

IEA Bioenergy Agreement: 2022-2024
Task 33: Gasification of Biomass and Waste
First semi-annual Task meeting, 2022
Hybrid meeting in Petten, Netherlands and virtual

18.-20. May 2022

Minutes

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

The list of attendees on 19. May 2022:

Name	Country	Affiliation	email
Berend Vreugdenhil	The Netherlands	TNO	Berend.vreugdenhil@tno.nl
Jitka Hrbek	Austria	BOKU	Jitka.hrbek@boku.ac.at
Xutong Wang	China	Tanjin University	wangxutong666@163.com
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
Rajesh Badhe	India	Indian Oil	badher@indianoil.in
Mohan Rao Dharamchela	India	Indian Oil	mohanrd@indianoil.in
Benjamin Berger	Belgium	ECAM	brg@ecam.be

IEA Bioenergy Agreement: 2022-2024

Task 33: Gasification of Biomass and Waste

First Semi-Annual Task Meeting, 2022

Hybrid meeting in Petten, NL and virtual

18.-20. May 2022

The Agenda of the Task 33 meeting was as following:

Day	Topic	Location
Wednesday 18 th May	Biofuel Workshop	Petten , NL
Thursday 19 th May morning	SNG Workshop	Petten , NL
Thursday 19 th May afternoon	Subtask discussion	Petten , NL
Friday 20 th May	Country updates + subtasks	Alkmaar, NL

Thursday 19.5. 2022

Item	Time	Who
Discussion on Subtask progress • Graphic representation • Website layout • Subtask Layout • Progress on subtask • Front page tekst – layman	13:00-15:00	All
Break	15:00-15:20	
Continuation discussion	15:20-17:00	All

Friday 20.5.2022

Item	Time	Who
Welcome	9:00 – 9:05	Berend
Country update	9:05 – 10:00	India, Germany
Emerging issues / IEA feedback	10:00 – 10:15	Berend
Project Ideas	10:15 – 10:45	All
Break	10:45 – 11:15	
Country update	11:15 – 13:00	Sweden, UK, Austria, Belgium
Lunch	13:00 – 14:00	
Country update	14:00 – 15:30	Netherlands, China, Italy
Break	15:30 – 15:45	
Country update	15:45 – 16:45	US and Canada
Wrap up / Highlights	16:45 – 17:15	

WS on “Innovations in Advanced Biofuels Production” (18.5.2022)

Joined workshop Task 33 and TNO. Workshop presentations and abstracts can be found here:

<https://www.converge-h2020.eu/workshopbiofuels/>

Workshop on “SNG” (19.5.2022)

- 2 short presentations regarding SNG (Status, Policy) – will be available on the Task website
- SWOT Analysis in 2 groups (in Petten and online)
- based on the SWOT analysis, the Task 33 will write a position paper (short, clear message, fact based) (Berend)

Afternoon session (19.5.2022)

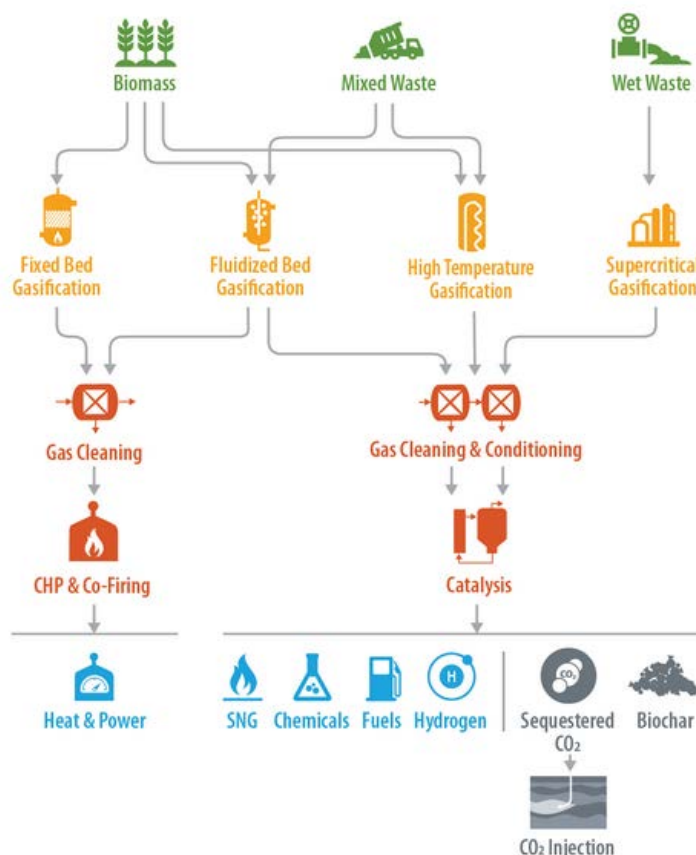
Task 33 Meeting discussions

Meeting Minutes from the last online meeting approved.

Task website

The Task 33 website will be re-designed again. The ExCo aim is to have the same website layout for all the Tasks. Thus Jitka will meet online Ernesto Lucarelli (ETA Florence), responsible for the website transition and discuss the layout and conditions for the website transfer.

Bob`s colleagues prepared graphic representation of gasification process and its products, this will be used, after small modifications, on the new Task 33 homepage.



Subtasks

The progress on subtasks presented. (6 subtasks on CHP, Biofuels, Biochemicals, SNG, Hydrogen and GHG balance). Berend sent a link to sharepoint at TNO, where the data regarding subtasks could be stored and actualized.

Task and Intertasks projects

In this triennium 2 inter-tasks projects will be realized (Hydrogen, GHG balance)

In Task budget some money left, thus Berend appealed to Task members to prepare proposals for Task project realization.

Topic 1: Hydrogen production and use in gasification systems – A knowledge synthesis

- in this project will participate Sweden, USA and UK

Topic 2: Chemical looping gasification

Topic 3: Update on factsheets (china)

Further proposals should be sent to Berend till the end of June 2022.

Next Task meeting

At the moment there are 2 different locations possible:

1. In October in Vienna, Austria
2. In Fall in Nevada, USA

Bob will check the possibility to visit FULCRUM (Gasif./FT) in Nevada and let us know.

The workshop topic should be chosen by the guest.

Update: Task meeting and workshop will be held 18.-20.10.2022 in Vienna, Austria.

Budget overview

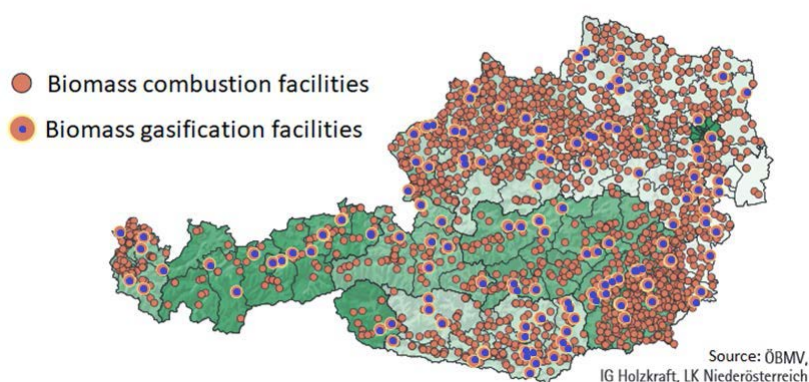
Category		Sub-categories		Budget 2022	Budget 2023	Budget 2024	Budget Triennium
Task Management	Task leader	Vreugdenhil	\$ 250	\$37,500	\$37,500	\$37,500	112,500
	Task co-leader	Hrbek		\$18,000	\$18,000	\$18,000	54,000
Additional items -TNO Budget		Vreugdenhil	15 k€/y	\$16,667	\$16,667	\$16,667	50,000
Travel		Vreugdenhil		\$6,000	\$6,000	\$6,000	18,000
		Hrbek		\$3,000	\$3,000	\$3,000	9,000
Other expenditure		Workshop		\$8,000	\$8,000	\$4,000	20,000
		Website management		\$3,000	\$3,000	\$3,000	9,000
		Webinars (3 events)		\$2,000	\$2,000	\$2,000	6,000
		Task meetings		\$4,000	\$4,000	\$3,000	11,000
Overhead		ExCo strategic funds (11 participants)		\$16,500	\$16,500	\$16,500	49,500
Projects	TP1	Reshaping task		\$20,000	\$20,000	\$20,000	60,000
Inter-Task Projects	ITP1	Hydrogen	T44	\$18,000			18,000
	ITP2	BECCUS	T40	\$15,000			15,000
	ITP3	Biofuels	T39				0
	ITP4	High value products	T36				0
Total				\$167,667	\$134,667	\$129,667	\$ 432,000
Income 2022 - 2024				\$181,667	\$181,667	\$181,667	\$545,000
Carry forward current triennium							\$10,289
Funds left for Projects							\$123,289

Country Reports Update

Austria, Jitka Hrbek, BOKU Vienna

Energy consumption and generation, research on gasification, industrial activities and implementations were presented.

In Austria, energy consumption is covered by around two thirds by mostly imported fossil fuels. Contrary to imports, renewable sources predominate in domestic energy production with a share of around 82 %.



Overview wood gas systems		Wood gas CHP plants		Feed-in of wood gas into gas network	Local green gas	Wood diesel	Hydrogen	Biochar
Plant manufacturer	Rated thermal input gasifier kW from-to	Electrical power kW from-to ^a	Thermal power kW from-to ^a					
Burkhardt GmbH		50-180	110-270					
Entrenco GmbH		25-50	60-120					
Fröling Heizkessel- und Behälterbau GmbH		46-56	95-115					
GLOCK ecotech GmbH		18-50	44-110					
Hargassner GmbH		20	60					
Holzenergie Wegscheid GmbH		65-133	130-270					
LIPRO Energy GmbH & CO. KG		30-50	60-90					
Polytechnik Luft- und Feuerungstechnik GmbH	400-1,500							
ReGaWatt GmbH	1,600-8,000	420-2,300	870-5,600			○	○	
Spanner Re ² GmbH		35-600	79.5-1,200					
Stadtwerke Rosenheim GmbH & Co. KG		50-180	110-380					
Syncraft® GmbH	700-3,000	200-1,000	155-1,540		x		○	x
URBAS Stahl- und Anlagenbau GmbH	500-2,000	120-600	250-1,000					
Windhager Zentralheizung GmbH	7-100							
Xylowatt S.A.	2,800-7,300	750-2,000	1,500-4,000				○	x
System designer								
BEST – Bioenergy and Sustainable Technologies GmbH ¹⁾	100-35,000	x			x	○	○	
GET – Güssing Energy Technologies GmbH		x		x	x	○	○	x
Güssing Renewable Energy GmbH	4,500-45,000	1,200-2,400	1,400-24,000			○	○	
Pörner Ingenieurgesellschaft mbH	500-45,000							
Repotec/Äichernig Engineering GmbH		x		x	x	○	○	x
ERNEUERBARE ENERGIE – Ing. Leo Riebenbauer GmbH		18-540	44-810	x	x	○	○	x
SMS group Process Technologies GmbH	1,000-20,000							

x = implemented commercial plants; ○ = no commercial systems available yet; ¹⁾ research facility; ²⁾ given information applies to one module. Company information, table makes no claim to completeness.

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, such as e.g. ADORe-SNG (Comprehensive Automation, Digitalisation & Optimization of Renewable & Sustainable SNG-production).

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.

Other projects:

Project Waste2Value



Belgium, Benjamin Berger, ECAM

Bioenergy status

- Bioenergy and waste represent 8% of total energy consumption for approximately 2 Mtoe
- Biomass (mainly solid) represents 80% of renewable energies in heating
- Main biomass plants (direct combustion) are now closed in Belgium so biomass for electricity is really low at the moment

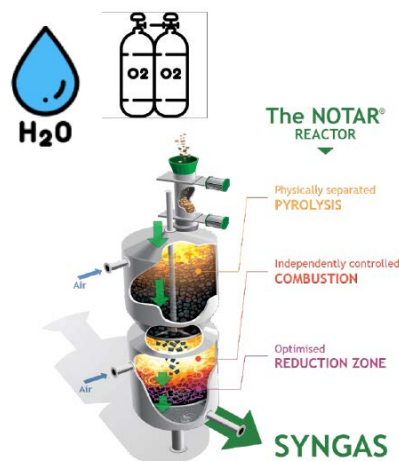
Project TTCogen

- HCCI engine using gas at high temperature without cooling and cleaning
- Compression ratio designed to have inlet above tar dew point
- Regional funding from Wallonia

- Partners: ECAM, Cpgemgreem S-A and ICLouvain
- Duration 4 years
- Full experim. Setup: gasifier from CMD + Engine and Auxilliaries (Cogengreen)
- Goal: sutp validated on more than 1000 op.h for 2025

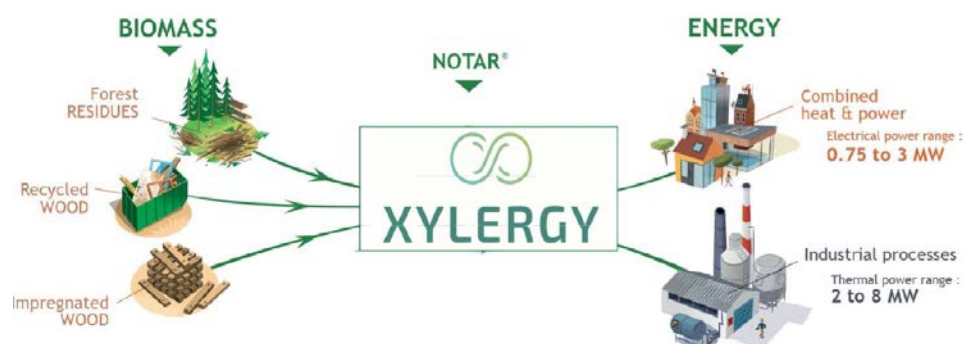
Enerbio

- Downdraft gasification (NOTAR) using superheated steam and O₂-enriched air
- High efficiency and high LHV
- Enhance tar reforming
- Pilot scale – up to 200 kW of syngas LHV
- Federal funding
- Partners: UCLouvain, UMon, ULB, CRA-W
- Duration 4 years



Xylergy – new company that bought Xylowatt

- Two patents on NOTAR technology
- One industrial gasifier 400 kWe and 1200 kWth
- One research gasifier UCLouvain Uni
- One project sold-building start in 2022, commissioning in 2023



Other industrial projects – several projects with Spanner (all now abandoned due to lack of technical skills for the maintenance).

Several projects focusing on waste gasification.

Canada, Fernando Preto, CanmetEnergy

CanmetENERGY was introduced

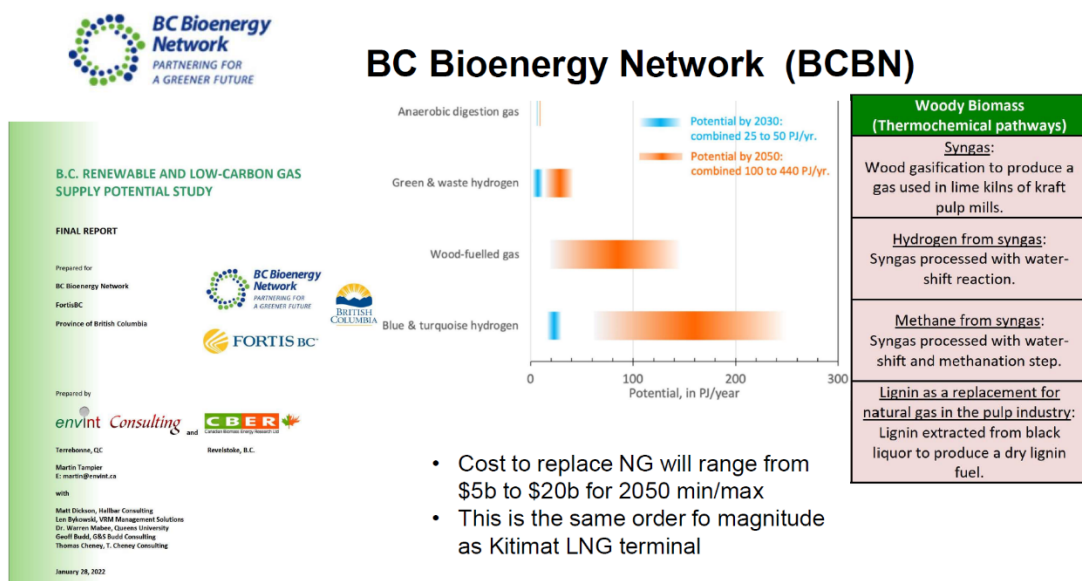
NG Utilities

Residential Gas Price: NG natural gas has the lowest delivered cost of any energy form at under \$8 per GJ, other fuels ~\$30/GJ

Fortis (British Columbia); Énergir (Quebec); Enbridge (Ontario), Enbridge

Fortis

- a provincially regulated utility, FortisBC submits potential projects to the British Columbia Utilities Commission (BCUC) for review. The BCUC reviews the projects to ensure they meet the requirements of the Greenhouse Gas Reduction Regulation.
- they expect that its original 2030 goal of 15 per cent of its gas supply being renewable and low carbon will be met or exceeded. In fact, a recent report commissioned by the Province of British Columbia, FortisBC and BC Bioenergy Network revealed that by 2050, the maximum potential supply of in-province renewable and low carbon gases could be as high as 440 PJ per year – roughly double FortisBC's current annual gas supply.



Natural Gas Offset, CHP & RNG: Nexterra Systems Corp.

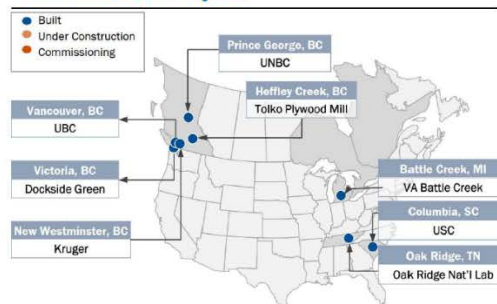
Business Description

- Founded in 2003, Nexterra is a provider of community scale (5 - 15 MW), energy-from-waste gasification systems for the production of clean syngas
- To date, Nexterra has built eight plants in North America and three in the UK. Other projects are under development in the UK, USA and Canada
- Nexterra has a flexible product offering, providing solutions for new and retrofit projects
 - Commercially proven systems operating on virgin wood (not pellets), forest residuals, and construction and demolition (C&D) waste wood
 - Refuse-derived fuel (RDF) has been demonstrated at our Product Development Center on 2 MWth gasifier

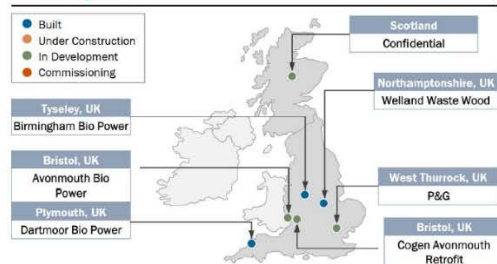
Existing Partners and Clients



North American Projects



UK Projects



Small scale gasification

Highbury Energy Inc. – based on technology developed at University of British Columbia - dual-bed steam gasification technology. Synthesis gas can be fired into a generator to make electricity or can be converted to high value liquid fuels, alcohols and chemicals.

Waste gasification

- PyroGenesis and Terragon Micro Automated Gasification System (MAGS) focus on small scale waste destruction with minor energy recovery
- Plasco Energy (\$400M project in Ottawa, Canada @85 tonnes/day, unsuccessful) is being resurrected as OMNI Conversion Technologies

Biofuels

Enerkem's Edmonton facility has the capacity to process 100,000 tonnes of solid waste and produce approximately 40 million litres of fuel-grade, cellulosic ethanol.

Thermochemical conversion R&D

- 125 kW(th) air/oxygen/steam blown fluidized bed biomass gasification system equipped with extensive on-line product gas and tar measurement capabilities
- CanmetENERGY-Ottawa (CE-O) is collaborating with FPIInnovations and University of British Columbia to assess residues available to BC pulp mills
- The types of biomass residues selected by BC Bio-products Alliance as being of importance to pulp mills in BC are:
 - Wood chips as baseline
 - Coastal BC forest residues
 - Interior BC forest residues
 - Salt-laden hog fuel
- A test plan is being developed to allow experimental results from the UBC and CE-O pilot plants (both labs have oxygen/steam blown CFBC gasifiers) to compare data and develop guidelines for gasification demonstrations

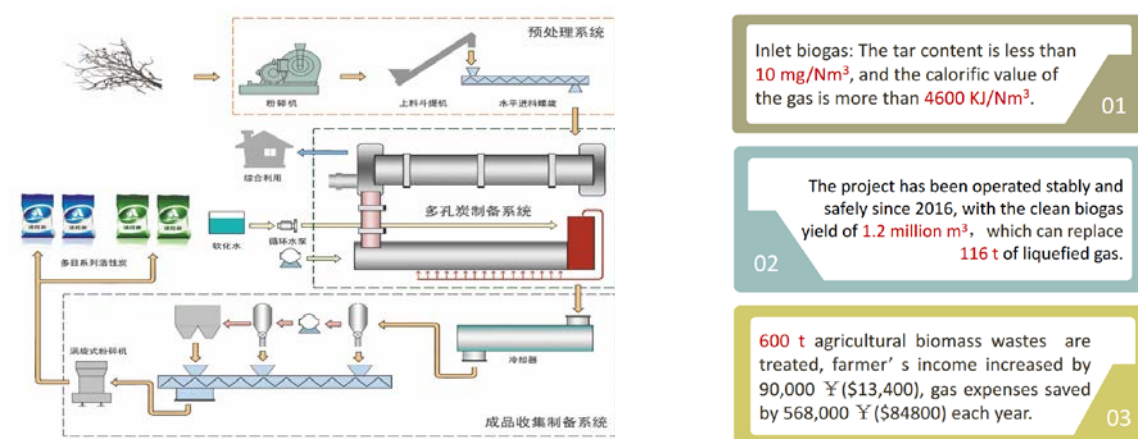
China, Xutong Wang, Tianjin University

Potentials of waste for gasification as well as principles for waste disposal were presented.

6 Case studies on gasification were presented:

1. Biomass gasification polygeneration project in Yichun

- gas and biochar generation
- 600 t/y of activated carbon
- 4000 m³ of gas/d



2. Biomass gasification project in Jingmen, Hubei

- coal replaced partly by biomass, 2x600 MW (8t/h), savings of 4t/h coal

3. Rice husk gasification project in Yingshang, Anhui

- electricity and carbon co-generation, 4 fixed bed gasifiers, capacity 150 t/d

4. Multi-source synthetic slurry gasification project

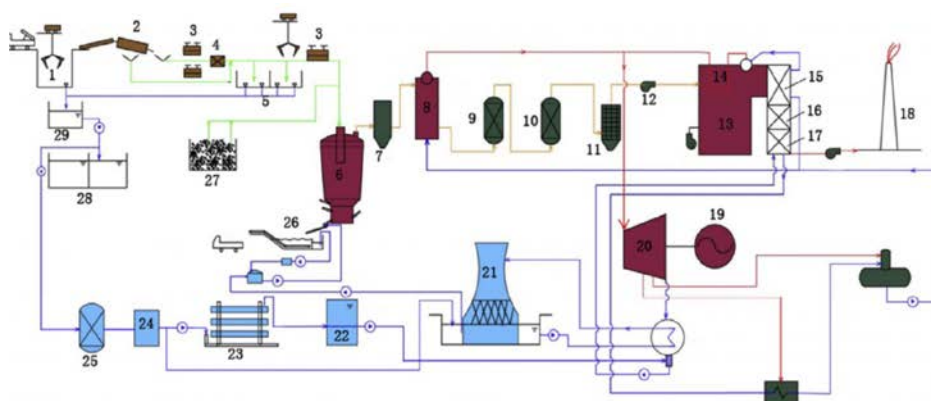
- Gasification is carried out with hazardous waste mixture, high volatile bituminous coal and some organic industrial wastewater as raw materials. The gas produced enters the gas boiler, and the steam formed is sent through the generator set to generate electricity for self-use or for sale.

- capacity 150000 t

5. Gasification of medicine residue in Shandong

- Employing "biomass circulating fluidized bed gasification" as the core technology, the key technologies include pretreatment system, pyrolysis gasification system, combustion steam production system, flue gas treatment system and intelligent control system.

6. MSW plasma gasification project in Bijie



1-Bunker; 2-Trommel screen; 3-Magnetic separator; 4-Shredder; 5-Pretreated feedstock bunker; 6-Plasma reactor; 7-Cyclone dust collector; 8-Waste heat boiler; 9-Desulfurization tower; 10-Demercuration tower; 11-Electrostatic precipitator; 12-I.D. fan; 13-Gas boiler; 14-Superheater; 15-Boiling economizer; 16-Air preheater; 17-Waste heat recovery set; 18-Stack; 19-Generator; 20-Steam turbine; 21-Cooling tower; 22-Desalination tank; 23-Reverse osmosis set; 24-Reclaimed water tank; 25-Filter; 26-Slag collector; 27-Black carbon & CaCO₃ container; 28-Leachate treatment unit; 29-Leachate collector.

India, Mohana Rao, Indian Oil Corporation Ltd.

India energy share was presented; coal is dominating in energy mix. Bioenergy share in total energy consumption is about 26%.

The current availability of biomass in India is estimated at about ~750 million metric tons per year with surplus availability of at about 230 million metric tons per annum equivalent to potential of about 28 GW.

Biomass co-firing in coal based power plants in India is an actual topic. It was decided to co-fire 5-10% of biomass in all thermal power plants.

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

Biomass gasification

- Several research institutions, industries and implementing agencies actively involved in development and deployment of biomass gasification in India during 1990-2010.

-
- The diagram illustrates the process of producing fuel cell-grade hydrogen from biomass. It is divided into three main sections: Gasification, Utility, and Hydrogen purification.
- Gasification:** This section is enclosed in a dashed orange box. It starts with a **Biomass feeding system** (dark blue box) which feeds into a **Biomass gasifier** (blue box). The output of the gasifier goes to **Syngas cleaning & conditioning** (blue box). This step is further detailed with three sub-processes: **Particulate removal**, **Particulate & condensate removal**, and **Impurities removal** (all in light blue boxes). The final output is **Conditioned gas** (blue box).
 - Utility:** This section is enclosed in a dashed blue box at the bottom. It includes an **Oxygen supply system**, a **Steam generation system**, and **Water treatment** (all in dark blue boxes). Dashed arrows indicate interactions between the Gasification and Utility sections.
 - Hydrogen purification:** This section is enclosed in a dashed blue box on the right. It starts with **Conditioned gas** entering a **Compression** unit (purple trapezoid). The output goes to a **Low pressure PSA** (light blue box). The PSA produces two streams: **99.97% Hydrogen** (light blue box) and **Tail gas ($H_2/CO/CH_4/CO_2$ mixture)** (light blue box). The tail gas is sent to **Hydrogen purification** (dashed blue box), which has a feedback loop to the **Utility** section.
- Text at the top:** Indian Institute of Science and Indian Oil Corporation Ltd. jointly working on development and demonstration of biomass gasification based hydrogen generation technology for producing fuel cell-grade hydrogen

SBR	0.75	1	1.4	1.5	1.8	2.4	2.7
ER	0.21	0.18	0.21	0.23	0.27	0.28	0.3
H ₂ yield (g/kg biomass)	66	68	71	73	94	99	104
H ₂ yield (vol %) on dry basis	41.8	45.2	43.1	45.2	49.6	51.6	50.5
CO yield (vol %) on dry basis	27.6	24.9	26.5	24.9	17	12.4	13
H ₂ /CO ratio	1.5	1.8	1.6	1.8	2.9	3.8	3.9
LHV (MJ Nm ⁻³)	8.9	8.6	8.8	8.7	8	7.4	7.4
Hydrogen efficiency (%)	73.7	63.2	67.2	63.5	70.5	61	63.7
Gasification efficiency (%)	85.8	76.8	80.8	77	79.5	70.5	71.5

Italy, Donatella Barisano, ENEA

National electricity balance from 2016-2020 was presented.

	TWh				
HEADING	2016	2017	2018	2019	2020
TOT grid requirement	314.3	320.5	321.4	319.6	301.2
Share of Total RES	105.1 (33.4%)	101.0 (31.5%)	111.4 (34.7%)	112.8 (35.3%)	113.6 (37.7%)
Share of Bioenergy	17.9 (5.7%)	17.9 (5.6%)	17.6 (5.5%)	18.0 (5.6%)	17.7 (5.9%)
Biomass	5.8	5.9	5.8	5.8	5.7
Biogas	7.4	7.7	7.6	7.7	7.5
Bioliq	4.7	4.3	4.2	4.5	4.5

The Italian recovery and resilience plan was presented.

An overview on gasification facilities was presented.

Geographic al Area	Region	N. Imp.						kWe					
		2016	2017	2018	2019	2020	2021	2016	2017	2018	2019	2020	2021
Northern Italy	Trentino Alto Adige	49	56	70	68	62	62	9782	10631	13249	12924	11338	11338
	Friuli	6	15	18	16	9	9	1975	4924	7866	7466	2890	2890
	Veneto	11	19	22	22	22	22	1723	2279	2875	2875	2875	2875
	Lombardia	9	15	17	17	17	17	2489	5058	6798	6798	6798	6798
	Piemonte	19	20	31	30	25	25	5408	5991	7759	7714	5995	5995
	Emilia Romagna	11	14	17	16	16	16	2597	3209	4434	3934	3934	3934
	Valle d'aosta	1	1	1	1	1	1	49	49	49	49	49	49
	Liguria	0	0	0	0	0	0	0	0	0	0	0	0
Central Italy	Toscana	14	17	23	23	21	21	2259	2526	4489	4489	4370	4370
	Umbria	8	14	16	16	16	16	1445	2095	2344	2344	2344	2344
	Lazio	7	12	13	13	13	13	573	1716	1915	1915	1915	1915
	Marche	4	8	8	8	8	8	283	804	804	804	804	804
Southern Italy and islands	Abruzzo	1	4	4	3	3	3	45	249	249	194	194	194
	Basilicata	2	1	2	2	2	2	399	199	399	399	399	399
	Calabria	1	4	7	7	7	7	45	315	764	764	764	764
	Campania	3	7	11	9	9	9	342	1303	2002	1614	1614	1614
	Molise	0	1	1	1	1	1	0	22	20	20	20	20
	Puglia	3	3	3	3	4	4	425	325	325	325	524	524
	Sardegna	1	4	5	5	5	5	90	583	903	903	903	903
	Sicilia	2	3	7	7	7	7	1049	1248	1143	1143	1143	1143
Total		152	218	276	267	248	248	30978	43526	58387	56674	48873	48873

As can be seen in the table the total el. production by gasification was 48 873 kWe in 2021.

Netherlands, Berend Vreugdenhil, TNO



SYNOVA

- polystyrene depolymerization for Trinseo (Belgium)
- MILENA, 2t/h PS-rich waste input
- start construction late 2022

GIDARA Energy and TU Delft to build Gasification innovation centre in Rotterdam

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:
 - o 5% Uptime expected
 - o 12 kton of rejects (all from the site)
 - o 50 kton of reject processed since startup
- Good availability in 2022, minor modifications planned

Stercore

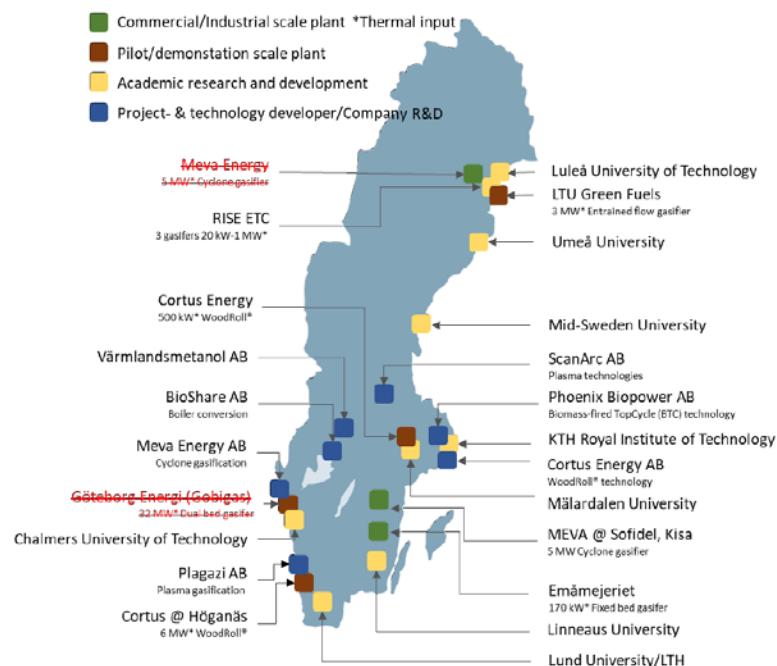
- Final verdict in the court case expected before end of May 2022
- Manure to green gas & bio-based carbon factory
 - o Economic due diligence finished
 - o Technical due diligence finished
 - o Technical detailed design and building design finished together with Emmtec Engineering as EPC

- o Off-take agreement for Bio-LNG with UK/NL oil major agreed upon as a fuel guarantee not depending on the SDE++ scheme
- o In compliance with first court ruling, expecting final verdict in December
- o Start building expected Q2-2022
- o First stage investment approx. 32 Meuro

Torrgas

- 1 MW Demo DNV-GL (TRL 7)
- Scalable to 100 MW
- 30 MW SNG Delfzijl nearing financial close
- 50 MW green hydrogen, working on funding
- currently started 3. global MeOH project
 - **Update:** SNG and H₂ similar GHG profile without biochar and CO₂ sequestration
 - ~80% reduction in GHG emissions compared to fossil fuels
 - Biochar allows negative emissions
 - Effect of feedstock transportation is marginal

Sweden, Joakim Lundgren, LTU



Commercial gasification projects – update

Cortus 6 MW WoodRoll® gasifier at the Höganäs steel plant

- Installed cyclones (spring 2021) were insufficient.
- Still problems with char particles in the pyrolysis gas -pipes clog over time.

- A new separator has been designed and manufactured during the winter and is now installed in series with existing cyclones.
- Start-up again in June

Cortus WoodRoll® in Mariposa (US)

- The Mariposa-project for delivery of 2,7 MW electricity is put on hold as well as the Engie-collaboration project (WoodHy) on biomass-to-hydrogen project in Bordeaux.
- New engineering study for a future plant for green diesel production with the Norwegian company BiojetAS.
 - Planned plant capacity = 750 tonnes of biomass per day = several parallel WoodRoll® needed (20 times larger than Höganäs).

Other Cortus WoodRoll® news

- Cortus AB recently got orders for two gasifiers from blueFLUXEnergy AG and HolznerDruckbehälter GmbH in Germany.
- Engineering work has started –gasifiers to be delivered in Q1 and Q2 in 2023.
- The first project is for hydrogen (0.5 MW) and the second for fossil gas replacement in heating furnaces in the brick industry (6 MW).

MEVA

- EF cyclone gasifier emanated from Luleå University of Technology
- Outputs 1.2 MW_{el} and 2.4 MW_{th}
- 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, **no updates**
- Renewable gas (4.2 MW) for tissue drying at Sofidelmill in Kisa, Sweden, **commissioning 2023**

Uniper and Sasol ecoFT – SkyFuelH2

- Sasol ecoFT has signed a LOI with Sollefteå municipality in collaboration with Sweden's energy company Uniper
- Investigate the possibility of establishing an industry-scale production facility for sustainable aviation fuel
- 100 000 ton SAF per year = ca 150 MW = 200 MW power + 100 MW biomass

Plagazi AB

- Plagazi AB has a concept for transforming waste into hydrogen through plasma gasification.
- Several new projects are announced:
 - Köping Hydrogen Park -Three Plagazi plants to recycle 66.000 tonnes of waste annually for production of 12.000 tonnes (51 MW) of hydrogen.
 - Planned to be operational in 2024
 - German project "Havelstoff" located in Brandenburg run together with Neue Energien Premnitz
 - LOI with WIRTZ Energie+ Mineralöl GmbH with the intent to form a long-term offtake agreement of 4 000 tons of hydrogen
 - Planned start Q2, 2023

BIOSHARE

- The company BioShare granted funding (≈1,7 M€, 2020-2024) to demonstrate integrated gasification and pyrolysis at a CHP-plant

- The reactor to be operated during three heating seasons to assess performance and gas quality with different feedstocks
- No updates reported

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 %
- Two H2020-projects; EUCANwin! and BioFlexGen

Swedish gasification-related R&D programs

- final report www.sfc-sweden.se

- The SFC RECAP –Radically Reduced CO2-Emissions via advanced thermochemical Conversion processes in innovative industrialApplications–proposal was rejected in January2022
- CurrentgasificationR&D is again fragmented
 - KTH –downstream processing (reforming, FT-synthesis) etc)
 - LTU –ash chemistry, systems analysis, planning for re-start of LTU GF etc
 - Chalmers –gasification of plastics etc
 - RISE –systems analysis, advisors

Efforts to find new funding opportunities for SFC are ongoing

Large industrial transformation in Norrbotten

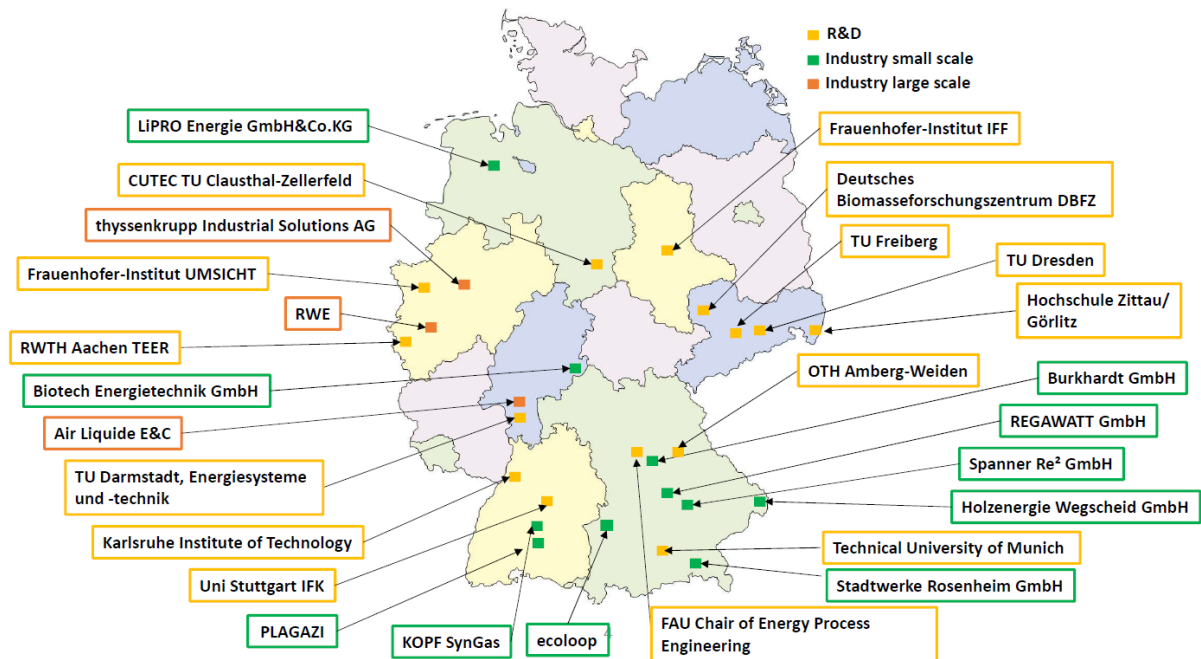
- LKAB–shift from iron ore pellets to CO2-free sponge iron, need 1000 kton H₂ per year
- SSAB–green steel making, need 100 kton H₂ per year
- H2Green Steel–green steel making, need 250 kton H₂ per year
- Grupo Fertiberia–green ammonia and fertilizers, need 80 kton H₂ per year
- Renewable power is needed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

LTU Green Fuels plant – CH₂ESS

- CH₂ESS -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

Gasification activities in Germany



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
- plant in Koblenz handed over to customer

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
- first start up campaign in June 2021: fuel supply and gasification operated successfully, dust extraction and steam supply to be reworked

- second campaign late Nov. 2021 and late Dec. 2021: dust extraction and steam supply worked properly
- further campaign with coal executed February, April and May 2022 for operation optimization

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

still no progress

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

BioTfuel

Update May 2022:

All test series have been successfully completed. The commercialization of the process chain based on PRENFLO gasification process is already in process, not only for SAF but also for methanol and hydrogen applications and many more.

Bioliq

Technical details campaign October 2021

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

Technical details campaign March 2022

- Heat transfer measurement cooling screen for scale up
- Influence of different ash quantities on slag layer
- Measurement of cenospheres in quench water and slag
- Flame characterization with high-speed camera

USA, Robert Baldwin, NREL

Fulcrum Bioenergy/Sierra Biofuels:

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

San Joaquin Renewables, San Joaquin, CA

- Gasifier: Frontline BioEnergy RNG (pressurized FB, 10 bar, air or O2 with steam)
- Feedstock: Ag waste
- Product: RNG (15 mill. Gallon-eq.)
- Status: engineering in progress, approvals for injection in existing pipelines received

Mote

- Gasifier: SunGas Renewables (press. FB, 10 bar with CCS)
- Feedstock: Ag residues
- Product: low-carbon hydrogen
- Status: initial stages of project planning

Velocys Natches MS and Immingham UK

- Microchannel FT reactor
- 35M GPY SAF from gasification of woody biomass; no other details available
- Status: Natches, Immingham – start up 2027

USA Bioenergy – Texas Renewable Fuels

- Gasif.+ FT
- Feedstock: woody biom.
- Product: SAF, renew. Diesel, naphtha
- Status: planning underway for 1. Biorefinery in Bon Wier, Texas

Lanzatech

- Gasifier: Sekisui (Japan), Ankur (India)
- Feedstock: biomass, MSW
- Product: bio-ethanol and other oxygenates
- Status: developmental work in progress

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 °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
 - Status: operational

The political climate

- DOE: Liquid transportation biofuels coming back on the table
 - o Sustainability: >70% life-cycle GHG reduction
 - o Very strong emphasis on waste carbon feedstocks, SAF, and marine diesel products
 - o Variety of SAF pathways under development (in addition to Fulcrum and RRB)
gasification => LanzaJet, Vertimass
 - o Pyrolysis => Alder Energy
 - o 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
 - o 3B GPY SAF is target by 2030 (BioEnergy Technology Office)

END