IEA Bioenergy
Technology Collaboration Programme

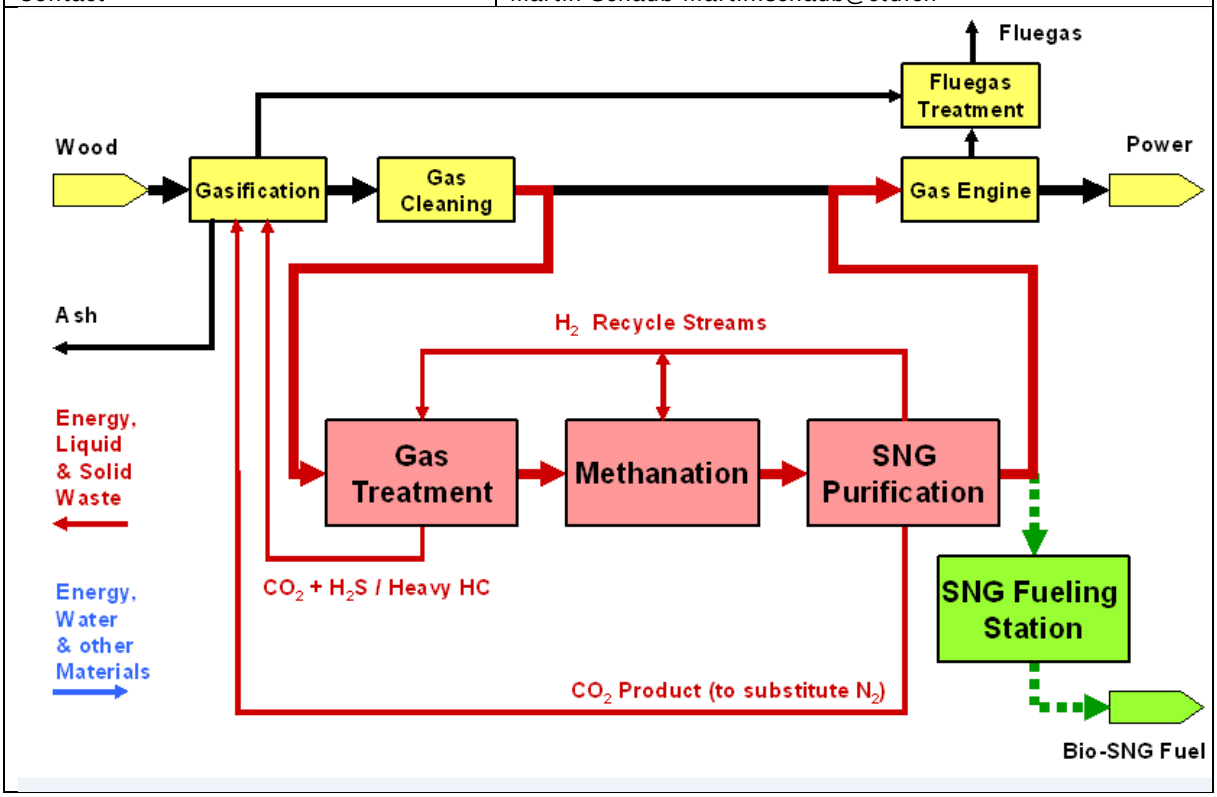
Status report on thermal gasification of biomass and waste 2021

Dr. Jitka Hrbek

Annex 4
Gasification facilities for fuel synthesis – Non-operational, historical (project cancelled before 2012), stopped while under construction, deconstructed, idle, on hold

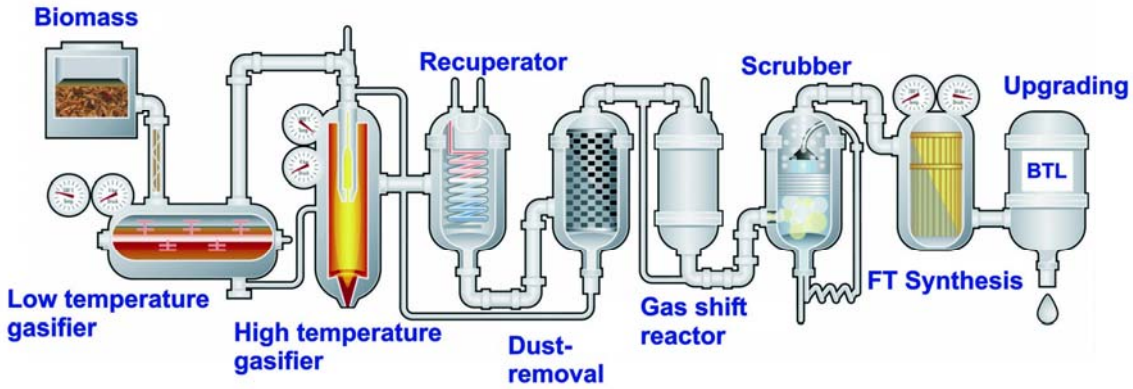
Project name	One Barrel per Day Pilot Plant
Project owner	Bioenergy 2020+
Status	On hold
Start up	2016
Country	Austria
City	Guessing
Type	TRL 4 - Demo
Technology	Fuel synthesis
Raw Material	Syngas from gasifier (50 m3/h)
Output Name	FT liquids
Output Capacity	53
Output 2 Unit	m3/y
Technology Brief	This pilot plant enabled to scale up from laboratory to pilot scale. In Guessing since 2005 research has been conducted at a biomass-based laboratory scale FT lab plant in the size of 10 LPD (liter per day) and valuable insights into the topics of gas purification and processing, long-term stability of FT catalysts, design of slurry reactors and product separation as well as fractionation have been gained. The collected findings have been incorporated into the planning of this pilot plant. The pilot scale represents an important if not the most important milestone on the way to a demonstration facility. The pilot plant consists of a gas cleaning section for purifying the synthesis gas to sulfur levels less than 10 ppbv. The gas is cleaned from aromatic compounds, sulfur, NH3 and water. The cleaned gas is subsequent compressed to a maximum pressure of 25 bar. The compressed gas enters the second part of the pilot plant, the synthesis part. H2 and CO are converted into a broad range from CH2-compounds ranging from C1 (methane) to more than C60.
Additional Information	https://www.bioenergy2020.eu/de/kompetenzbereiche/alle_projekte/view/394
Contact	Email: gerald.weber@bioenergy2020.euPhone: + 43 (0) 3322 42606-154 , reinhard.rauch@kit.edu

Project name	Synthesis Demo Guessing
Project owner	Bio SNG Guessing
Status	Operational
Start up	2008
Country	Austria
City	Guessing
Type	TRL 6-7 Demonstration
Technology	Fuel synthesis
Raw Material	Lignocellulosic crops
Input 1 Name	Syngas from gasifier (FICFB Guessing)
Input 1 Capacity	350
Input 1Unit	m3/y
Output 1 Name	SNG
Output 1 Capacity	576
Output 1Unit	t/y
Partners	Vienna University of Technology, Austria; Paul Scherrer Institute, Switzerland; Repotec, Austria
Contact	Martin Schaub martin.schaub@ctu.ch

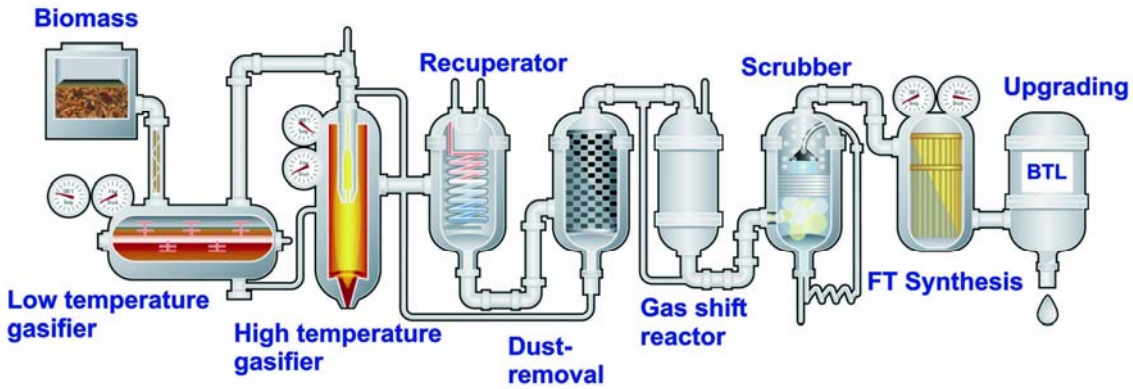


Project name	BioDME
Project owner	Chemrec AB
Status	Idle
Start up	2011
Country	Sweden
City	Piteå
Type	TRL 4 - pilot
Technology	Fuel synthesis
Raw Material	Lignocellulosics
Input 1 Name	Black liquor gasification
Input 1 Capacity	20
Input 1Unit	t/d
Output 1 Name	DME
Output 1 Capacity	1 800
Output 1Unit	t/y
Total investmenst	EUR 28 500 000
Technology brief	The project was cancelled in 2012. The recovery boiler in the paper mill is replaced or supplemented by a gasification based fuel generating and pulp mill cooking chemicals recovery system. The BioDME pilot is an integrated part of heavy DME fuelled vehicle fleet trials.
Partners	AB Volvo, Haldor-Topsoe, Preem, Total, Delphi, ETC
Contact	Patrik Lownertz patrik.lownertz@chemrec.se

Project name	Synthesis CHOREN alpha plant Freiberg
Project owner	CHOREN Industries GmbH
Status	Idle
Start up	2002
Country	Germany
City	Freiberg
Type	TRL 4-5 Pilot
Technology	Synthesis
Raw Material	Lignocellulosic biomass
Output 1 Name	FT liquids
Output 1 Capacity	53
Output 1Unit	t/y
Contact	info@choren.com +49 3731 2662 0



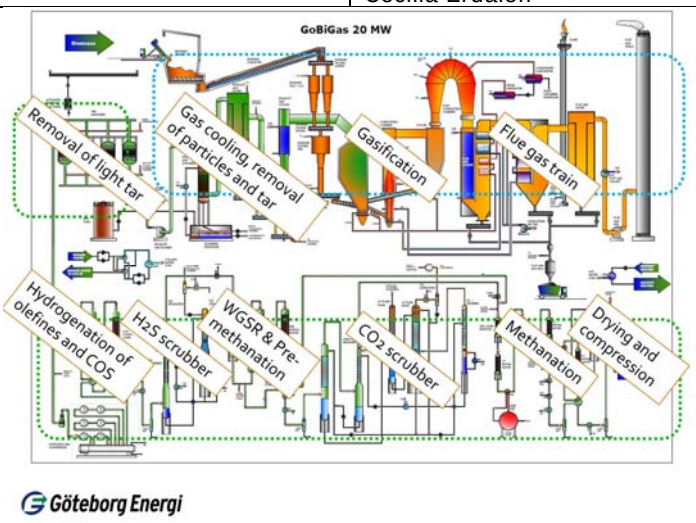
Project name	Synthesis CHOREN beta plant Freiberg
Project owner	CHOREN Fuel Freiberg GmbH
Status	Idle (project cancelled before 2012)
Start up	2002
Country	Germany
City	Freiberg
Type	TRL 6-7 demo
Technology	Synthesis
Raw Material	Lignocellulosic biomass
Input	dry wood chips from recycled wood and residual forestry wood; additionally in the future fast growing wood from short-rotation crops
Output 1 Name	FT liquids
Output 1 Capacity	13 500
Output 1Unit	t/y
Total investment	EUR 190 000 000
Contact	info@choren.com +49 3731 2662 0



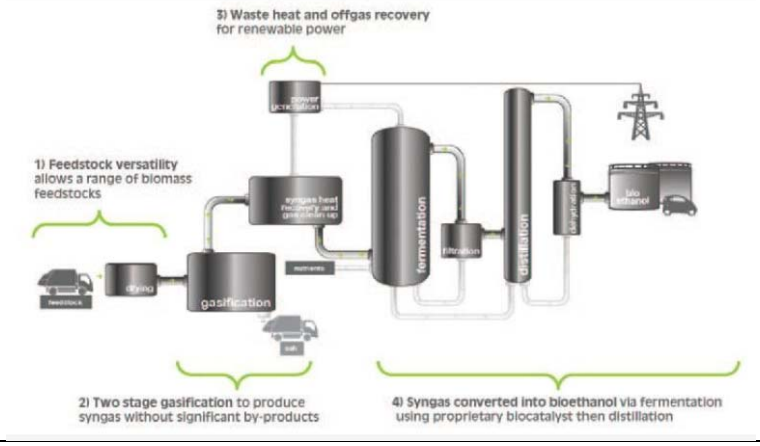
Project name	Synthesis CHOREN sigma plant Schwedt
Project owner	CHOREN Industries GmbH
Status	Stopped while under construction
Start up	
Country	Germany
City	Schwedt
Type	TRL 8 First-of-a-kind commerial demo
Technology	Fuel synthesis
Raw Material	Lignocellulosic crops
Input 1 Name	Dry wood chips from recycled wood; fast growing wood from short-rotation crops
Output 1 Name	FT liquids
Output 1 Capacity	200 000
Output 1Unit	t/y
Contact	info@choren.com +49 3731 2662 0

Project name	Project Genesis
Project owner	Cool Planet
Status	historical (project cancelled before 2012)
Country	USA
City	Alexandria, LA
Type	TRL 8 First-of-a-kind commercial
Technology	Fuel Synthesis
Raw Material	forest residues
Input 1	wood residues
Output 1	gasoline-type fuels (30,000 t/y)
Funding	USD 91,000,000
Partners	State of Louisiana
Additional Information	proceeding for biochar production
Contact	Wes Bolsen info@coolplanet.com

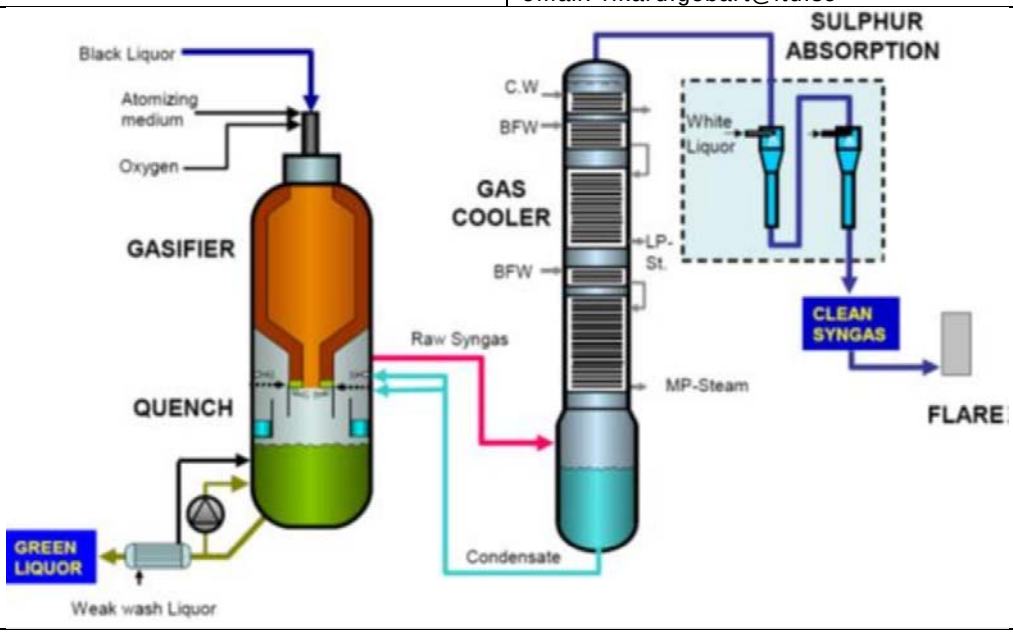
Project name	Bio2G
Project owner	E.ON Gasification Development AB
Status	idle
Start up	
Country	Sweden
City	Scania province
Type	TRL 9 Commercial
Technology	Fuel Synthesis
Raw Material	Other
Input 1 Name	Woody Biomass
Input 1 Capacity	300
Input 1Unit	MW
Output 1 Name	SNG / bio-methane
Output 1 Capacity	200
Output 1Unit	MW
Output 2 Name	Heat
Output 2 Capacity	50
Output 2 Unit	MWth
Partners	Partners in the technical and project development phase has been Andritz Carbona Oy and Haldor Topsoe AS
Technology Brief	The technology selected for the gasification system is based on pressurised oxygen blown gasification in a fludized bed followed by hot gas cleaning (tar reforming, HAT filter), cold gas cleaning (water scrubber, acid gas removal), compression, WGS and synthesis of methane.
Contact	Björn Fredriksson-Möller +46 40 255 716 email: bjorn.moller@eon.se

Project name	GoBiGas (phase I)
Project owner	Goeteborg Energi
Status	idle
Start up	2014
Country	Sweden
City	Ryahamnen, Göteborg
Type	TRL 8 First-of-a-kind commercial demo
Technology	Fuel Synthesis
Raw Material	Lignocellulosic crops
Output 1 Name	SNG
Output 1 Capacity	11 200
Output 1Unit	t/y
Output 2 Name	Heat
Output 2 Capacity	5
Output 2 Unit	MWth
Output 3 Name	Power (electricity)
Output Capacity	6
Output Unit	MWel
Partners	Repotec, Metso Power, Jacobs Process, Haldor Topsoe
Total investment	EUR 150 000 000
Technology Brief	The gasification technology is based on the Repotec indirect gasification, which is supplemented by gas upgrading and SNG synthesis. Goteborg Energi decided to divest the plant in 2017, and this process is on-going.
Additional Information	http://gobigas.goteborgenergi.se/
Contact	Cecilia Erdalen
	

Project name	Synthesis INEOS Plant Vero Beach
Project owner	INEOS New Planet BioEnergy
Status	Idle
Start up	2012
Country	USA
City	Vero Beach, FL
Type	TRL 4-5 Pilot
Technology	Fuel Synthesis
Raw Material	other
Input 1	Vegetative waste, MSW (300 t/d)
Output 1	cellulosic ethanol (3.469 m3/h)
Output 2	power (electricity) (6 MWel)
Partners	INEOS Bio, New Planet Energy, EPC firm AMEC
Technology Brief	The process consists of four stages, which include gasification, fermentation, purification and power generation. In the first step, the biomass is fed into a gasification chamber which results in the production of syngas. This step results in negligible by-products, such as ash, which are sent to a nearby landfill to be used as daily ground cover. The most important step of the process is the anaerobic fermentation of the gases produced during gasification. In this step, naturally occurring bacteria transform the gases into ethanol. Purification of the ethanol is then carried out by distillation. The purified ethanol is sold as fuel for transportation. The final step includes collection of waste heat and off-gas recovery. These gases are fed into a steam turbine to produce renewable power.



Project name	DP1+DME pilot
Project owner	LTU Green Fuels
Status	On hold
Start up	2011
Country	Sweden
City	Pitea
Type	TRL 4-5 Pilot
Technology	Fuel Synthesis
Raw Material	Other
Input 1 Name	Black Liquor
Input 2 Name	Pyrolysis oil (co-gasification with black liquor)
Output 1 Name	Clean Syngas
Output 1 Capacity	2
Output 1Unit	MW
Output 2 Name	DME
Output 2 Capacity	4
Output 2 Unit	t/d
Output 3 Name	Methanol
Output 3 Capacity	4
Output 3 Unit	t/d
Partners	For the Biosyngas program the partners are Chemrec AB, Haldor Topsöe, Volvo Truck, Preem, Smurfit Kappa, Sveaskog, Perstorp, Södra, Holmen, Flogas and ETC.
Technology Brief	The Chemrec process uses a refractory-lined entrained bed reactor in which concentrated black liquor (or black liquor + pyrolysis oil) is gasified under reducing conditions at around 1000°C. The liquor is decomposed in the reaction zone into melt droplets consisting of sodium compounds, and a combustible gas containing H2 and CO. The melt droplets and the combustible gas are separated in a quench dissolver where they are simultaneously brought into direct contact with a cooling liquid. The melt droplets dissolve in the liquid to form a green liquor solution. The gas leaving the quench dissolver is cooled producing steam. The cooling is done in counter current mode which means that the gas is efficiently washed of particulate matter. The gas is then free of melt droplets and can be scrubbed for H2S removal and then used as a clean fuel or syngas. The DME pilot was installed in 2011. Since the end of the Chemrec BLG program and the Bio-DME project in 2012, an industrially co-funded 160 MSEK R&D program was initiated in 2014 with the obejct ive of widening the fuel basis, develop new synthesis gas cleaning and synthesis reactror and catalyst technologies
Additional information	Until May 2016 the plant has been operating as follows: • Entrained flow gasifier: 27 000 hours, most of the time with pressure close to 30 bar and fuel flow rate corresponding to 3 MWth. The oxidant has after initial optimization been nearly 100% oxygen (and small amounts of nitrogen for safety and purging purposes). In the spring of 2016 we co-gasified pyrolysis oil with black liquor for over 1000 hours. The pyrolysis oil came from two commercial plants in Finland (Fortum) and Holland (Empyro) and was transported in trucks to Piteå, Sweden. • Downstream syngas train: 12

	000 hours, more than 1000 ton DME. In the last few months of operation we extracted slightly more than 50 ton raw methanol for testing purposes. The DME and methanol has been used in field tests by partners Volvo Trucks, Flogas and Perstorp.
Contact	Rikard Gebart ph: +46 920492196 email: rikard.gebart@ltu.se
	

Project name	Synthesis TUBITAK MRC Kocaeli
Project owner	TUBITAK MRC - ENERGY INSTITUTE - TURKEY
Status	Idle
Start up	2009
Country	Turkey
City	Kocaeli
Type	TRL 4-5 Pilot
Technology	Fuel Synthesis
Raw Material	Biomass / biomass coal blends
Output 1 Name	SNG
Output 1 Capacity	0,2
Output 1Unit	MW
Partners	Nationally Funded Project
Technology Brief	Down draft fixed bed gasifier
Contact	Synthesis Kocaeli Mr. Alper Unlu

Project name	FT pilot Guessing
Project owner	Vienna University of Technology / BIOENERGY 2020+
Status	On hold
Start up	2005
Country	Austria
City	Guessing
Type	TRL 4-5 Pilot
Technology	Fuel synthesis
Raw Material	Syngas from FICFB Gasifier
Output 1 Name	FT liquids
Output 1 Capacity	5
Output 1Unit	kg/day
Output additional Information	Raw FT product 5 kg/d
Technology Brief	Aim of the work is to convert the product gas (PG) of the Biomass gasification plant with a Fischer-Tropsch (FT) process to liquid fuels, especially to diesel. A FT-pilot plant is operated, which converts about 5 Nm3/h PG at 20bar in a Slurry reactor to FT-products. The gas cleaning of the raw PG consists of several steps and consists of wet scrubbers and dry adsorbers. As catalyst in the slurry reactor, iron and cobalt based catalyst are used. The results from a Cobalt catalysts give mainly an n-alkane distribution from C1 to compounds higher than C60 n-alkanes. The iron based catalysts give more alkenes and oxygenated compounds. The analyses of the diesel fraction from the distillation of the FT-raw product show that the obtained diesel from the Cobalt catalyst has cetan-numbers of about 80 and is free of sulphur and aromatics.
Contact	Reinhard.rauch@kit.edu