

Country Report Germany for IEA Task 33 Thermal Gasification of Biomass (Final 3)

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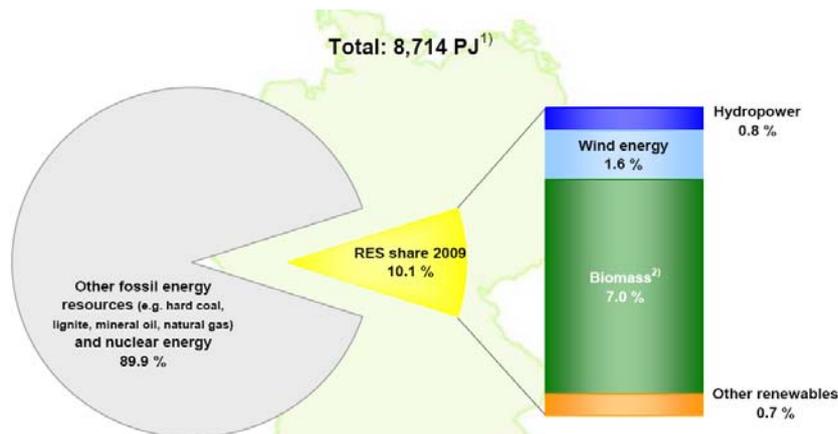
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Gasification technology for solid fuels (coal and lignite) has a long tradition in Germany [1]. German companies like Lurgi, Uhde and Siemens are working today on large scale gasification of primarily coal. Biomass is co-fired with coal in an IGCC-plant (Uhde), large scale biomass fired gasifiers are under development (Lurgi and Uhde). In the last 15 years a number of companies have started to develop and built small scale gasifiers for biomass.

This report gives an overview of the activities in biomass gasification (R&D and operation), the regulatory framework and the governmental supporting measures for Germany.

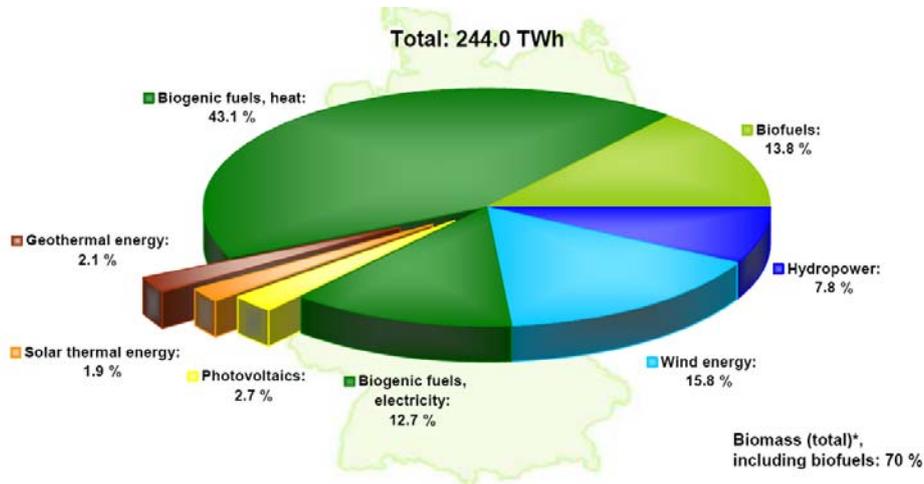
Policy & Supporting Measures

Renewable energy sources RES contribute with 10.1 % to final energy consumption in Germany, 2009 [2]. Biomass covers almost 7.0 % of Germany's final energy consumption [2]. The biogenic fuels are mainly used for heat (61.9 %) and electricity generation (18.3 %) in combustion processes. The rest (19.8 %) is used for production of first generation biofuels. No significant share of biomass is used in gasification technologies up to now.



¹⁾ Working Group on Energy Balances (AGEB); ²⁾ solid and liquid biomass, biogas, sewage and landfill gas, biogenic share of waste; deviations in the totals are due to rounding.
RES - Renewable Energy Sources; Source: BMU-KI III 1 based on Working Group on Renewable Energies-Statistics (AGEE-Stat) and the Centre for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW), according to AGEB, as at: September 2010; all figures provisional

Figure 1: Shares of renewable energy sources among total final energy demand in Germany 2009 [2]



* Solid and liquid biomass, biogas, sewage and landfill gas, biogenic share of waste and biofuels; deviations in the totals are due to rounding.
Source: BMU-KI III 1 according to Working Group on Renewable Energies-Statistics (AGEE-Stat), as at: September 2010; all figures provisional

Figure 2: Structure of final energy supply from renewable energy sources in Germany 2009 [2]

The technical potential for energy provision from biomass in Germany is in a range of about 1,210 -1,700 PJ/year in a medium to long term perspective under the assumption of constant food and feed production [3]. This is about 10-15 % of Germany's primary energy demand. The perspective is based on the use of biomass as whole plants and application of efficient technologies for heating, combined heat and power, second generation biofuels and biogas as fuel (Bio SNG).

The share of RES has to be increased significantly in the period up to 2020 in order to achieve the targets described in the "The EU Climate and Energy Package" announced in April 2009 [4] and in Germany's "Integrated Energy and Climate Change Programme (IEKP)" of August 2007 [5].

The targets concerning the use of biomass are laid down in the "National Biomass Action Plan for Germany", 2009 [6]:

- Increasing the share of renewable energy in electricity production to at least 30 % by 2020.
- Increasing the share of biofuels in overall fuel consumption to 7 % of net greenhouse gas reductions by 2020 (equivalent to approximately 12 % energy content).
- Increasing the share of RES-generated heat to 14 % by 2020.

In line with the "Integrated Energy and Climate Change Programme" 2007 [5] the following acts and rules regulate the subsidies for the use of biomass in Germany.

Concerning heat from biomass, Germany's "Renewable Energy Heat Act" (EEWärmeG) came into effect on January 1st, 2009. Under the Act, bioenergy receives subsidies when highly efficient technologies are applied or when district heating is generated partly by RES or CHP.

Concerning electricity from biomass, the amended "Renewable Energy Sources Act (EEG)", which came into force on January 1st, 2009, provides for numerous changes. The most important new provisions involve incentives to foster new technologies with higher energy efficiency and for extended use of biogenic waste and waste substances. For the different subsidies more detailed information is available within the EEG [7].

Concerning biofuels the "National Biomass Action Plan for Germany" 2009 [6] includes a promotion of second generation biofuels. Therefore projects on producing synthetic fuels from biomass using differing processes will be conducted to find ways to produce second generation fuels in pilot and industrial quantities. The projects will help to evaluate new technologies and answer unresolved issues regarding environmental and economic impact assessments.

Concerning Bio SNG the "National Biomass Action Plan for Germany" 2009 [6] is focused on simplified feed-in conditions into the national gas grid. Additionally a 6 % target for 2020 and a 10 % target for 2030 for Germany's gas demand to be met with biomethane have been set.

Additional acts and rules are contained in the "Gas Grid Access Ordinance" (GasNZV, GasNEV and AregVO) and the draft "Sustainable Biomass Ordinance" (BioNachV [8]).

All the targets mentioned in the “National Biomass Action Plan for Germany” 2009 [6] effect also further developments of biomass gasification technologies and the demonstration of existing techniques, because gasification is one of the key technologies for advanced CHP plants and second generation bio fuel production.

The German Government wants to support the development of biomass conversion sectors by research, development and demonstration projects. Research activities, in line with the “High-Tech Strategy” 2009 [9] of the German Government, are foreseen for example to develop new, efficient combined heat (refrigeration) and power technologies for biomass use according to the “National Biomass Action Plan for Germany” 2009 [6].

R&D Programs and Funding

In Germany, energy production from biomass is supported in a large number of *different* programs by the Federal Government and the Federal States. In the following only the main public R&D programs are mentioned.

The Federal Ministry of Economics and Technology (BMWi) is responsible for the programmatic orientation of the energy research policy and the “5th Energy Research Programme” 2005 [10]. In addition, there are the following individual departmental responsibilities:

The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) is responsible for the project-oriented funding of research and development of "renewable energies",

the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) for supporting research and development in "bioenergy",

and *the Federal Ministry of Education and Research (BMBF)* for the institutional funding of the research centres of the Helmholtz Association in the field of "energy".

The German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) has drawn up a program for „Promoting projects to optimise biomass energy use“ 2009 [11,12] in the framework of “Germany’s National Climate Initiative” [13,14]. The program supports further development of the current discourse on the generation of power, heat and fuels from biomass, up to the preparation of a sustainable and supportable biomass strategy. Furthermore, the funding program will focus on the development and optimisation of climate-friendly and energy efficient technologies for the utilisation of biomass for energy, taking into consideration their sustainability and climate protection aspects.

Thematic area 1	Utilisation of residues
Thematic area 2	International cooperation (focus on Non-EU Eastern Europe States)
Thematic area 3	Biomass gasification (combined heat and power, CHP)
Thematic area 4	Biomethane strategy
Thematic area 5	Bioenergy strategy (biofuels)
Thematic area 6	Regional bioenergy (regional concepts, small-scale combustion plants)
Thematic area 7	Strategy development: biomass (strategic projects, service and support projects etc.)
Table 1: Thematic areas of the Funding Program for „Promoting projects to optimise biomass energy use“ in Germany [15]	

The subject of the funding is the research and development of energy efficient technologies and the optimisation of processes and procedures. Feasibility studies, monitoring programs, pilot and demonstration projects are supposed to contribute substantially in the light of sustainability and climate change issues to improve the energetic use of biomass. As shown in table 1, funding is provided for studies, pilot and demonstration projects in seven thematic areas. Within Top 3 “biomass gasification” the development and demonstration of biomass gasification technologies for combined heat and power (CHP) applications will be supported. Top 1 “utilisation of residues”, Top 4 “biomethane strategy” and Top 5 “bioenergy strategy (biofuels)” are related to biomass conversion technologies including gasification. Additional information see [13-16].

The funding strategy of the German Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) is focused on the sustainable, environmentally-friendly production and use of biomass. This applies to both domestic production and the production of imported goods [17,18].

On behalf of the BMELV, the *Agency for Renewable Resources / Fachagentur Nachhaltige Rohstoffe FNR* [19, 20] acts as Public Trustee in awarding R&D grants. Funding research projects is central to the work and goals of FNR. The main instruments for managing and supporting projects are

- the “Research Program Renewable Resources” [21,22],
- the “Market Introduction Program Renewable Resources” [21] and
- the “Directive on Bioenergy Demonstration Projects” [21,23] .

The funding scheme concentrates on demonstration projects for plants and technologies whose practicability have already been proven at pilot stage. Furthermore, they must be state of the art and likely to continue running on a commercial scale after the demonstration project. Within the area of solid biomass utilisation for CHP and biofuel production, the optimisation of CHP and gasification technologies and the application of new technologies like fluidized bed systems are among others considered for research and development activities [22,23]. BMELV/FNR support for example the demonstration of the bioliq[®] technology of the Karlsruher Institut für Technologie (KIT) [24] and the demonstration of the Repotec fluidized bed technology at a CHP project of the Stadtwerke Ulm [24] .

The Federal Ministry of Education and Research (BMBF) intends with its “Basic Energy Research 2020+” [25,26] funding concept, to initiate research that contributes to a doubling of energy productivity between 1990 and 2020, which the federal government has set itself as a target [25,26]. The funding concept therefore focuses on areas of energy research in which new technological options will be developed on the basis of fundamental, long-term research work. The BMBF's funding measure "Bioenergy 2021 – Research for the Use of Biomass" [27] was taken up on the recommendation of the German Advisory Council on Global Change (WBGU) [28]. The BMBF intends to apply its funding in the following three areas of research for energy efficiency

- institutional funding of fundamental and long-term research,
- project funding of system-oriented research,
- research approaches for greater energy efficiency in existing programs within the research areas of “Key Technologies” and “Sustainability” .

In the area of institutional funding for energy from biomass the Helmholtz Association of German Research Centres, HGF is mainly funding the research projects “Renewable Energies (EE)” and “Efficient Energy Conversion and Use” (REUN) in the Research Field “Energy” with primarily the three HGF centres Karlsruher Institut für Technology, KIT; Research Centre Jülich, FZJ and Deutsche Forschungsanstalt für Luft- und Raumfahrt, DLR involved in the biomass related topics.

For further R&D Programs of the Federal States of Germany and other funding organisations see [29].

R&D Projects, Research Institutes and Universities

In Germany, there are a large number of universities and research institutes, which are involved in bio energy research. They have carried out in cooperation with partners from industry numerous biomass gasification related projects. It is not possible to list all projects and the involved R&D partners within this report. Further information about the projects and the involved organisations is available at the websites of the project management organisations, which work on behalf of the German ministries. Table 2 gives an overview of the German ministries, the involved project management organisations and the links for the project lists.

German ministry	project management organisation	contact project management organisation	project information is available at
BMELV	FNR	http://www.bio-ener-gie.de/foerderung/foerderuebersicht/	http://www.nachwachsenrohstoffe.de/projekte-foerderung/projekte/aktuell/bioenergie/
BMU	PTJ	http://www.fz-juelich.de/ptj/klimaschutzinitiative	http://www.fz-juelich.de/ptj/lw_resource/datapool/_pages/pdp_638/Projektliste_091006.pdf http://www.fz-juelich.de/ptj/lw_resource/datapool/_pages/pdp_638/DBFZ_Vorstellung%20Service-%20und%20Begleitvorhaben.pdf http://www.energetische-biomassenutzung.de/de/vorhaben.html
BMBF	PTJ	http://www.fz-juelich.de/ptj/netzwerke-grundlagenforschung/	http://www.ngee.de/regenerative-gase

Table 2: German ministries, their project management organisations and web sites, at which information about projects is available

Companies

Table 3 gives examples of German companies, their technologies and their main activities in the biomass gasification area. The information given is based on public data available from the companies. Detailed information is available at the websites of the companies. Because of the large number of companies, it is not possible to mention all companies within this report. Extensive information about companies and their

technologies concerning small scale CHP systems is available for example within the study “Schwachstellenanalyse an BHKW Vergaseranlagen” [30].

company	technology	plants / sites	website
entrained flow technology			
CHOREN Industries GmbH, Freiberg	Carbo-V [®] technology; entrained flow	Germany, Freiberg, β -plant; BTL; process of commissioning; In preparation - hydrogen production plant in Chile, - BTL production plant in France and - biomass gasification plant in Norway;	http://www.choren.com/en/
Lurgi GmbH, Frankfurt	Lurgi MPG based technology; entrained flow	bioliq [®] gasifier, KIT, plant in construction, start of operation in 2012	http://www.lurgi.com/website/index.php?L=1
Uhde GmbH, Dortmund	PRENFLO [™] - PDQ; entrained flow with direct quench	BioTfuel project; two pilot plants France; Projects in planning	http://www.uhde.eu/competence/technologies/gas/syngas.en.html
fluidized bed technology			
Agnion Technologies GmbH, Pfaffenhofen	Heat pipe reformer; FB; allotherm; steam blown	First plant in Pfaffenhofen, plant is in operation	http://www.agnion.de/index.php?id=2&L=1
h s energieanlagen GmbH, Freising	Heat pipe reformer; FB; allotherm; steam blown	First plant in Neufahrn near Freising, plant has been tested	www.hsenergie.eu
VER Verfahrensingenieure GmbH, Dresden	CombiPower Process; FB; coke and preheated air (620°C); oxygen enrichment up to 50 % by volume	Großenhain, project in planning	http://www.ver-gmbh.com/Startseite/Neue_Dateien/CombiPower_D_07.html
separated gravity driven moving bed technology			
Blue Tower GmbH, Herten	Staged reforming technology; allotherm; steam blown	Herten, plant in construction	http://www.blue-tower.de/index.lang5.195.1313.html
fixed bed technology			
Biomass Energiesysteme GmbH & Co. KG, Dortmund	Fixed bed technology from biomass engineering Ltd. UK	First plant in Arnsberg-Wildshausen; in total 4 plants have been built	http://www.biomass-energiesysteme.de/
Kuntschar GmbH, Wolfhagen	Fixed bed	More than 10 plants have been built	http://www.kuntschar-holzgas.de/
Mothermik GmbH, Pfalzfeld	Fixed bed	About 20 plants have been built	http://www.mothermik.de/unter-1konz.html
Regenis, Quakenbrück	Staged gasifier, allotherm, with steam reforming; heat supply with an external burner		http://www.rewenergy.de/
Spanner RE ² GmbH, Neufahrn	JOOS-VERGASER [™] and CHP plant of Konrad Weigel Energietechnik Company; fixed bed	7 plants have been built with personal contributions of the plant operators	http://www.holz-kraft.de/

Table 3: German biomass gasification industries

Implementations

Table 4 gives examples of biomass gasification plants in Germany which are in construction or in operation. The information given is based on public data available from the companies. More information is available at the websites of the involved companies and within the study “Schwachstellenanalyse on BHKW Vergaseranlagen” [30].

plant operator	technology	fuel load/ power of the plant	location of the plant	provider of the technology	additional information
entrained flow technology					
Choren Industries GmbH http://www.choren.com/en/	Carbo-V [®] technology; entrained flow; steam/oxygen blown	45 MW _{th} (β -plant)	Freiberg	Choren Industries GmbH, Freiberg	BtL production; 3-staged gasification at 6 bar with Fischer Tropsch Synthesis; demonstration plant; the plant is in the process of commissioning
KIT Karlsruhe Institut of Technology http://www.bioliq.de/english/index.php	bioliq [®] - process; decentralized pyrolysis (slurry production); centralized entrained flow gasifier; gasification based on Lurgi Multi-Purpose-Gasification – (MPG) Process; oxygen blown	5 MW _{th}	KIT Karlsruhe	Lurgi GmbH, Frankfurt KIT	Gasification up to 80 bar, BtL production; engineering, construction, supply, installation and commissioning by Lurgi; start of operation in 2012
fluidized bed technology					
agnion Technologies GmbH / Biomasse Heizkraftwerk Pfaffenhofen http://www.agnion.de/index.php?id=2&L=1	heat pipe reformer; FB; allotherm; steam blown	0.5 MW _{th}	Pfaffenhofen	agnion Technologies GmbH, Pfaffenhofen	pilot plant for syngas generation; future CHP and SNG applications
hs energieanlagen gmbh www.hsenergie.eu	heat pipe reformer; FB; allotherm; steam blown	0.5 MW _{th}	Neufahrn bei Freising	hs energieanlagen gmbh	CHP; heat supply for a nearby electrical distributor and the h s energieanlagen gmbh office
CUTEC - Institut GmbH http://www.cutec.de/	CFB; steam oxygen blown	0.4 MW _{th}	Clausthal-Zellerfeld	EcoEnergy Gesellschaft für Energie- und Umwelttechnik mbH, Walkenried	BtL production; atmospheric gasifier; artfuel project
Stadwerke Ulm / Neu-Ulm http://www.swu.de/	FICFB; allotherm; steam blown	15 MW _{th} ; 4.6 MW _{el}	Neu-Ulm	Repotec GmbH, Güssing	CHP; gas engines 4 MW _{el} and ORC 0.6 MW _{el} ; plant in construction; FNR funding; start of operation 2011
Wärmeversorgung Großenhain / POW AG http://www.ver-gmbh.com/Startseite/Neue_Dateien/Combi-Power_D_07.html	CombiPower Process; FB; air blown; preheated air up to 620°C; oxygen enrichment up to 50 % by volume;	21 MW _{th} ; 6 MW _{el} and 8 MW _{heat}	Großenhain/Naundorf	VER Verfahrenstechnik Ingenieure GmbH, Dresden	CHP; project plans are underway
separated gravity driven moving bed technology					
H2Herten GmbH http://www.wasserstoffstadt-herten.de/Firmen_103.0.html?&L=0	Staged reforming technology; separate gravity driven moving bed reactors; allotherm; ceramic balls as heat carrier; staged reforming technology; steam blown;	13 MW _{th}	Herten	Blue Tower GmbH, Herten	power generation and H ₂ production (up to 150 m ³ /h); gas engines for power generation; ORC plant for waste heat utilization; demonstration plant
fixed bed technology					
HEH Holz-energie http://www.moethermik.de/untern-1konz.html	fixed bed downdraft gasifier; air blown	4 x 250 kW _{el}	Pfalzfeld	Mothermik [®] CHP Technology GmbH	CHP
Stadwerke Düsseldorf http://www.swd-ag.de/	fixed bed downdraft gasifier; air blown	270 kW _{el}	Arnsberg-Wildhausen	Biomass Energiesysteme GmbH & Co. KG Dortmund	CHP

Table 4: Biomass Gasification Plants in Germany (Further information about small scale plants is available at [30])

In the following some examples of biomass gasification plants in Germany are shown in more detail.

KIT Karlsruhe bioliq[®] BtL production test plant

The bioliq[®] process, developed at the Karlsruhe Institut für Technologie (KIT) [31, 32], aims at the production of synthetic fuels and chemicals from biomass. The bioliq[®] technology is based on a two step process with decentral pyrolysis for the production of transportable slurry from biomass (e.g. straw) and central slurry gasification and BtL production. At KIT Karlsruhe a pilot plant with 2 MW fast pyrolysis and biosyn-crude production and 5 MW_{th} high pressure entrained flow gasifier operated up to 8 MPa (both in cooperation with Lurgi GmbH, Frankfurt), as well as the hot gas cleaning (MUT Advanced Heating GmbH, Jena), dimethylether and final gasoline synthesis (Chemieanlagenbau Chemnitz GmbH) are in operation respectively under construction.

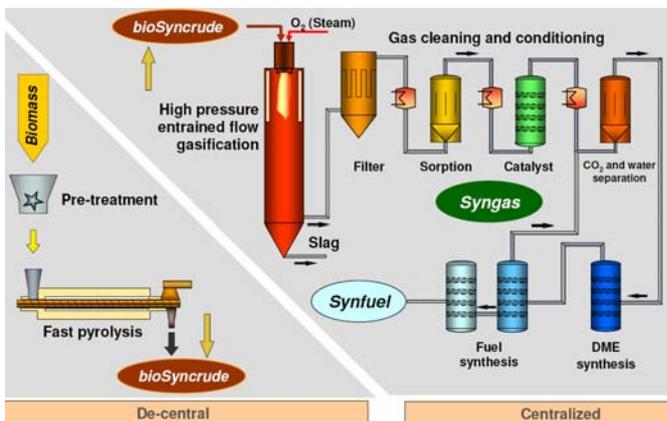


Figure 3: The bioliq[®] - process technology [31,32]



Figure 4: bioliq[®] pilot facility [31,32]

Choren Freiberg BtL production β -plant

The β -plant of Choren in Freiberg is a BtL plant based on biomass gasification (Carbo-V[®] process) in combination with Fischer Tropsch (FT) Synthesis. The Carbo-V Process is a three-stage gasification process involving the following sub-processes: low temperature gasification, high temperature gasification and endothermic entrained flow gasification.



Figure 5: Choren β -plant Freiberg - BtL production in semi industrial scale [33]

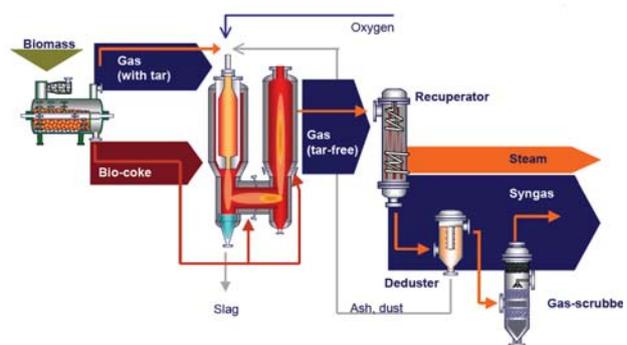


Figure 6: Choren β -plant Freiberg - Biomass gasification concept [33]

The gasifier of the β -plant has a thermal load of 45 MW_{th}. The plant is to be operated with 65,000 t/year of energy woodchips to produce 18,000 m³/year FT fuel. The pressure within the entrained flow gasifier is 6 bars. The investment for the whole plant is in the range of 190 mio €. The plant is in the commissioning phase. The figures 5 and 6 give an overview about the plant and show the gasification concept

SWU Stadtwerke Ulm CHP demonstration plant

The biomass CHP-plant of SWU in Senden will be operated with wood chips. The thermal load of the plant is 15.1 MW_{th} (4.55 MW_{el}). The technology is based on the FICFB Güssing (repotec) gasification technology. The plant will provide power for 21,000 inhabitants of Senden. Figure 7 shows details of the technology of the plant.

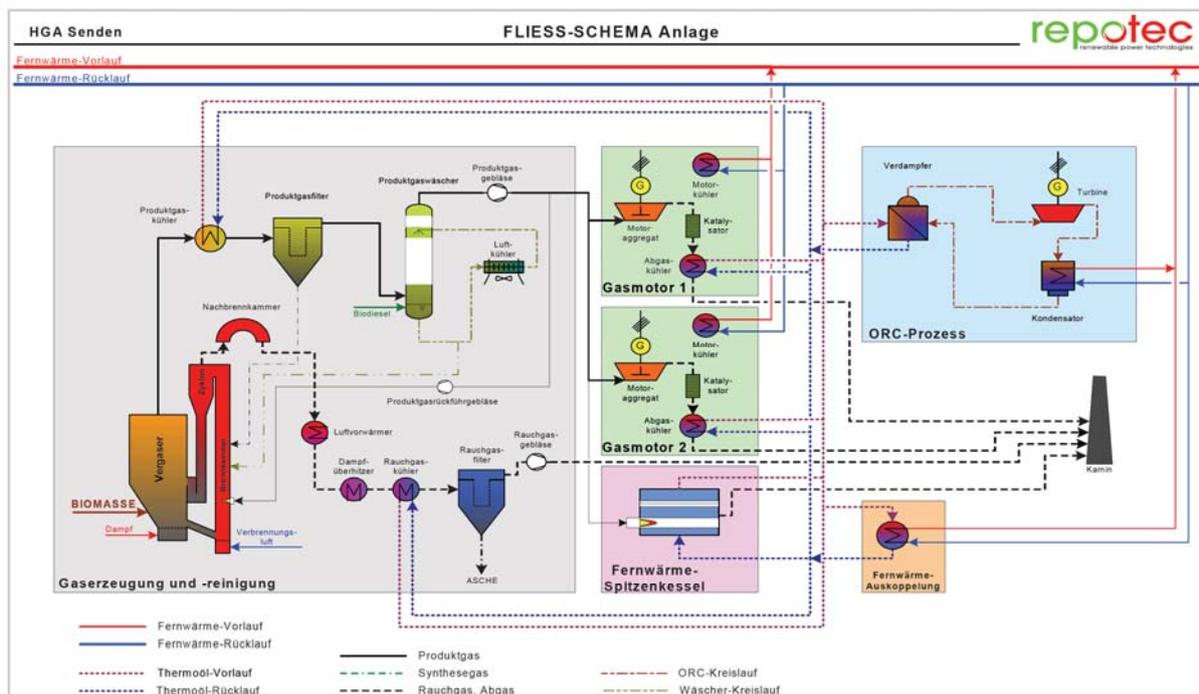


Figure 7: Flow sheet of the CHP plant in Senden [34]

Blue Tower CHP and H₂ production demonstration plant in Herten

As part of the H₂Herten demonstration project, a staged reforming gasifier with a capacity of 13 MW_{th} is to be constructed in Herten, starting in 2009. Figure 8 shows the Blue Tower gasification technology. The project company responsible for the demonstration project is H₂Herten GmbH. The total investment amounts to 24.6 mio €.

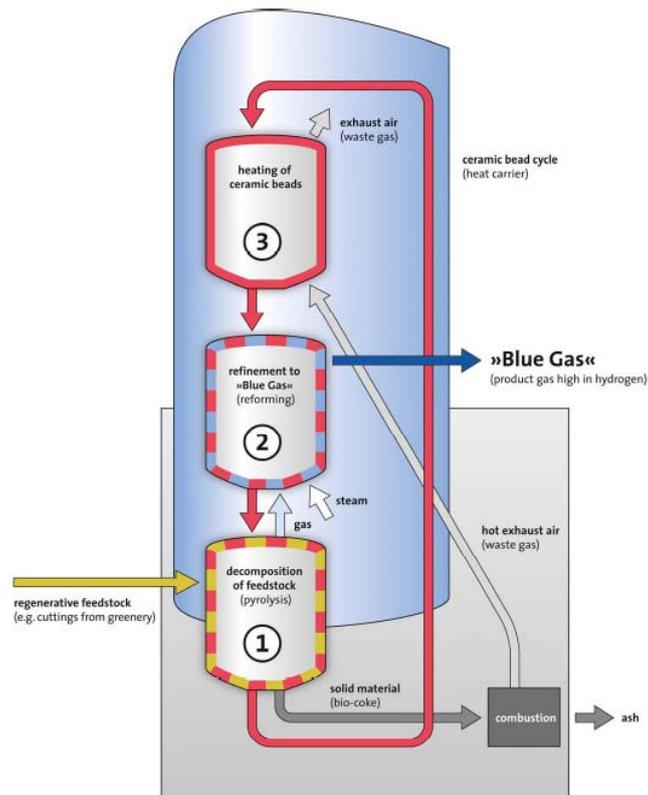
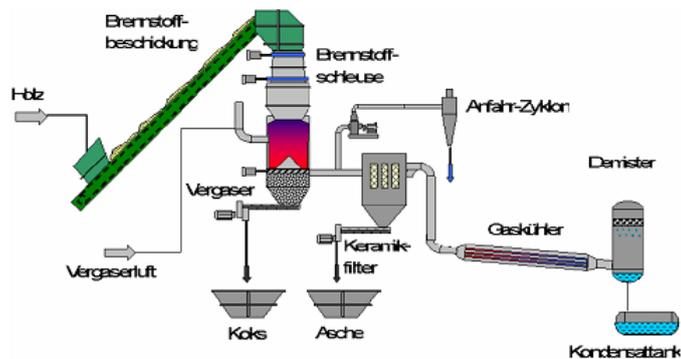


Figure 8: Blue Tower gasification technology [35]

Wood gas demonstration plant of Stadtwerke Düsseldorf in Arnsberg-Wildshausen

The plant, built by Biomass Energiesysteme Dortmund in collaboration with Stadtwerke Düsseldorf AG (contracting model), has a thermal power of 1 MW. The gross power of the plant is 270 kW_{el}. Additionally 410 kW_{th} heat can be used. The gasification technology and the gas cleaning system are based on the technology from Biomass Engineering Ltd., UK (fixed bed air blown down draft). The plant is operated with woodchips [30, 36].



Frischholz-Vergasertechnologie mit Kraft-Wärme-Kopplung

Figure 9: Flow sheet of the Biomass Energiesysteme gasification system [36].

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