9:15	Berend
IEA feedback	9:15 – 9:30	Berend
Status CP report	9:30 – 10:15	Johannes, Jitka, Working group
Status of gasification report	10:15 – 10:30	Jitka
Break	10:30 – 11:00	
Country update	11:00 – 13:00	India, Uk, Sweden and the Netherlands
Lunch	13:00 – 14:00	
Discussion on next triennium setup	14:00 – 15:00	All (Website, Schedules, Layouts of reports)
Country update	15:00 – 15:30	Austria
Break	15:30 – 16:00	
Country update	16:00 – 17:30	US, Germany, Italy
Wrapping up	17:30 – 17:45	

Task 33 Meeting discussions

Meeting Minutes from the last online meeting approved.

IEA feedback

- Less travel
- Luc Pelkmans will be the Technical coordinator in the new triennium
- In future IEA Bioenergy materials in digital form
- ExCo Chair is Paul Bennet, and vice chairs are Dina Bacovsky and Sandra Hermle
- There is a bit of stress in the Strategic funds so providing complete back up funding in two ITPs seems not possible. Tasks were asked to invest a bit more themselves if possible

Discussion on Collaborative report (T33/T42) on "Biorefineries"

- Johannes Lindorfer presented the project part of T 42. The case studies from T 33 are the information sources for the T42.
- Johannes will send a draft version to Task 33 for the feedback
- Joakim will try to send an additional information to Johannes

Status Report on gasification

- will be published in the beginning of 2022.

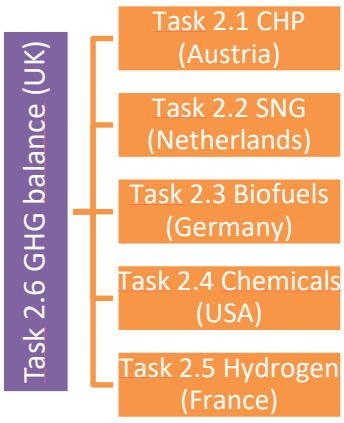
NEXT TRIENNIUM activities

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.

Topic	NL	Au	D	S	UK	US	It	B	In	Cn	Can	Fr	Lead
CHP	P	L	-	-	-	-	P	P	-				At
SNG	L	P	P	P	P	-	P	-	-				NL
Fuels	P	P	L	P	P	P	P	-	-				D
Chemicals	P	P	P	P	P	L	P	-	-				US
Hydrogen	P	P	P	L	P	-	P	-	P				F
GHG balance	P	P	P	P	L	P	P	-	P				UK

Unfortunately, Sweden is leaving the Task 33 with the end of 2021.

The topic 2.5 Hydrogen will be thus led by France (Madeleine Alphen).

Organization of meetings in upcoming triennium

	2022				**2023**				**2024**			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
T2.1 – T2.6	x		x		x		x		x		x	
Task meeting		x		x		x		x		x		x
If due to COVID-19 we cannot have face to face meetings we need to improvise (see below)												
T2.1 – T2.6	x		x		x		x		x		x	
Hybrid EU		x						x				
Hybrid US/Can				x						x		
Hybrid Ind/Cn						x						x

T2.x meetings more focussed on the specifics of the subtasks

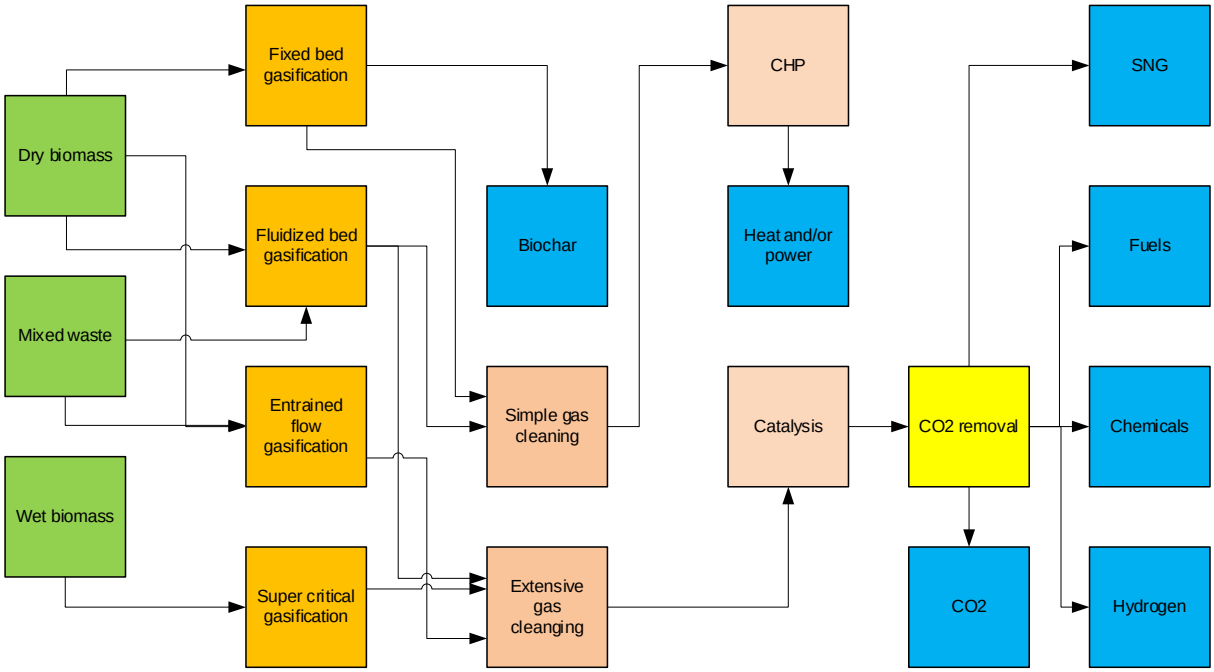
Task meeting is the traditional several days meeting, now including time for T2.x discussions

Hybrid tasks, both online and physical so that countries that can travel are present and can join in the discussions.

Organisation of sub-tasks

- Focus on show case materials development
- Explaining the high-over approach to this application (next slides)
- Identify threat / opportunity
- Listing the companies, we represent from our task active in this field
- Provide input to subtask on GHG balance

Overview on applications (in blue)



Implementation strategy – first on SNG, next Fuels

- Executive Summary
- Technology explanation
- Listing the benefits (Low Costs for cities, easy to implement, versatility, CO2 footprint)
- Boundary for implementation (tech. Econ. Env. Societal etc..)
  workshop in the making for May 2022 (week after the EUBCE, in NL)
- Listing providers / Activities
- Conclusion on how to support implementation

Next Task 33 meeting should take place in May 2022 (week 16.-20.5.)

Country Reports Update

Austria, Jitka Hrbek, BOKU Vienna

New publication “Wood gas” 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) – Josef Ressel Zentrum
- 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 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). Ingenieurbüro Axel Preuß + SynCraft +other partnes created CarStorCon® - concrete with biochar as an additive.

Other projects:
Project Waste2Value
- at the moment commissioning

India, Mohana Rao, Indian Oil Corporation Ltd.

India energy share was presented; coal is dominating in energy mix. Bioenergy share is about 20%. Installed biomass power capacity is about 10.6 GW. Energy target and bioenergy potential in India were presented as well.

National Hydrogen Energy Mission (NHM) announced in the union budget for 2021-22

•Honorable prime minister launched NHM on India's 75th Independence Day
•Aims to make India a green hydrogen hub as well as export of green hydrogen
•Green H2 spearhead India’s transition to clean energy and aid in meeting India’s climate targets
•India’s total hydrogen demand expected to be nearly double from current 6.7 Mt to 11.7 Mt by 2030

•Govt. has plans to bring down cost of green hydrogen to Rs 160 per kg by 2029-30
•Aims to extend PLI scheme for manufacturing electrolyzers

COP 26 climate summit – commitment for India

- Increase India's share of non-fossil energy capacity to 500 GW by 2030
- Meet 50% of India's electricity requirements from renewable energy by 2030
- Reduce one billion tonnes (1 Gt) of carbons emission from the projected emissions by 2030
- Reduce carbon emissions intensity of it's economy by 45% by 2030 compared to 2005 levels - 28% already achieved
- By 2070, set to achieve the target of Net Zero emissions

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

Biomass gasifiers technology providers/manufacturers were presented.

Research institutions working on gasification were presented.

Resent developments related to advanced biofuels

- IISc and IOCL jointly working on development and demonstration of biomass gasification based hydrogen generation technology for producing fuel cell-grade hydrogen
- Oxy-steam biomass gasification process adapted for generation of hydrogen rich syngas
- Vacuum Pressure Swing Adsorption (VPSA) considered for production of fuel cell grade hydrogen
- Developed technology demonstrated at 2 kg/h hydrogen production
- Optimization of operating conditions and generation of scale up data is under progress
- Mangalore Refinery and Petrochemicals Limited (MRPL) awarded LanzaTech a contract in September, 2020 to commence the basic engineering for an integrated processing facility to convert agricultural residues to ~16 ktons/year of FG ethanol
- LanzaTech deploy gasification technology of M/s Ankur Scientific
- Use LanzaTech's gas fermentation technology for conversion of syngas to ethanol
- LanzaTech & Spray Engineering Devices Ltd. (SED) announced bagasse-to-ethanol project in India in October, 2021

Italy, Donatella Barisano, ENEA

The Italian recovery and resilience plan was presented.
Green hydrogen is one of the future energy scenarios, hydrogen from gasification and other thermochemical processes of biomass and waste included. H_2 production costs should be about 3€/kg.

An update on EU and national projects was presented. The objectives of the project activities are quite diversified, ranging from CHP production, to advanced liquid and gaseous biofuels, with particular attention to the latter for hydrogen.

EU Projects on gasification involving Italy

Name	Funding	Aim	Reactor design	Present Status	Partners	link
REFFECT AFRICA	H2020	Renewable energies for Africa: effective valorization of agri-food wastes	Different tech.	From 1 Nov 2021 to 31 Oct 2026	**UJA (ES)**, several African Countries, TREE S.r.l. (IT), UniPI (IT), TIFEO SRL (IT) et al; 29 partners	Website to be published
GOLD	H2020	Bridging the gap between phytoremediation solutions on growing energy crops on contaminated lands and clean **biofuel** production	Different tech.	From 1 May 2021 to 30 April 2025	**CERTH (GR)**, RE-CORD (IT), ETA (IT), UniBO (IT) et al.; 19 partners	Website to be published
CERESiS	H2020	ContaminatEd land Remediation through Energy crops for Soil improvement to **liquid biofuel** Strategies	SCWG	From 1 Nov 2020 to 30 April 2024	**NTUA (GR)**, CERTH (GR), Strath (UK), Uni Tuscia (IT), CNR (IT), et al.; 12 partners	Website to be published
FlexSNG	H2020	Flexible Production of **Synthetic Natural Gas** and Biochar via Gasification of Biomass and Waste Feedstocks	Fluidized bed	From 1 June 2021 to 31 May 2024	**VTT OY (FI)**, CERT (GR), EIFER (DE), WOOD (IT), ETA (IT) et al.; 12 partners	Website to be published
WASTE2H2	H2020 - CSA	Producing **hydrogen** from waste biomass	Different tech.	From 1 Jan 2021 to 31 Dec 2023	**IPPortalegre (PT)**, KTH (SE), ENEA (IT), KIT (DE)	Website to be published
GICO	H2020	Development of small to medium scale residual biomass gasification plants integrated with CO2 capture and conversion (outputs: **CHP** and **Biofuels**)	Dual Fluidized Bed gasifier	From 1 Dec 2020 to 30 Nov 2024	**USGM (IT)**, ENEA (IT), TECNALIA (ES), ICI (IT), TU/e (NL), CSIC (ES), MTEC (FR), CALIDA (DE), FZJ (DE), IRIS (IT).	https://www.gicoproject.eu/
AUGIA	LIFE	Sewage oxy-gasification for **chemicals** production	Downdraft	From 1 Sept 2020 to 31 Agust 2023	**UniMolise (IT)**, UniPI (IT), SIME srl (IT), BioSyn srl (IT), COSIB (IT)	http://www.life-augia.unimol.it/
GLAMOUR	H2020	Full conversion of the crude glycerol into **biofuels** (synthetic paraffine kerosene (FT-SPK) to be used as jetfuel and into marine diesel oil (MDO))	auto-thermal reforming/gasification/chemical looping	From 1 May 2020 to 30 April 2024	**University of Manchester (UK)**, TU/e (NL), TNO (NL), CSIC (ES), VITO (BE), CiaoTech (IT), SIIRTEGNIGI S.P.A (IT), Argent Energy (UK), INERATEC (DE), C&CS (DE)	https://www.glamour-project.eu/
BioSFerA	H2020	Gasification of biogenic residues and wastes to produce **biofuels** for aviation and maritime transport via syngas fermentation (hydrotreatment of triacylglycerides)	Dual Fluidized Bed gasifier	From 1 April 2020 to 31 March 2024	**EKETA (EL)**, VTT Oy (FI), CARTIF (ES), BBEU (BE), CSIC (ES), Q8 R&T (NL), RINA (IT), Sumitomo SHI FW (FI), SeaNRG BV (NL), NTUA (EL), Environment Park S.p.A (IT)	https://biosfera-project.eu/
BLAZE	H2020	Developing an advanced zero-emission **CHP** technology in the capacity range from small (25-100 kWe) to medium (0.1-5 MWe) by using low-cost and short-chain biomass feedstocks.	Bubbling fluidized bed	From 2019-03-01 to 2022-02-28, ongoing	**USGM (IT)**, UNIVAQ (IT), ENEA (IT), EPFL (CH), Walter Tosto (IT), SOLIDpower (CH), HyGear (NL), VERTECH GROUP (FR), EUBIA (BE)	http://www.blazeproject.eu/
CLARA	H2020	Chemical Looping gAsification foR sustainAble production of **biofuels.**	Dual fluidized bed reactors	From 2018-11-01 to 2022-10-31, ongoing	**EST**, REPOTEC, CHALMERS, UNIVAQ et al.; 13 partners	https://clara-h2020.eu/
LIG2LIQ	RFCS	Economically efficient production of **liquid fuels**, such as FT fuels or methanol, from lignite and SRF from municipal waste.	HT-Winkler reactor	From 2018-08-01 to 2022-01-31, ongoing	**TUDA**, UNIVAQ, ULSTER, CERTH, ICHPW, RWE, TKIS	https://www.lig2liq.eu/
MEMBER	H2020	Advanced MEMBranes and membrane assisted proCEsses for pre- and post-combustion CO2 captuRe	Different tech.	From Jan 2018 to 31 Dec 2021, ongoing	TECNALIA, ..., ECO RECYCLING SOCIETA A RESPONSABILITA LIMITATA	https://member-co2.com/content/objectives
HyFlexFuel	H2020	Hydrothermal liquefaction: Enhanced performance and feedstock flexibility for efficient biofuel production	HTL & Catalytic-hydrothermal gasification (cHTG)	From 1 Oct 2017 to 30 Sept 2021	**Bauhaus Luftfahrt EV** (DE), Aarhus Uni (DK), Aalborg Uni (DK), PSI (CH), DBFZ (DE), Uni Hohenheim (DE), OWS NV (BE), ENI (IT), HT AS (DK), ARTTIC (FR)	https://www.hyflexfuel.eu/
Heat-To-Fuel	H2020	Biorefinery combining HTL and FT to convert wet and solid organic, industrial wastes into **2nd gen. biofuels** with highest efficiency	Dual circulating fluidized bed	From 2017-09-01 to 2021-08-31, ongoing	**GUSSING Energy Technologies**, RE-CORD, TUV, BIOENERGY 2020+, RE-CORD, PoliTO, CRF et al.; 14 partners	http://www.heattofuel.eu/
BECOOL	H2020	Brazil-EU Cooperation for Development of **Advanced Lignocellulosic Biofuels** (twinned with the Brazilian BioVALUE project)	Indirect Circulating Fluidized Bed	From 2017-06-01 to 2021-05-31, ongoing	**UniBO (IT)**, BIOCHEMTEX SPA (IT), CREA (IT), RE-CORD (IT), BTG, ECN et al.; 13 partners	https://www.becoolproject.eu/
BRISK II	H2020	**Biofuels Research Infrastructure** for Sharing Knowledge II	Fluidized and Fixed Beds	From 2017-05-01 to 2022-04-30, ongoing	**KTH**, BIOENERGY 2020+ GMBH, ECN, KIT, ENEA et al.; 15 partners	https://www.brisk2.eu/

Italian projects on gasification supported by national programmes

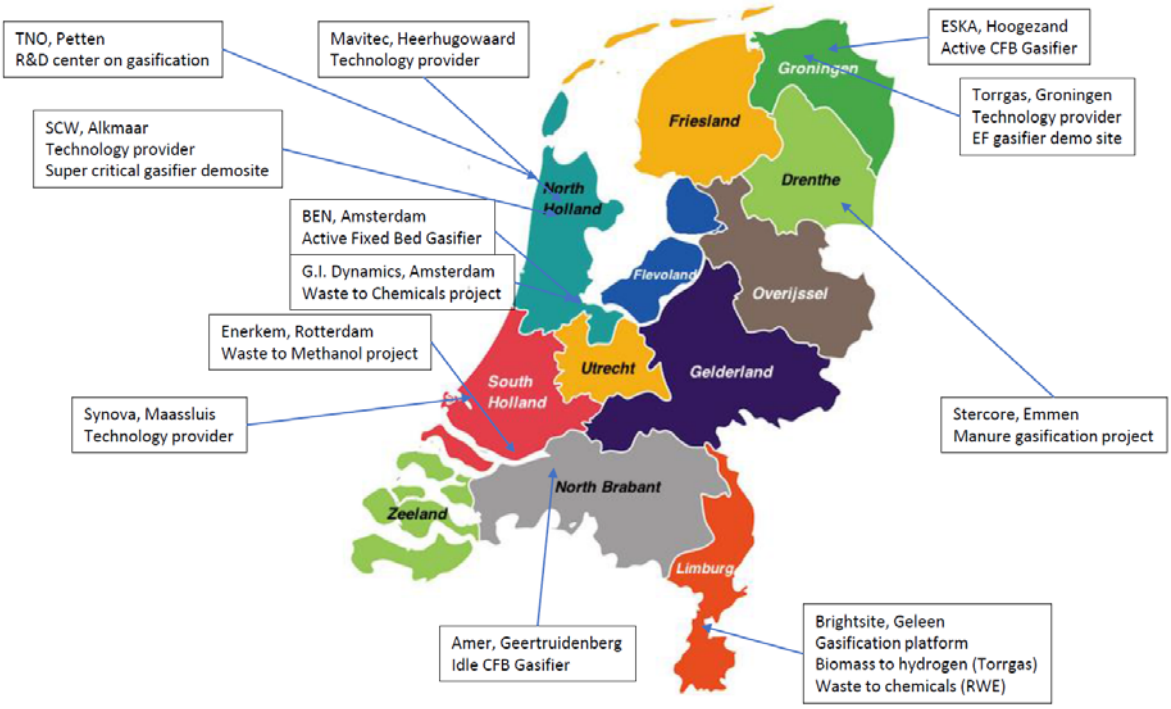
Italian Region	Name	Funding	Project aim/Activity on Gasification	Reactor design	Present Status	Note
Abruzzo, Lazio, Puglia	AIRE	MIUR	Gasification and biomethane synthesis	Dual FB	Next start	**NEXTCHEM**, UNIVAQ, Walter Tosto, DIZIOINOXA, USGM, UNISALENTO, UNIROMA2
Basilicata & Campania	RECOVERY	MISE	Energy valorization of residual materials coming from the agro-food industry through syngas from gasification for self-production and self-consumption of **electricity**.	Downdraft	Next start (January 2022)	**CMD S.p.A**, Giaguaro S.p.A, ENEA
Basilicata & Calabria	WW-GREEN FUEL	MISE	Development of gasification process (dry and SCWG) for the exploitation of large-scale biomass and production of liquefied **SNG**.	Pyro-gasifier	Next start (January 2022)	**ENEA**, CNR, UNICAL, UNIBA, POLITO, SOTACARBO, CALABRA Maceri, et al.
Basilicata & Campania	EMERA	Regional	Efficient Micro Energy networks **powe**red by only RES for the autonomy and independence of rural areas from the centralized system.	Downdraft	Next start (January 2022)	**CMD S.p.A**, DIGIMAT, EES, ESA, ENEA, CNR
Campania & Basilicata	GREEN FARM	MISE	**Power** production from residual biomass via gasification, integrated with other RES, for self-reliance in cultivation and food processing systems.	Downdraft	In progress (2020-2023)	**UniNA**, CMD SpA, CNR, Graded SpA
Basilicata	PIBE	Regional	**Infrastructure** and R&D activities aimed at producing biofuels, innovative biolubricants, biomethane and **syngas** for frontier energy applications.	Different types	In progress	**ENEA**, CNR, UNIBAS
Basilicata & Sicily	EMAP	Regional	Demonstrative plant for **energy** and **material** recovery (activated carbon for super capacitor electrodes) from disposed tires.	Pyro-gasifier	In progress	**Baucina Tyre**, Energia Futura , ENEA
Basilicata, Campania, Apulia, Sardinia, Lazio	COMETA	MUR	Use of residual biomass for **CHP** and **biofuels** production.	Downdraft & BFB	In progress	**Novamont**, ENEA, CREA, Uni Sassari, CIHEAM-Bari, et al. https://www.novamont.com/cometa
Campania	PROMETEO	MISE	Gasification technology industrialization for **energy** recovery and cost-effective management of waste from urban green and agri-food residues industry.	Downdraft	In progress	**CMD S.p.A**, EPM https://prometeoenergia.com/
Emilia-Romagna	UNIHEMP	MUR	Use of biomass from industrial hemp for **energy** production and new **biochemicals**.	Downdraft	In progress	**DHITECH**, Avantech, CREA, UniMORE, et al. http://unihemp.dhitech.it/
Sardinia	CEEP-3	Regional	Optimization of BFB gasification process for **hydrogen** production from plastic waste	Fluidized Bed	In Progress	**Sotacarbo** http://www.sotacarbo.it/en/
Sardinia	Bi.Ar.	Regional	**Energy** recovery from brewer's spent grain	Down-draft	In Progress	**Sotacarbo**, UNISS, Porto Conte Ricerche
Sicily	NAUSICA	MUR	Exploitation of ship-generated waste via catalytic thermal gasification and treatment under supercritical gasification conditions for **low carbon fuel** production.	Bubbling Fluidized Bed, SCWG	In Progress	**NAVTEC**, CNR-ITAE, UniPA, UniCT, et al.

Netherlands, Berend Vreugdenhil, TNO

Opportunities for gasification

- The NL is steering away from CHP from biomass, but biomass should be crucial by production of biofuels and biochemicals
- Horizon Europe has a clear theme on 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



ESKA

- CFB technology supplied by Leroux & Lotz (TPS technology)
- 10 - 13 MWth input CFB gasifier, depending on LHV rejects
- Boiler produces 5 – 16 ton/h steam (196°C, 13,6 barg)
- Fully automatic operation
- Build in 2016, in operation since Oct-2016
- 2021 facts:
    - 5% Uptime expected
    - 12 kton of rejects (all from the site)
    - 50 kton of reject processed since startup

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
    - In compliance with first court ruling, expecting final verdict in December
    - Start building expected Q2-2022
    - First stage investment approx.32 Meuro

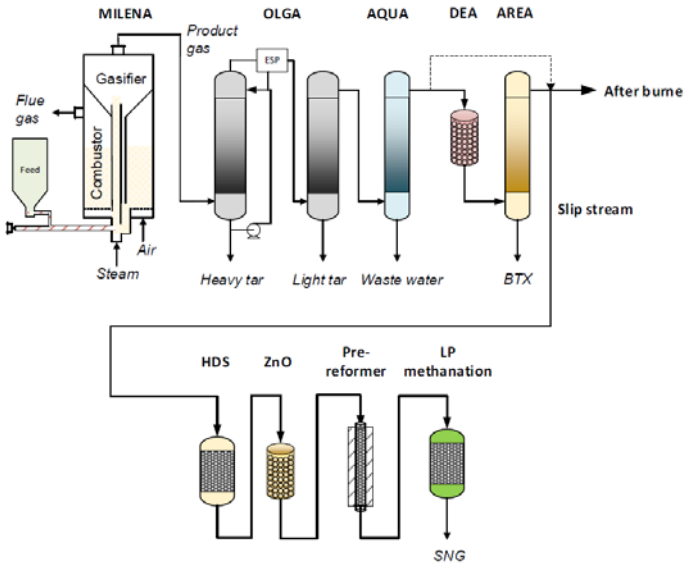
Torrgas

•1 MW Demo DNV-GL (TRL 7)

•Scalable to100 MW
•30 MW SNG Delfzijl nearing financial close
•50 MW green hydrogen, working on funding
•currently started 3. global MeOH project

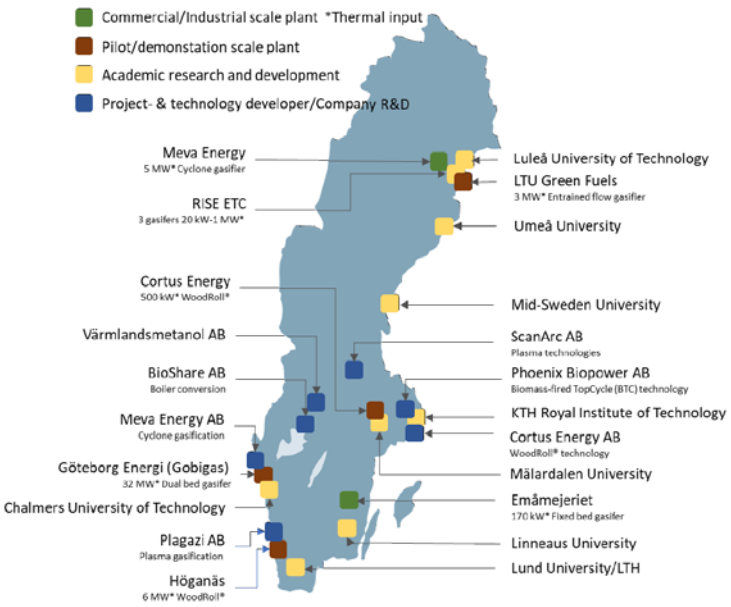
- **Update:** SNG and H_2 similar GHG profile without biochar and CO_2 sequestration
- ~80% reduction in GHG emissions compared to fossil fuels
- Biochar allows negative emissions
- Effect of feedstock transportation is marginal

TNO – SNG development



- SNG developed based on clean biomass (demolition wood A/B)
- Future feedstocks will contain more impurities (e.g. more S)
- This has an effect on specifically HDS and pre-reformer
- Plastics effect on HDS, on performer was presented
- Conclusions:
    - When adding plastic both olefins and aromatics increase, reducing the capability of the HDS/Pre-reformer to function properly
    - DEA reduces olefins, allowing HDS to return to its window of operation
    - AREA removes BTX allowing steam consumption on the pre-reformer to be reduced

Sweden, Joakim Lundgren, LTU



Commercial gasification projects – update

Cortus 6 MW WoodRoll® gasifier at the Höganäs steel plant

- Large efforts to reach Milestone 3 -pressurized syngas production during 168 h without interruptions
- 24 h were reached, when the pyrolyser failed
- Measures to increase the process stability are currently made before re-start

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

- 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)
- Applications: CHP, fossil process gas replacements and industrial drying processes

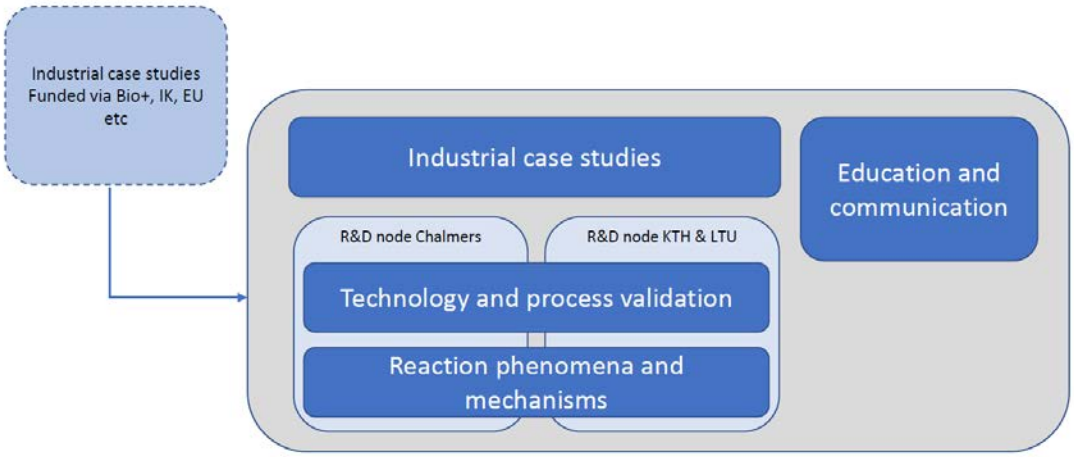
- Low value wood residue to renewable gas and power (2.4 MW) at IKEA Industry production unit in Zbaszynek, Poland
- Renewable gas (4.2 MW) for tissue drying at Sofidelmill in Kisa, Sweden

Plagazi AB

- PlagaziAB has a concept for transforming waste into hydrogen through plasma gasification.
- Several new projects are announced:
    - Neue Energien Premnitz and Plagazi to build the first Plagazi plant in Europe. Planned start Q2, 2023. No updates announced
    - New pre-study on plastics to H2(unknown customer)
    - New Basic Engineering study on several Plagazi plants for waste-to-industrial gas for fossil-free steel making (unknown customer)
    - Feasibility study on Automotive Shredder Residue (ASR) to H2 in Switzerland
    - Successful tests regarding conversion of wind turbine blades

SFC

SFC RECAP –Radically Reduced CO2-Emissions via advanced thermochemical Conversion processes in innovative industrial APplications



Total budget: 9 MEuro, 2022-2028
Expected decision in February 2022

Large industrial transformation in Norrbotten

- LKAB–shift from iron ore pellets to CO2-free sponge iron, need 1000 kton H_2 per year
- SSAB–green steel making, need 100 kton H2 per year
- H2Green Steel–green steel making, need 250 kton H2 per year
- Grupo Fertiberia–green ammonia and fertilizers, need 80 kton H2 per year
- Renewable power is needed for electrolysis and electric arc furnaces–approx. 65 TWh per year corresponding to 40% of Sweden's current power production

LTU Green Fuels plant – CH_2ESS

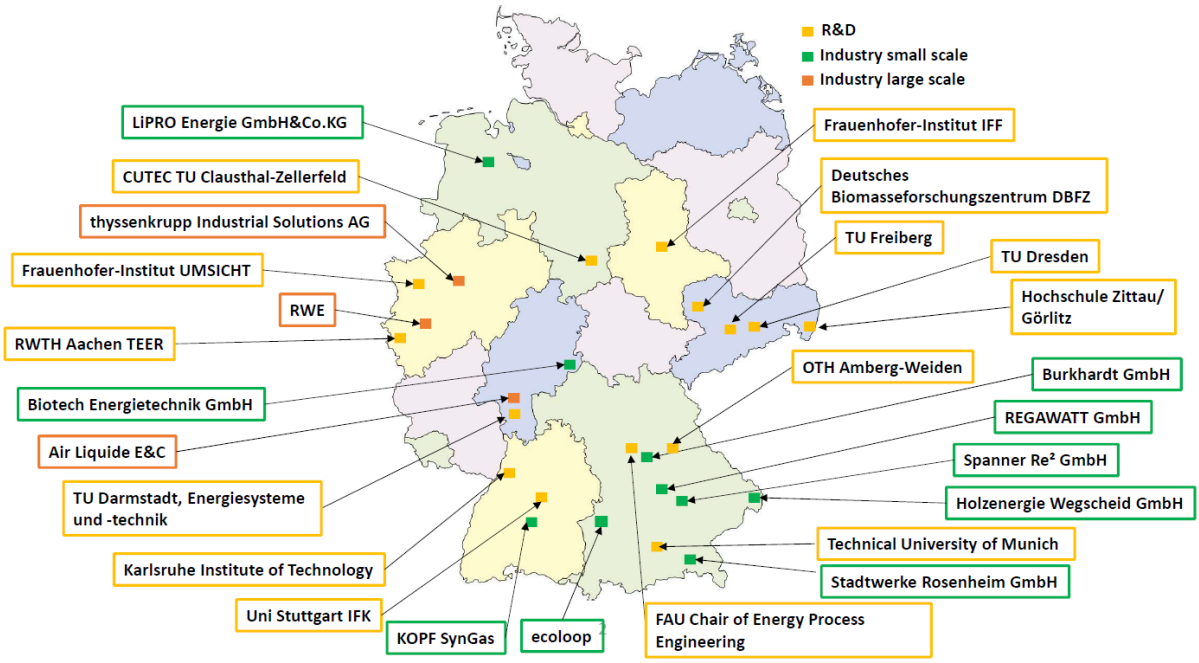
- CH_2ESS -Centre for Hydrogen use in industry and the Energy System Sweden.

- 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
- Aim to cover the whole value chain, including the power system

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.

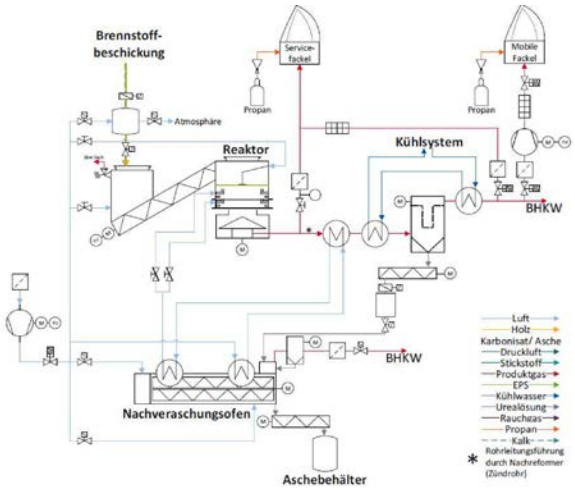
Gasification activities in Germany



Industrial activities

Ecoloop

Project owner	Ecoloop GmbH
Status	operational
Start up	2020
Country	Germany
City	Lauingen
Type	TRL 7 Demonstration
Technology	Fixed Bed/Counterflow Power/CHP
Raw Material	lignocellulosics
Input 1 Name	**Wood chips**
Input 1 Capacity	28
Input 1Unit	kg/h
Input 2 Name	**EPS (Expanded Polystyrene)**
Input 2 Capacity	11,4
Input 2Unit	kg/h
Output 1 Name	Power
Output 1 Capacity	68
Output 1Unit	kWel
Output 2 Name	Heat
Output 2 Capacity	123
Output 2 Unit	kWth



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
- Successful acceptance run in 2021
- fuel quality adjustments are currently being made to ensure more stable operation
- VOB acceptance is scheduled for in 2 weeks

RWE Phosphorus from sewage 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
- start up July 2021, operating tests since July

Blue Energy CHP

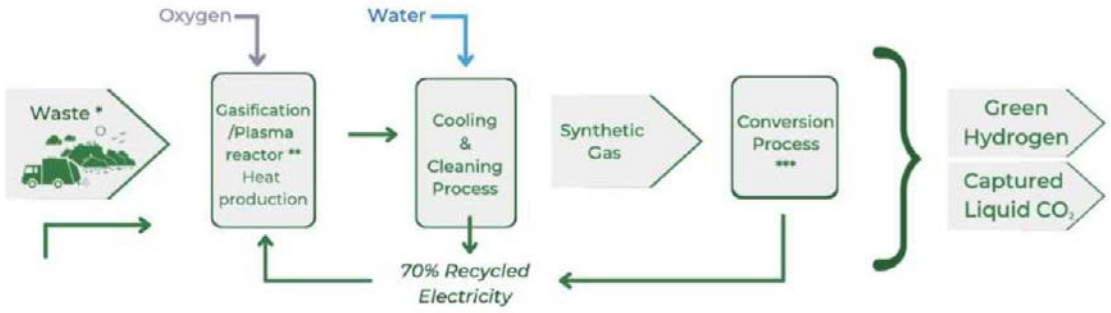
Wood gas cogeneration plant to be converted into an advanced bio-energy park
Future Products:
-Heat and Power
-Bio-oil
-Hydrogen
Update:

Plant out of operation 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

Plagazi

- Green hydrogen from any type of waste via plasma gasification
- CO2 is captured in CCS
- 70% of energy need is recycled internally
- Neue Energie Premnitz: Plagazi AB and Richter Recycling GmbH have entered an agreement to conduct a pre-study for constructing a Plagazi waste-to-hydrogen plant in Potsdam. The aim of the project team is to have the plant up and in operation by 2023.
- Dillinger GmbH have entered an agreement to conduct a pre-study for constructing a Plagazi waste-to-hydrogen plant.
- The pre-study will highlight the feasibility to include a Plagazi plant at their steel mill facility in Dillingen, Saar.
- CH: Feasibility study for Automotive Shredder Residue (ASR) Recycling in Switzerland



Bioliq

Technical details campaign April/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

Technical details campaign October 2021

- Production of 800 l raw petrol for refuel project
- First petrol from miscanthus pyrolysis oil

United Kingdom, Patricia Thornley, Aston University

UK biomass relevant reports:

- UK Hydrogen strategy; August 2021
- Advanced Gasification Technologies; October 2021
- UK Biomass Policy Statement; November 2021
- UK Biomass strategy; next year 2022

UK hydrogen strategy

- The development of a low carbon hydrogen sector in the UK is a key plank of the government's plan to build back better with a cleaner, greener energy system.
- Low carbon hydrogen has a critical role to play in the transition to net zero, by helping to bring down emissions in vital UK industrial sectors and providing flexible energy for power, heat and transport.

Advanced Gasification Technologies

- AGTs: thermal conversion technologies (gasification or pyrolysis) for conversion of biomass or waste into aviation fuels, diesel, hydrogen, methane & other hydrocarbons.
- Goal: understanding the current development status of AGTs and to inform future policy direction and innovation spending in relation to this class of technologies.

UK Biomass Policy Statement

- UK Government provides a strategic view on the role of biomass across the economy in different timelines: short (2020s), medium (by 2035), and long-term (by 2050) timelines.
- Key policy aims for biomass use across the economy (electricity, heat, transport and industry).

UK Biomass strategy

- BEIS are still developing the UK Biomass Strategy. They are currently analyzing the feedback provided by stakeholders through a call for evidence and from a series of round table discussions.
- This consultation ran from April until June 2021; and the UK Biomass Strategy is expected to be published in 2022.

UK industry update

Altalto Immingham Waste to Sustainable Aviation Fuel Project

- Plan to build what could be Europe's first waste-to-SAF plant
- 500,000 tonnes of residual waste saved from incineration or landfill per year
- Enough fuel to power over 1,000 transatlantic flights with net-negative carbon emissions
- Over 300,000 tonnes of CO2 saved per year
- Collaboration between Velocys and British Airways
- Uses Velocys proprietary Fischer-Tropsch technology combined with TRI gasifier and other demonstrated technologies

KEW technology

Unique technology that converts all types of non-recyclable resources and low-grade biomass into a wide-range of sustainable energy vectors (hydrogen, power, heat and advanced fuels) for a zero carbon future.

- First UK technology to achieve "End of Waste" status
- Pressurised operation: making system compact and cost-effective
- Pressurised syngas allows industrial integration and synthesis applications
- Patented Equilibrium approach reformer: normalises gas composition independent of input feedstock

ABSL

- First large-scale industrial plant, situated in the Protos energy park near Ellesmere Port in Cheshire.
- The facility will be able to convert 133,000 tonnes of waste into biohydrogen and biomethane, while capturing the CO2 with no polluting emissions to air and no particulate or dioxin emissions.
- Front-End Engineering and Design (FEED) is expected to be completed in Q3 2022, with construction and commissioning complete by the end of 2025.

BEIS funding for £5M design projects on H2-BECCS May-Oct 2022
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1030656/uk-net-zero-research-innovation-framework.pdf

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
- **Plant now undergoing start-up operations**
- 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 completed Fall 2021

  2) Holloway Bioenergy; Lost Hills, CA
  Aries down-draft gasifier; Ag wastes from California's Central Valley
  165 TPD ag waste feedstock producing 86 MWe/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; **$165M new funding recently 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)

Arbor Renewable Gas

- 1,000 BPD renewable gasoline (MTG) from woody biomass in Beaumont, Texas
- Gasifier: SunGasRenewables
- MTG: HaldorTopsoe

Velocys Natches MS

- 35M GPY SAF from gasification of woody biomass; no other details available

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

The political climate

- DOE: Liquid transportation biofuels coming back on the table
    - Sustainability: >70% life-cycle GHG reduction
    - Very strong emphasis on waste carbon feedstocks, SAF, and marine diesel products
    - Variety of SAF pathways under development (in addition to Fulcrum and RRB) gasification => LanzaJet, Vertimass
    - Pyrolysis => Alder Energy
    - Arrested anaerobic digestion (volatile fatty acids upgrading) => Alder Energy

- Infrastructure bill ($1.2T) has large investments in hydrogen
- Nothing specific called out for biomass
- DOE has issued a roadmap to stand up 4-5 operating biofuels demonstration plants (each at approx. 1M GPY) by 2030

END