

IEA Bioenergy Agreement: 2022-2024
Task 33: Gasification of Biomass and Waste
First semi-annual Task meeting, 2023
Hybrid meeting in Edmonton, Canada and virtual

18.-20. April 2023

Minutes

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

The list of attendees on 18. April 2023:

Name	Country	Affiliation	email
Berend Vreugdenhil	The Netherlands	TNO	Berend.vreugdenhil@tno.nl
Jitka Hrbek (online)	Austria	BOKU	Jitka.hrbek@boku.ac.at
Christoph Pfeifer (online)	Austria	BOKU	Christoph.pfeifer@boku.ac.at
Guanyi Chen (online)	China	Tanjin University	chen@tju.edu.cn
Donatella Barisano	Italy	Enea	donatella.barisano@enea.it
Joakim Lundgren	Sweden	LTU	Joakim.lundgren@ltu.se
Sabine Fleck	Germany	KIT	Sabine.fleck@kit.edu
Robert Baldwin	USA	NREL	Robert.baldwin@nrel.gov
Rajesh Badhe (online)	India	Indian Oil	badher@indianoil.in
Mohan Rao (online)	India	Indian Oil	mohanrd@indianoil.in
Benjamin Berger	Belgium	ECAM	brg@ecam.be
Marion Maheut	France	Engie	Marion.maheut@engie.com
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Travis Robinson	Canada	CanmetENERGY-Ottawa	travis.robinson@NRCan-RNCan.gc.ca
Paula Sanchez	UK	Aston University	p.blanco-sanchez@aston.ac.uk
Massimiliano Materazzi	UK	UCL	massimiliano.materazzi.09@ucl.ac.uk
Observers			
Fredrik Gransberg	Sweden	LTU	Fredrik.gransberg@ltu.se

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:

18.4.2023	Task meeting
19.4.2023	Workshop “Hydrogen produced from gasification and implemented in gasification”
20.4.2023	Site visit Enerkem plant

18.4.2023 – Task meeting - agenda

Item	Time	Who
Welcome (Members/Guests)	8:00 – 8:30	All
Country updates (China/India)	8:30 – 9:30	Rajesh, Guanyi
General issues - Website and subtasks status - Agenda towards end of triennium	9:30 – 10:15	Jitka Berend
Update on the ITP's (H ₂ and BECCUS)	10:15 – 10:45	Joakim /Miriam online
Country update (Austria, France, Belgium, Italy, Germany)	10:45 – 12:30	Jitka , Chourouk , Benjamin, Donatella , Sabine
Lunch	12:30 – 13:30	
Country update (Sweden, NL, UK)	13:30 – 14:30	Joakim, Berend, Massimiliano
Discussion on ongoing projects H ₂ → Sweden lead Gas cleaning → Austria lead	14:30 - 15:30 15 minute break around 15:00	All
Budget overview Proposal next triennium	15:30 - 16:30	All
Country update (US and Canada)	16:30 – 17:15	Bob, Travis
Closing the meeting → Any other business	17:15 – 17:30	

19.10.2022 – Workshop - agenda

TIME ZONE				SPEAKER	TITLE
Edmonton (local)	Amsterdam	Delhi	Shenyang		
08:30	16:30	20:00	22:30	B. Vreugdenhil	Welcome
08:45	16:45	20:15	22:45	G. Chen	Gasification for hydrogen production in China
09:15	17:15	20:45	23:15	A. Mohammadi	HTW® 2.0: A proven path towards sustainable fuels
09:45	17:45	21:15	23:45	R. Post v d Burg	TorrGas modular syngas platform for the production of green hydrogen, circular synthetic chemical products and biofuels
10:15	18:15	21:45	0:15	BREAK (15 min.)	
10:30	18:30	22:00	0:30	V.Gubin/F.Thelen	Decentral production of PEMFC suitable hydrogen from air gasification of wood
11:00	19:00	22:30	1:00	A. Borgogna	Circular ethanol and hydrogen through waste gasification
11:30	19:30	23:00	1:30	T. Ginsberg	Circular economy pilot plants and projects at the RWE Innovation Centre in Niederaußem
12:30	20:30	0:00	2:30	BREAK (30 min.)	
13:00	21:00	0:30	3:00	R. Bock	Green hydrogen from waste
13:30	21:30	1:00	3:30	J. Lundgren	ITP Synergies
14:00	22:00	1:30	4:00	F. Granberg	Production of bio-electrofuels at LTU Green Fuels.
14:30	22:30	2:00	4:30	BREAK (30 min.)	
15:00	23:00	2:30	5:00	J. Stolaroff	Mote: Carbon-negative hydrogen from waste biomass
15:30	23:30	3:00	5:30	B. Jackson	Carbon-negative bright green TM hydrogen
16:00	0:00	3:30	6:00	B. Vreugdenhil	Closure

20.4.2023 – Site visit Enkern plant

Enkern's disruptive technology converts non-recyclable, non-compostable waste into biofuels and other renewable chemicals. Enkern operates a commercial-scale facility in Edmonton, Alberta, Canada as well as an innovation centre in Westbury, Quebec, Canada. The company is currently developing several facilities around the world, to facilitate the transition to a circular economy.

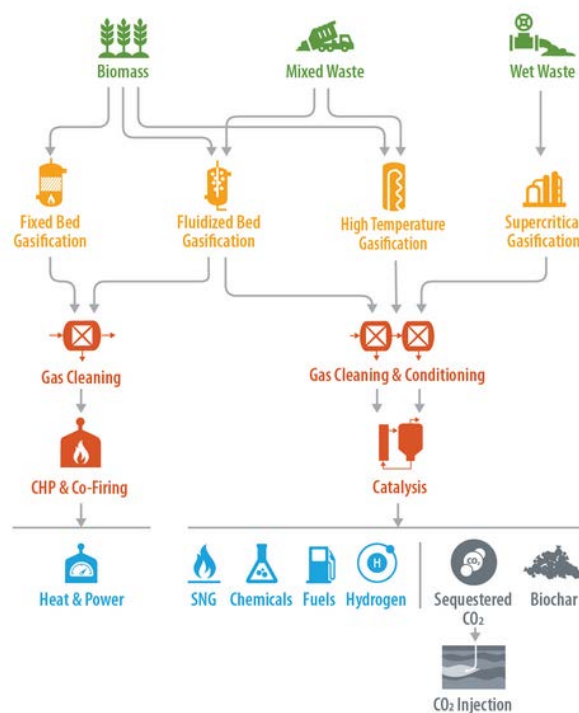


Task 33 Meeting discussions

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. The works on the new website are now ongoing and should be finished as soon as possible. Thus, the meeting with Subtasks leaders will be organized to discuss the status of the work.



Newsletter

Joakim proposed to put together a short informative newsletter after each meeting. The NTLs should send him a short teaser text with the highlights in their country.

Agenda toward end of triennium

Next meetings

18.-20.10. 2023 Lyon, France – details regarding workshop topic will be known soon

Middle of May 2024 China

October 2024 Sao Paulo, Brasil

Task and Intertasks projects

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

The Status of the ITPs was presented by Joakim and Massimiliano. The slides can be found in member area of the website.

Access member area:



User: task33_member

Password: %task33_n8wb3r!

Budget overview

Triennium budget (USD)			
based on income projections - with updated # participants			
2022	2023	2024	Triennium
12	12	12	
\$15.000	\$15.000	\$15.000	
\$180.000	\$180.000	\$180.000	\$540.000
\$18.000	\$18.000	\$18.000	\$54.000
\$162.000	\$162.000	\$162.000	\$486.000
\$10.289			\$10.289
\$0			\$0
\$3.750	\$4.250		\$8.000
\$176.039	\$166.250	\$162.000	\$504.289

Topic	Budget	Who
Deep cleaning for fuels and chemicals synthesis	25000 EUR	Austria
Negative emissions	35000 EUR	Austria
Status report gasification 2024	15000 EUR	Austria
H2 – a synthesis report	40000 USD	US, SWE, NL, UK
Position paper on chemicals	10000 USD	US, NL

Last meeting we allocated budget for no.1, 3 and 4, which is roughly 80 kUSD.

Jitka asked for more budget for the project on Deep gas cleaning, Berend agreed to increase the budget from 25 000 to 40 000 Euro (3 project partners will work together on the project).

Next triennium

Lead

Berend was leading the Task during the last 2 trienniums and based on the rules of IEA Bioenergy, where the leader can serve just 2 periods, it is necessary to find a new leader.

As an upcoming leader Jitka was proposed.

Task projects

Berend encouraged all Task members to already think about the proposals for the next triennium.

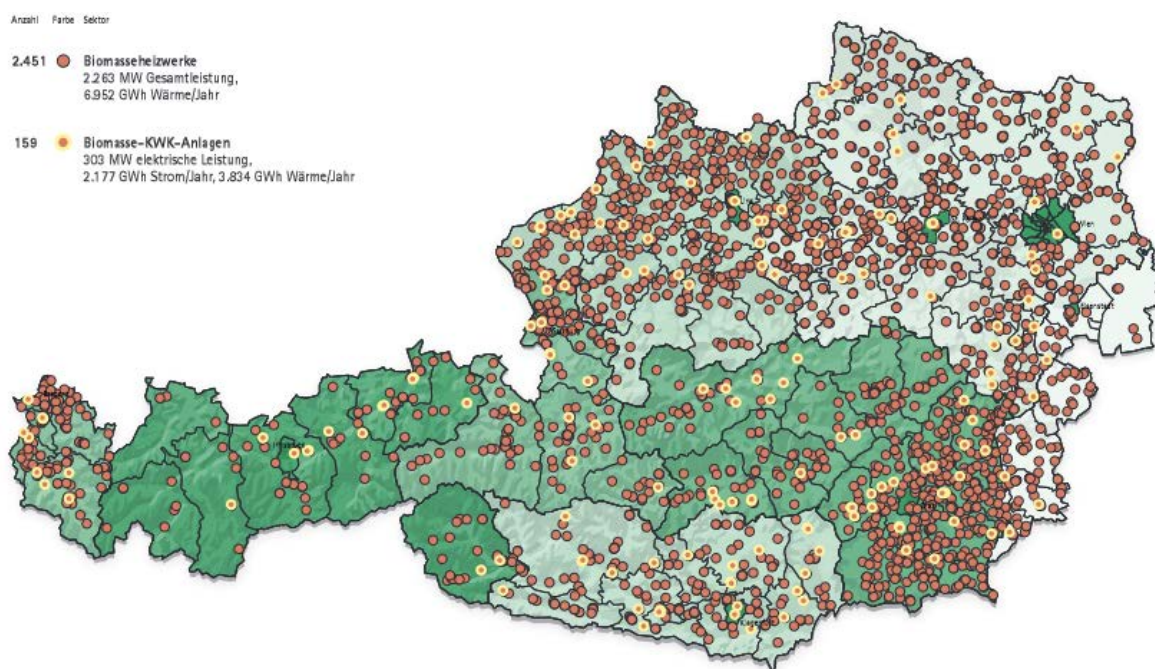
Country Reports Update

Austria, Jitka Hrbek, BOKU Vienna

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

Domestic energy generation is mostly based on bioenergy (45%), hydropower (27%), about 15% is covered by fossils (natural gas, oil). Contrary to imports, renewable sources predominate in domestic energy production with a share of around 82 %.

Nowadays, there are about 150 operational gasification facilities producing 2177 GWh power/y and 3834 GWh heat/y.



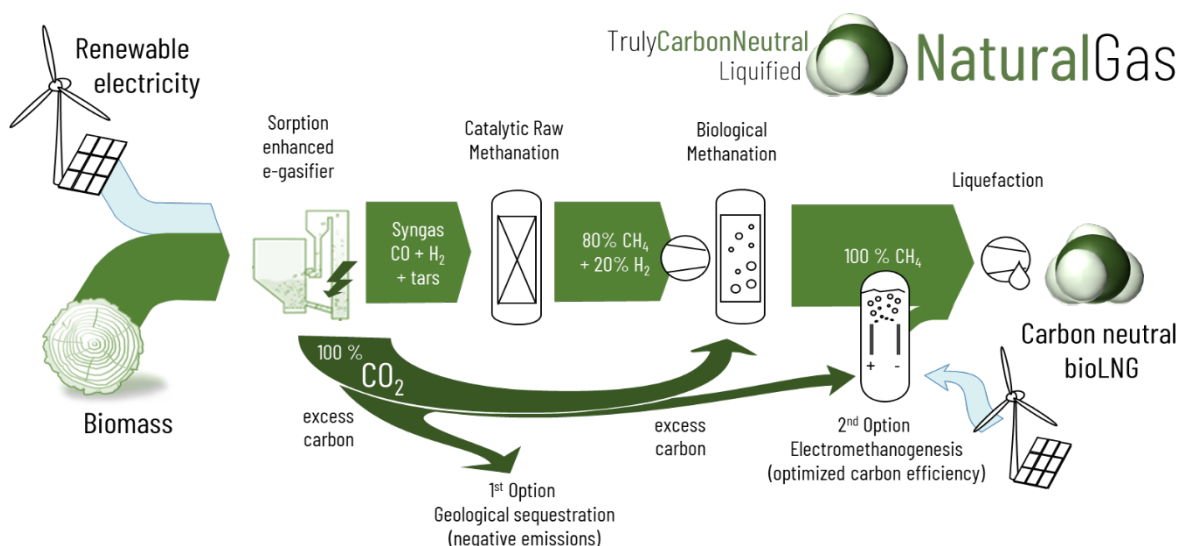
Overview wood gas systems		Wood gas CHP plants				
Plant manufacturer	Rated thermal input gasifier kW from-to	Electrical power kW from-to ^a	Thermal power kW from-to ^a	Feed-in of wood gas into gas network	Local green gas	Wood diesel
Burkhardt GmbH		50-180	110-270			
Entrenco GmbH		25-50	60-120			
Fröling 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	79.55-1,200			
Stadtwerke Rosenheim GmbH & Co. KG		50-180	110-380			
Syncraft® GmbH	700-3,000	200-1,000	155-1,540		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			
System designer						
BEST – Bioenergy and Sustainable Technologies GmbH ¹⁾	100-35,000	x			x	
GET – Güssing Energy Technologies GmbH		x		x	x	
Güssing Renewable Energy GmbH	4,500-45,000	1,200-2,400	1,400-24,000			
Pöchner Ingenieurgesellschaft mbH	500-45,000					
Repotec/Alchemig Engineering GmbH		x		x	x	
ERNEUERBARE ENERGIE – Ing. Leo Riebenbauer GmbH		18-540	44-810		x	
SMS group Process Technologies GmbH	1,000-20,000					

x = implemented commercial plants; 0 = 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

The research areas as well as actual projects were presented, such as e.g. CarbonNeutralLNG (Trully Carbon Neutral electricity enhanced Synthesis of Liquefied Natural Gas from biomass). The aim of the project is decarbonisation of industrial processes with efficient fluidized bed systems. BOKU is a partner in this project and coordinator is Friedrich-Alexander-Universität Erlangen-Nürnberg.



Actual research in **MCI JRZ** was presented.

Central outcome of research year 2 (production of biochar):

Adopted gasification reactor runs successful – stable gas production from waste wood (A I – A III)

Lab-scale activation successful (up to 1900 m²/g with chemical activation)

Scale-up of activation reactor for in-situ-activation successful – continuous operation possible

Central outcome of research year 2 (utilization of biochar):

Lab methods for all applications in waste water treatment are established

A two-line pilot-scale WWTP plant was installed in Zirl/Tyrol. Test runs with AC as an additive started.

Concept I: addition of AC directly in the biological stage

Concept II: addition of AC in a downstream contact reactor (4th treatment step)

A six-line lab-scale continuous operated anaerobic reactor was installed. Test runs with AC as an additive started.

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.

New CHP (SynCraft) is in operation in Perg, since the beginning of 2023.

Update concerning the project Waste-2-Value was presented.

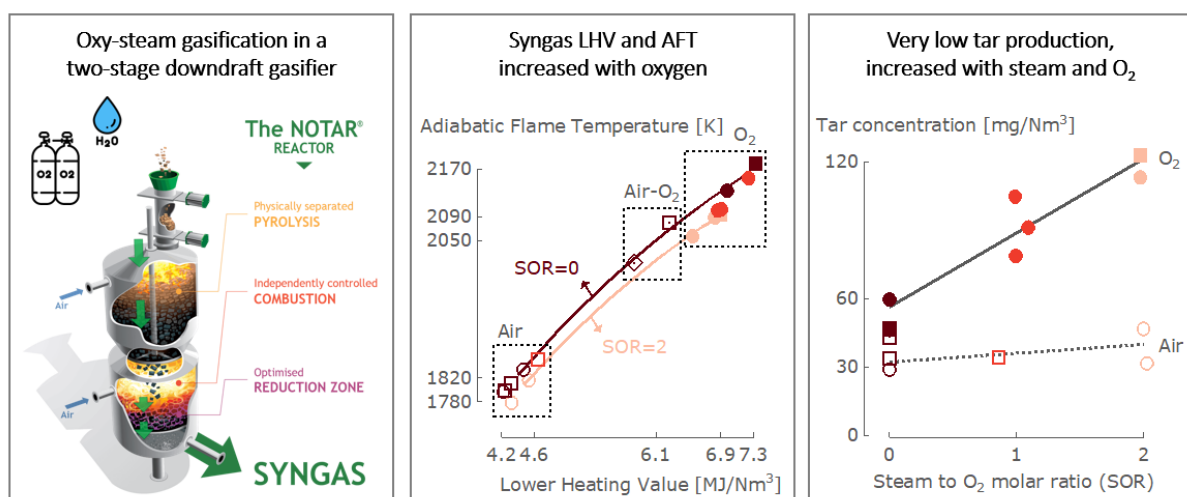
Belgium, Benjamin Berger, ECAM

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

Enerbio

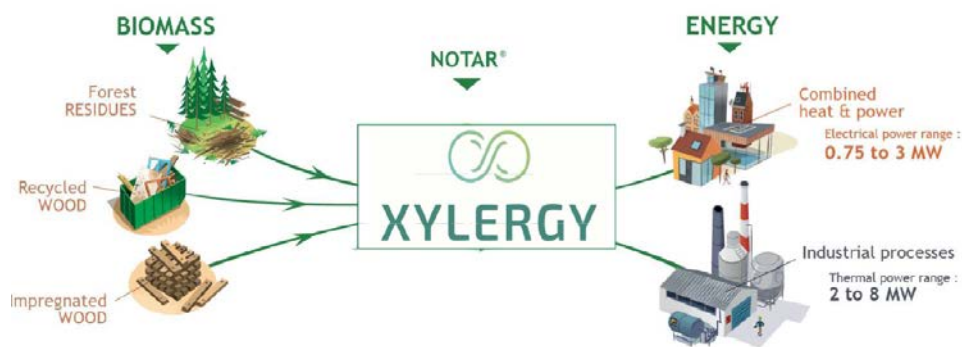
- Project from UCLouvain
- Gasifier from Xylergy with engine and auxiliaries
- Results of steam and oxygen enriched gasification presented during last workshop



Project TTCogen

- HCCI engine using gas at high temperature without cooling and cleaning
- Compression ratio designed to have inlet above tar dew point
- Duration 4 years
- Full experim. Setup: gasifier from CMD + Engine and Auxilliaries (Cogengreen)
- Goal: sutp validated on more than 1000 op.h for 2025
- **First Environmental permit for Brussels**
- **1 year of legal and technical work**

Xylergy – new company that bought Xylowatt



Belgium – Mont-Godine hospital

- Engine reached end of lifetime (60 000 hours)
- New engine, same manufacturer (GE Jenbacher)
- Increased electricity efficiency to 37%
- Power increased to approx. 700 kW_e

Japan – Masumoto (first NOTAR in Asia)

- Commissioning Q3 2023
- Plant aimed at testing different types of biomass
- Biomass with higher ashes content

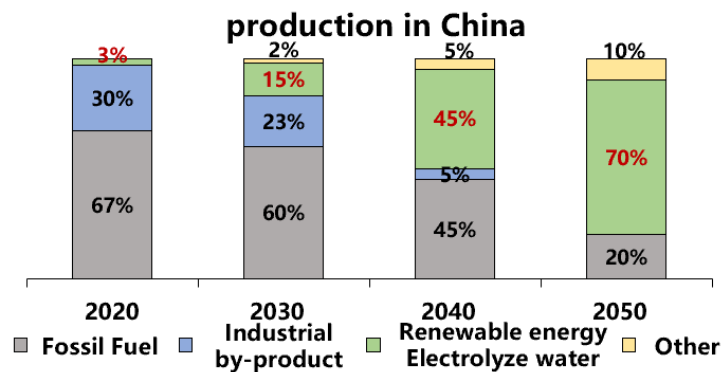
China, Guanyi Chen, Tianjin University

Policy frame and background information were presented. Large amount of biomass/wastes are currently still not well used and even treated in rural area e.g. MSW, agricultural waste and forest residues and industrial solid waste.

Gasification is a re-growing interest in China because of gas demand.

The presentation was this time focused on renewable hydrogen production through gasification.

Structure and prediction of hydrogen



There are several ways how to produce hydrogen through gasification:

1. High temperature gasification (water-gas shift)
2. Tar/volatiles reforming for hydrogen-rich syngas production
3. Steam/oxygen gasification
4. Supercritical water gasification
5. Plasma gasification for hydrogen-rich syngas production

Actual demo projects in China

In total, less than 10 plants of biomass gasification for hydrogen production are running in China. Several plants are in preparation

No.	Location	Company	Description
1	Dangtu, Ma' Anshan, Anhui (2022.10 - today)	China Datang Co. Ltd.	• Biomass pellet gasification-chemical looping for hydrogen generation (H_2: 10~18%). • Downdraft gasifier with the feedstock of 15 kg/h. • Hydrogen-Heat-Electricity (Energy efficiency: >57%)
2	Fangshan, Beijing (2022.8 - today)	China National Chemical Engineering Co., Ltd. (CNCEC)/ WUHUAN Engineering Co., Ltd	• MSW (biomass, Stale MSW, oil sludge, etc) high-temperature gasification • Handling capacity: 2 tons/day of feedstock • 2000m² for gasification plant • Syngas and vitreous product • Hydrogen purity can reach 99%
3	Nantong, Jiangsu (in preparation)	Jin Tong Ling Technology Group Co.Ltd	• Straw high temperature and ultra-high pressure heat and power cogeneration project (30MW) • Handling capacity: 300000 tons/year • Heat-power-fertilizer-hydrogen(0.1 billion m³/year)
4	Pianguan, Shanxi	Invite tenders	• Total investment is 4.500 million yuan

Future of hydrogen production:

1. Bio-oil reforming for hydrogen (pyrolysis, gasification)
2. High moisture content waste for hydrogen
3. Chemical looping gasification for hydrogen

Gasification for hydrogen production at TJU and TJUC

1. Microwave tar reforming
2. Microwave tar reforming – toluene cracking

3. Microwave tar reforming – NEA of actual gasification case
4. Chemical looping gasification with oxygen uncoupling
5. Catalytic reforming of biogas slurry/residues for hydrogen
6. Catalytic reforming of aqueous phase oil for hydrogen
7. Catalytic reforming of landfill leachate for hydrogen

All the pathways are nearly described in the CR update (available online).

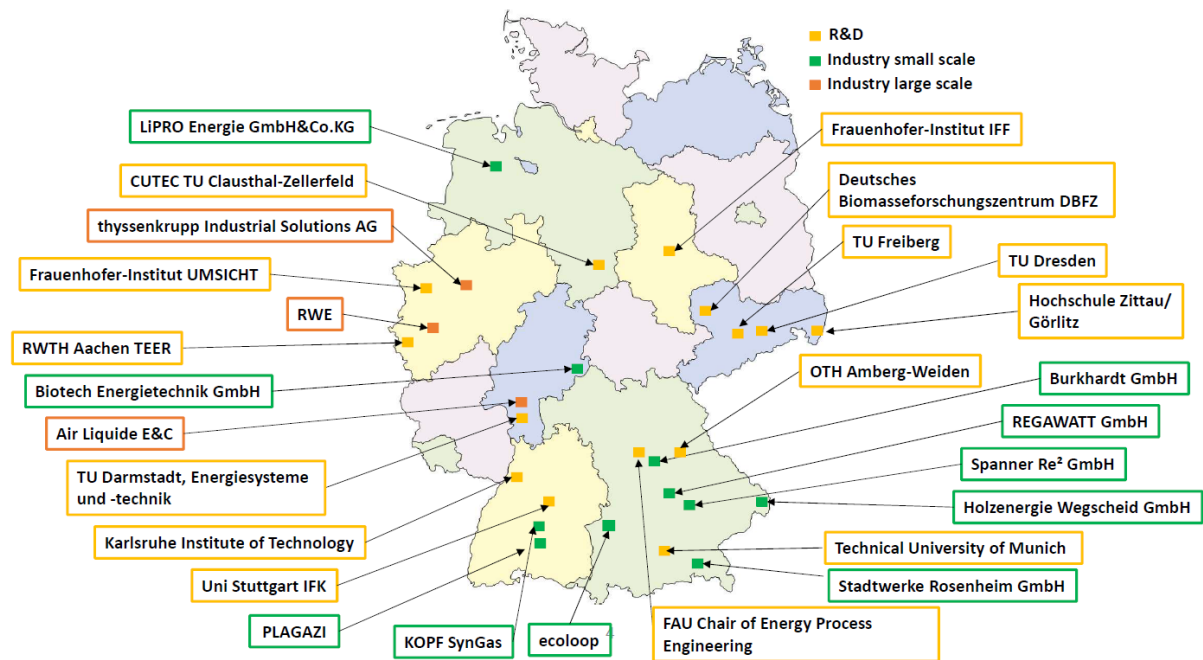
All the Task members were invited to take part in the conference.



Germany, Sabine Fleck, KIT

Statistics regarding GHG savings as well as renewable energy for el. power were presented. Information regarding nuclear phaseout was presented.

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

- Status April 2023:

- After Buy Off plant in batch operation.
Contractual relationship:
Stadtentwässerung is owner of the plant
Kopf SynGas responsible for maintenance, service and plant operation with own personnel
- Deficiency of precipitant as consequence of Ukraine crisis and generally reduced amount of sewage sludge lead to deficiency of fuel and discontinuous operation.
- Plant shall be adapted for acceptance of external sewage sludge to meet with the fuel deficiency

Blue Energy CHP

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

still no progress

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 campaigns with coal executed February, April and May 2022 for operation optimization
- Update April 2023
 - Last summer: problems with start up burner, cooling water pump and temperature measurements inside the gasifier
 - Max. duration of operation limited to 4 h (generally 1 to 1.5 h) before break-down of pneumatic conveying due to problems with pneumatic conveying of lignite powder, which could not be fluidized properly
 - New campaign in beginning of April with hard coal powder, better conditions for use of sewage sludge expected
 - Project ITZ-CC will be finished end of May 2023
 - Actual status will be reported at the workshop (Wednesday, April 18):
Talk: "Circular economy pilot plants and projects at the RWE Innovation Centre in Niederaußem"

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
- **Workshop presentation**

Bioliq

- New slag log commissioned successfully
- Experiments carried out to receive data for scale-up for model and technical slurries:
 - Glycol + glass beads (4.5 and 8.6 wt%)

- Increase in mineral content leads to increase in slag thickness for constant temperature
 - important for scale-up, as slag input per cooling screen area increases with reactor size
- Reducing stoichiometry leads to increase in slag thickness with low reduction in temperature
- Beechwood pyrolysis oil + 20 wt% beechwood char
 - Reduction of stoichiometry leads to increase in slag thickness
- Beechwood pyrolysis oil + 20 wt% miscanthus char
 - High ash content of 6 wt% and high ash melting temperature lead to increase in slag thickness and blocking of cooling screen mouth

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%. Ambitious target of 500 GW RES capacity by 2030.

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.

Bioenergy deployment

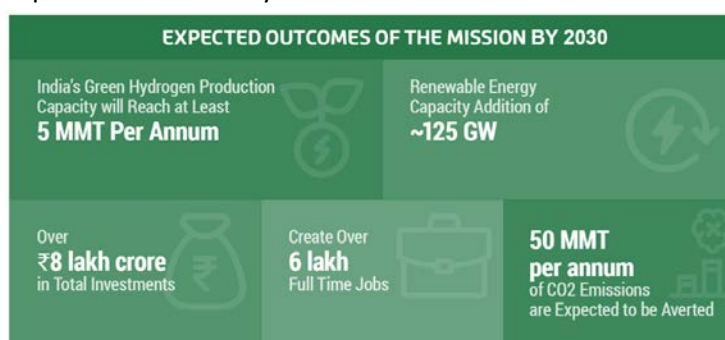
Electricity and heat energy	• Biomass gasification – electricity & thermal energy generation • Bagasse based cogeneration • Biomass co-firing in existing coal based power plants
Compressed Bio Gas (CBG)	• Sustainable Alternative Towards Affordable Transportation (SATAT) scheme launched by MoPNG in Oct'18 • PSU Oil Marketing Companies invite Expression of interest to procure CBG from potential entrepreneurs • As on 31st Mar'23, 4090 LOIs issued & 46 plants commissioned. CBG quantity sold – 16,164 tonnes
Bio-ethanol	• Second generation (2G) ethanol bio-refineries using cellulosic and lignocellulosic materials like rice/ wheat straw, corn cobs, cotton stalk etc. • PSUs Oil Companies are in the process of setting up 12 2G ethanol plants in various parts of the country • One 2G ethanol plant commissioned

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.

Central financial assistance under waste to energy scheme and biomass and biogas scheme were presented.

Update on National Green Hydrogen Mission

- Main objective of the mission – to make India global hub for production, usage & export of green hydrogen and its derivatives
- The mission will lead to significant decarbonisation of the economy and reduce dependence on fossil fuel imports
- Green hydrogen policy framed by GOI for implementation by all the concerned stakeholders
- Mission covers biomass-based hydrogen production systems. Hydrogen/ ammonia produced from biomass named as GREEN
- Proposed to initiate focused pilots to arrive at workable models for biomass based green hydrogen production
- Expected outcomes by 2030

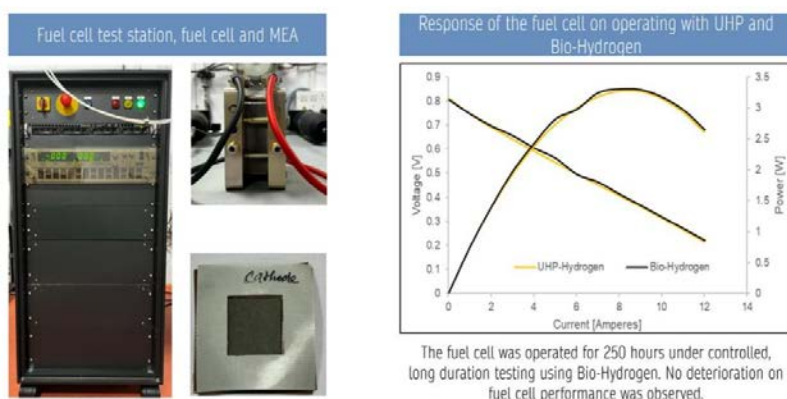


Update on biomass gasification-based hydrogen generation

- Indian Institute of Science and Indian Oil Corporation Ltd. jointly working on
- Development and demonstration of biomass gasification based hydrogen generation technology
- Generate fuel cell-grade hydrogen
- Down draft fixed bed gasification system with oxygen and steam
- Generated syngas subjected rigorous gas cleaning
- Vacuum pressure swing adsorption system

Demonstration of bio-hydrogen generation

- Optimization of oxy-steam biomass gasification process & vacuum pressure swing adsorption (VPSA) system completed
- Average hydrogen yield in syngas : 100 – 105 g/ kg biomass
- Hydrogen recovery in VPSA : 70 – 72%
- Demonstrated production of fuel cell grade bio-H₂ in a 5 kg/h H₂ generation system



Quantification of impurities specified under ISO were presented as well as ISO 14678 specifications.

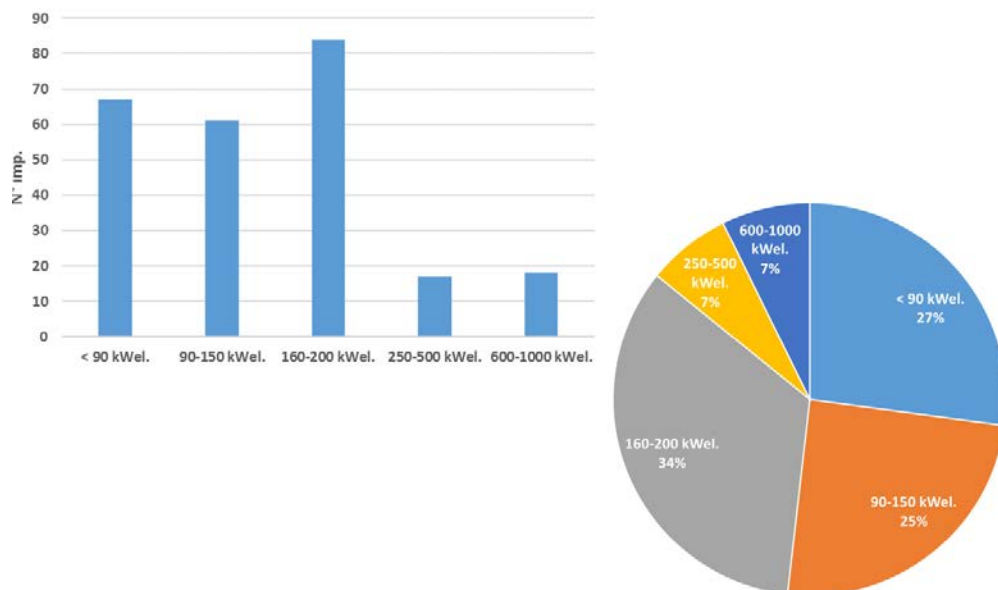
Italy, Donatella Barisano, ENEA

National Electricity Balance from 2016 to 2021 was presented as well as the Italian National Recovery and Resilience Plan.

Trend in the biomass gasification plants; nr. of units and installed power

Geographical Area	Region	N. Imp.							kWe						
		2016	2017	2018	2019	2020	2021	2022	2016	2017	2018	2019	2020	2021	2022
Northern Italy	Trentino Alto Adige	49	56	70	68	62	62	60	9782	10631	13249	12924	11338	11338	11120
	Friuli	6	15	18	16	9	9	9	1975	4924	7866	7466	2890	2890	2890
	Veneto	11	19	22	22	22	22	22	1723	2279	2875	2875	2875	2875	2875
	Lombardia	9	15	17	17	17	17	17	2489	5058	6798	6798	6798	6798	6798
	Piemonte	19	20	31	30	25	25	25	5408	5991	7759	7714	5995	5995	5995
	Emilia Romagna	11	14	17	16	16	16	17	2597	3209	4434	3934	3934	3934	4059
	Valle d'aosta	1	1	1	1	1	1	1	49	49	49	49	49	49	49
	Liguria	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Central Italy	Toscana	14	17	23	23	21	21	21	2259	2526	4489	4489	4370	4370	4370
	Umbria	8	14	16	16	16	16	16	1445	2095	2344	2344	2344	2344	2344
	Lazio	7	12	13	13	13	13	13	573	1716	1915	1915	1915	1915	1915
	Marche	4	8	8	8	8	8	8	283	804	804	804	804	804	804
Southern Italy and islands	Abruzzo	1	4	4	3	3	3	3	45	249	249	194	194	194	194
	Basilicata	2	1	2	2	2	2	2	399	199	399	399	399	399	399
	Calabria	1	4	7	7	7	7	7	45	315	764	764	764	764	764
	Campania	3	7	11	9	9	9	9	342	1303	2002	1614	1614	1614	1614
	Molise	0	1	1	1	1	1	1	0	22	20	20	20	20	20
	Puglia	3	3	3	3	4	4	4	425	325	325	325	524	524	524
	Sardegna	1	4	5	5	5	5	5	90	583	903	903	903	903	903
	Sicilia	2	3	7	7	7	7	7	1049	1248	1143	1143	1143	1143	1143
Total		152	218	276	267	248	248	247	30978	43526	58387	56674	48873	48873	48780

Number of gasification plants vs power distribution



Netherlands, Berend Vreugdenhil, TNO

Gasification activities in the NL



Stercore

- Manure to green gas & bio-based carbon factory

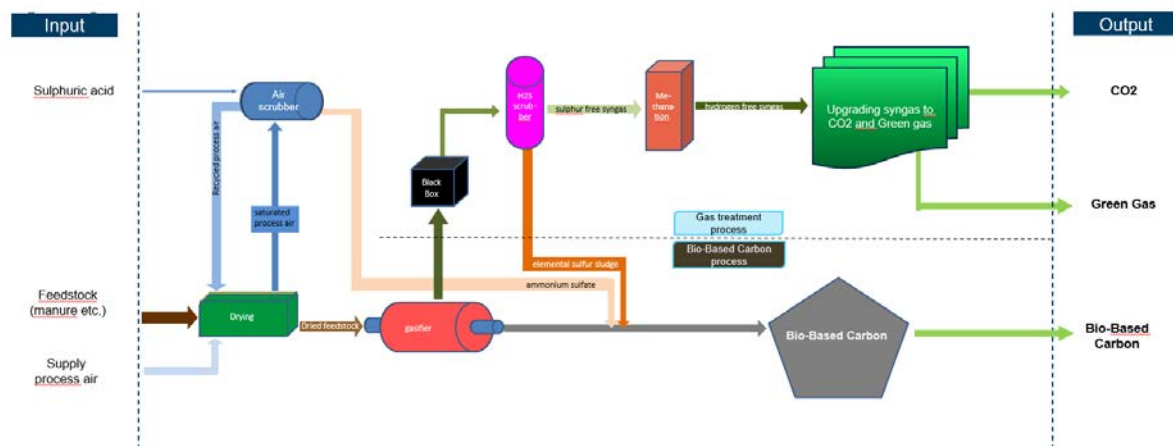
Process flow



Products

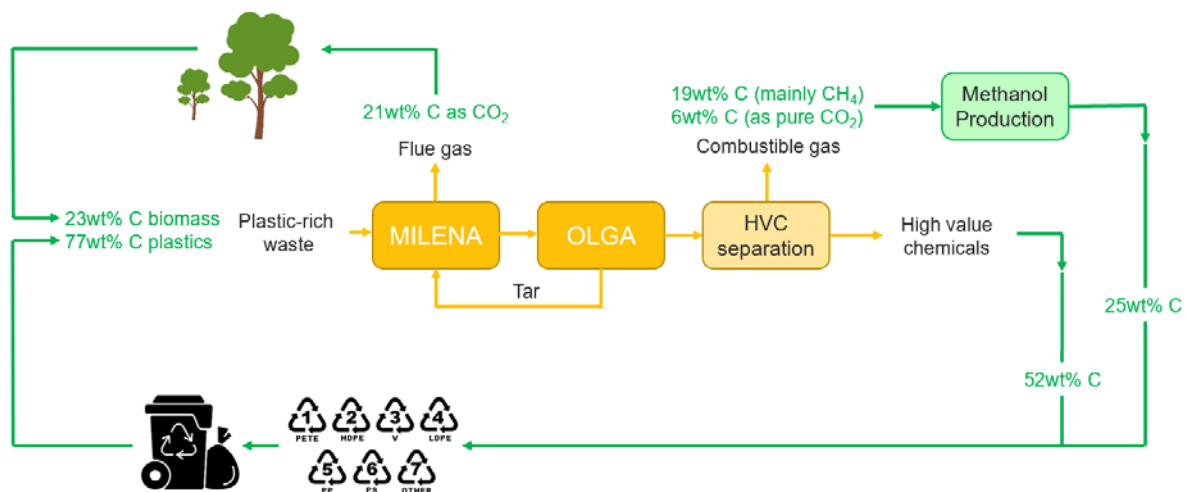


Detailed technical process flow



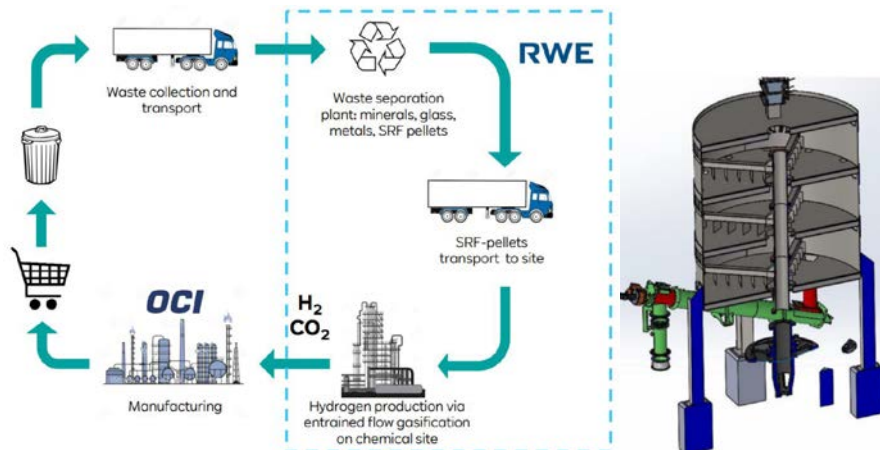
SYNOVA

- Plastic recycling



- Commercial plant in Canada (Edmonton)
 - o 90 MWth producing IMPCA methanol and ASTM ethanol
- Rotterdam, NL

FUREC RWE



- Waste-2-hydrogen
- “fuse, reuse, recycle”
- Design basics and next steps – multiple hearth furnace pilot plant
 - Low temperature pyrolysis of lumpy feedstock at 260-320°C in order to enable grinding of fuels like biomass or pelletized RDF

HoSt

- Large Bioenergy company in the Netherlands. Active in the field of digesters and gasifiers. Past years mainly on digestion, combustion, CO2 capture and gas upgrading.
- Recently entered the hydrogen market by purchasing Hygear, now SMR, PSA, electrolysis and hydrogen recovery part of the portfolio.
- Two important projects running
 - Developing MeOH reactor technology
 - Refurbishing an existing CFB gasifier to O2/H2O blown gasification for SNG production
- Well-equipped company capable of delivering turn-key solutions from gasification, cleaning to end-product

NettEnergy

- Turning side road grass into hydrogen and biochar.
- Pilot technology

Gasunie

- Still supporting the SNG projects in the Netherlands, actively supporting projects to realise the Dutch 2 bcm ambition. Involved in:
 - SCW Systems
 - Torrgas
- Gasunie and Perpetual Next formed a Joint Venture to be able to better support the market introduction of Green Gas / Syngas platforms.

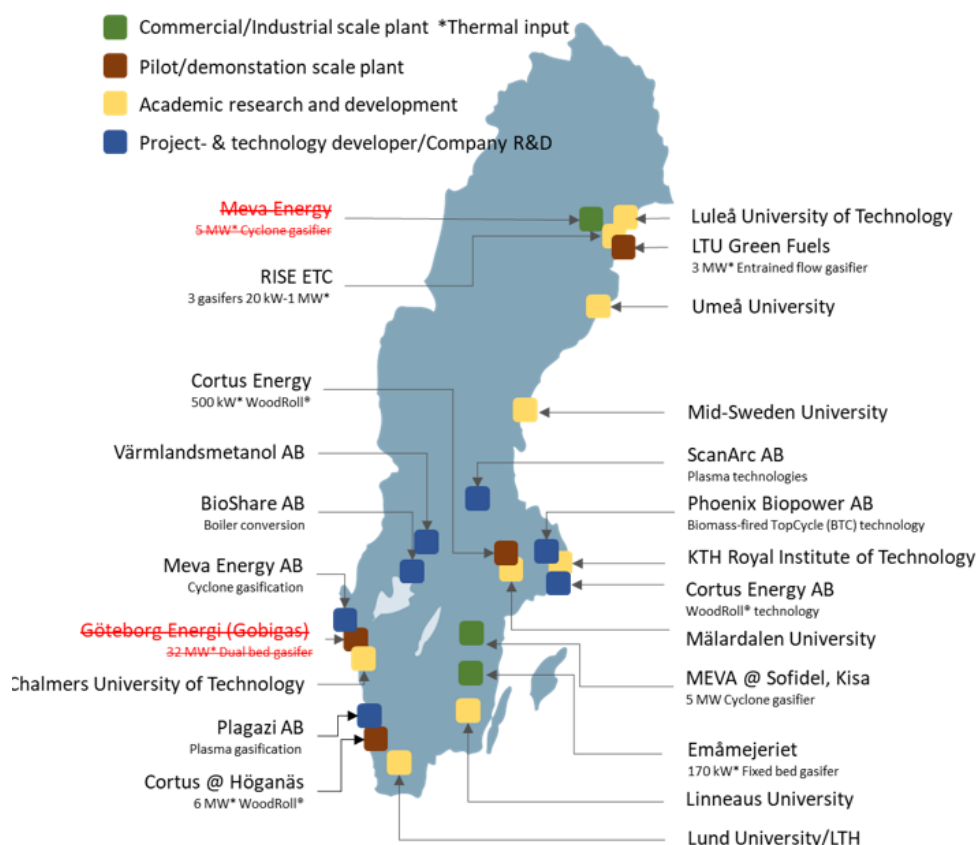
SCW

- Produced SNG based on super critical water gasification

Sweden, Joakim Lundgren, LTU

Share of energy from renewable sources in 2021 was presented.
Total final energy use in Sweden was presented.

Status on gasification



Commercial gasification projects – update

Cortus 6 MW WoodRoll® gasifier at the Höganäs steel plant

- Integrated operation with maximum energy recovery* during 7 days of continuous syngas production (MS3) was achieved in Oct 22.
- The next step is to replace natural gas in a band furnace.
- The radiation tubes for the burners had to be replaced, primarily due to the non-continuous operation.
- Currently, the plant re-start is in progress

* more than 90% of the energy comes from pyrolysis gas

Other Cortus WoodRoll® news

- Cortus AB has received an order for the installation of ceramic lining for a new 0.5 MW WoodRoll® gasifier under construction at the German company Holzner Druckbehälter. Delivery summer of 2023.

- A WoodRoll® gasifier placed in Bayern will be combined with a hydrolysis unit from blueFLUX. Planned start of this facility is the end of Q3, 2023.
- Engineering study for a future plant for green diesel production with the Norwegian company Biojet AS.
 - Planned plant capacity = 750 tonnes of biomass per day = several parallel WoodRoll® needed (20 times larger than Höganäs).
- A term sheet (preliminary agreement) with the Norwegian company Glocal Green AS on gasification of forest residues for the production of renewable methanol for shipping.
- An engineering study on a 6 MW WoodRoll® gasifier in Ireland for RNG-production has recently been delivered.

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
- Renewable gas (4.2 MW) for tissue drying at Sofidelmill in Kisa, Sweden
 - Currently testing water system and monitoring instruments
 - First gas deliveries planned in May 2023
 - Fall 23 and Spring 24, plant optimization and evaluations
- Low value wood residue to renewable gas and power (2.4 MW) at IKEA Industry production unit in Zbaszynek, Poland
 - 2*1220 kg/h fuel (twin gas trains with shared auxiliary systems)
 - 1.2 + 1.2 = 2.4 MW of green electricity, possibly use of residual heat for heating Ikea's nearby buildings
 - Initial process design work completed, now detailed design
 - Start procurement of time-critical equipment in spring 2023 with start-up of the facility Q3-Q4 2024
 - Environmental impact assessment in progress

Uniper and Sasol ecoFT – SkyFuelH2

- Sasol ecoFT has signed a Lolwith 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
- Proposal for a feasibility study recently submitted to the Swedish Energy Agency
- Ambition to start construction in 2024 and fuel deliveries 2026.

Plagazi AB

- PlagaziAB has a concept for transforming waste into hydrogen through plasma gasification.
- Several new projects are announced:
 - Köping Hydrogen Park -Three Plagaziplants to recycle 66.000 tonnesof 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 EnergienPremnitz

- LOI with WIRTZ Energie+ MineralölGmbH with the intent to form a long-term offtake agreement of 4 000 tons of hydrogen
 - Planned start Q2, 2023

BIOSHARE

- BioShare's technology enables additional products in addition to heat and power.
- Their fluidized bed solutions can be applied utilizing separate bed material or share bed material with a boiler.

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
- **New project granted by SEA - BioPower2023**
 - Continued development of the BTC technology.
 - Validate the technology for robust and flexible operations with low quality fuels.
- **Two pre-feasibility studies for demonstration plants operating with mixtures of waste wood and forest residues (Sweden) and energy crops (UK).**
- **Collaboration with Zorya-Mashpoekt (UA) on Top Cycle gas turbine**
- **First commercial plant commissioned by 2029**

Selected gasification R&D projects

- Initiative on bio-e-methanol (based on work in LTU Biosyngas programme)
- Circular and renewable feedstocks to the Swedish chemical industry (gasification of pyrolysis liquid)
- From forest residues to sustainable aviation fuels (RE-SAF)

FerroSilva

- Project funded by the Swedish Energy Agency and an industrial and research consortium,
- Techno-economic conditions for production of sponge iron (DRI)
 - Several options for integrating the production of biogenic syngas with a reduction process with high utilization of the top gas of the DR-process
 - Great GHG-performance –CO₂-sink with CCS
 - Reduction with syngas from biomass seems competitive against all other current alternatives under Swedish conditions.
- The next step is to build a demonstration plant of 50 ktonDRI
- No updates

Large-scale production of biocarbon as renewable feedstock in fossil-free value chains within the iron and steel industry

- Aim: Develop a reactor concept enabling large-scale production of biocarbon and which can be integrated into existing fluidized bed boilers.
- 2022-2026 - funded by Swedish Energy Agency
- Partners: Chalmers, Luleå University of Technology, RISE, BioShare, E.ON, Höganäs, SSAB

Catalytic steam reforming of tar and methane at high pressure for H₂ production

- Increased the understanding of catalytic steam tar and hydrocarbon reforming of biomass gasification raw gas at pressurized conditions (10-20 bar)
 - Tests to be performed in collaboration with Topsoe A/S and Phoenix BioPower AB
Determine relevant operational conditions based on gas composition
 - Focus monolithic catalyst
 - Test campaigns planned for May-June and August 2023

UK, Massimiliano Materazzi, Aston University

UK Biomass relevant programmes:

- Net Zero Innovation Portfolio (NZIP); 2021
 - Biomass feedstock innovation programme; 2022
 - UK Hydrogen BECCS Innovation programme; 2023
- UK Biomass strategy; to be published soon

UK industry updates

Altalto Immingham Waste to Sustainable Aviation Fuel Project

- Plan to build Europe's first waste-to-SAF plant
- 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
- December 2022: Altalto was awarded a grant of up to £27 million by the UK Department for Transport ("DfT"), subject to matched funding, to deliver the Front-End Engineering Design stage of the project, ahead of construction to begin in 2025.
- The plant is expected to be operational in 2028 and produce 37.4kt/y of SAF when at full operational capacity.

KEW Technology, Wednesbury, UK

- BEIS NZIP Industrial fuel switching awarded: Kew & NSG Pilkington's Modular approach to decarbonisation of energy (MADE) for glass project.
- Developing an industrial co-location solution using modular advanced gasification units to provide syngas as a pressurised natural gas substitute to reduce consumption of carbon-intensive natural gas.
- Aims to decarbonise the glass production process and achieve a 30% reduction of on-site emissions by 2030.

ABSL, Swindon

- First facility in the world to convert household waste into grid-quality bioSNG.
- The waste is first conveyed to an oxy-steam fluidised bed gasifier to produce a dirty syngas. This gas is then treated in a plasma reformer to convert tars and melt ashes.
- Construction of the plant is complete. Cold and wet commissioning is also complete and the plant will be fully operational in 2023.
- Once operational, the plant will be a template for large scale commercial facilities
 - PROTOS facility

- The facility will be able to treat 133,000 tonnes of waste each year to produce biohydrogen and biomethane, while capturing the CO₂ with no polluting emissions to air and no particulate or dioxin emissions.

ABSL and UCL have been awarded a £4.8m grant from the DAC and Greenhouse Gas Removal Innovation Programme, Phase 2 of the competition launched by BEIS for developing pilot plants for hydrogen production and CCS.

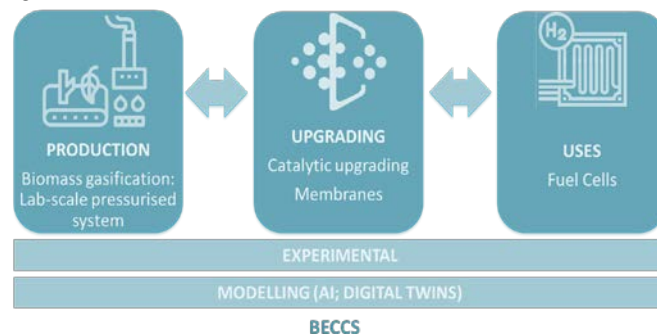
UK ongoing projects

HyDEX (Hydrogen Development and knowledge Exchange)

- a three-year programme with eight universities which are all associated with the Midlands-based Energy Research Accelerator (ERA); including Aston University.
- Each partner is making their hydrogen facilities, research capabilities and expertise available to businesses in order to accelerate innovation in hydrogen.
- Aston University: High-hydrogen syngas & Fuel cell applications

EBRI, Aston University

- has received ~£0.5M funds from the Wolfson foundation to acquire a lab-scale pressurised gasifier, a membrane reactor and a fuel cell.
- The gasifier: fluidised bed, capacity of up to 250 g/h, up to 10 bar pressures.
- To undertake experimental studies on catalytic gasification and syngas production. To be operational in 2024.



- Development of CO₂ guidelines
 - 6-month project led by Aston University (PI: P. Blanco), in joint with Progressive Energy & The Energy Institute
 - Work on the development of guidelines for CO₂ measurements, including streams with diverse impurities. Current gap in this area.
 - Will be useful for diverse stream containing CO₂ (including syngas) and applicable for diverse sectors looking at decarbonisation.

USA, Robert Baldwin, NREL

Bioenergy in the USA was presented.

Fulcrum Bioenergy/Sierra Biofuels:

- Fulcrum Bioenergy/Sierra Biofuels, Reno NV: (11MM GPY nameplate)
- MRF operational since 2016; at landfill 10 miles from biorefinery
- 350,000 tons per year raw MSW => 175,000 tons per year prepared MSW

- 120 TPH throughput
- Gasification/FT
- MSW feedstock/TRI indirectly heated fluid bed steam reforming gasifier
- Johnson Matthey DAVY™/BP fixed-bed FT (CANS reactor)
- Phase I is for Fischer-Tropsch wax
- Wax to be refined by Marathon
- 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'; scale up (3X) planned with parallel trains
- 12 new projects currently planned/underway
- **Status: First gallon of product in December, 2022; plant now ramping up to full operation**



Red Rock Bio

- **Project cancelled**

Other commercialization activities

New DG Fuels

- 12,000 BPD renewable fuels (primarily SAF) project announced
- Gasification/FT – few details provided
- Low CI products with extensive renewable hydrogen (and oxygen) utilization and CO₂ abatement (CCS)
- First project announced in Louisiana

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

Arbor Renewable Gas, Beaumont TX

- Gasifier: SunGas Renewables, MTG: Haldor Topsøe
- Feedstock: woody biomass
- Product: 1 000BPD renew. Gasoline (MTG)
- Commercial production in 2024

Madera Gas, Houston TX

- Gasifier: SunGas Renewables, with CCS
- Feedstock: woody biomass 100 000 TPY
- Product: RNG (5B SCFY RNG)
- Status: construction on first train in 2023; operational in 2024

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, BA fuel offtaker
- Natchez Bayou Fuels: engineering unerway – start-up in 2027; SouthWest Airlines fuel offtaker

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
 - 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

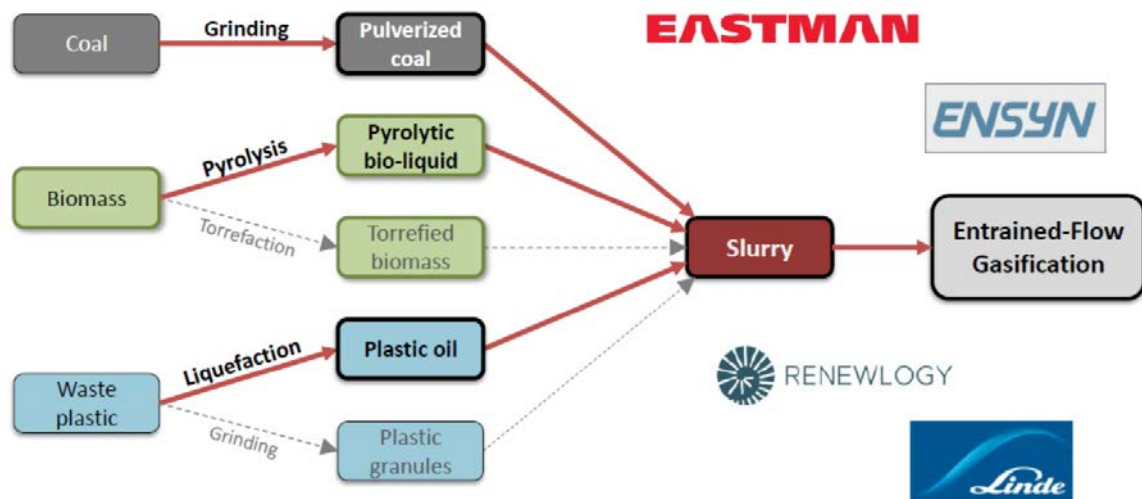
420KWe/D and biochar
Operational since 2017

Status: 3 projects operational (NJ, CA, TN)

Sierra Energy

- Gasifier: FastOx technology; blast furnace design (~2,200 °C)
- Feedstock: 20 MTD military waste + woody biomass
- Product: 500 KWhe electricity + 1 BBL/D FT diesel fuel
- Status: operational

R&D Highlights – University of Utah



The political climate

- DOE has issued a roadmap to stand up 4-5 operating biofuels demonstration plants (each at ~1M GPY) by 2030
 - SAF Grand Challenge: 3B GPY SAF is target by 2030; 35B GPY by 2050
 - Gasification + FT is included as a key technology pathway
- Biomass gasification now back in favor (sort of) => low carbon pathways
- BiPartisan Infrastructure Law (BIL) and Inflation Reduction Act (IRA) both have large investments in hydrogen
 - Hydrogen hubs (4 x \$2B each) now being competed
 - Deployment, not R&D
 - Nothing specific called out for biomass but low carbon hydrogen emphasized
- New Funding Agency => Office of Clean Energy Demonstrations
 - DOE/OCED; funding on the order of \$3B/yr
 - Mission => steel in the ground

END