

IEA Bioenergy Agreement  
Task 33: Thermal Gasification of Biomass (2001-2003)  
**TECHNOLOGY BRIEF**  
Fixed-bed gasification

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### **Introduction and background**

Fixed bed gasification is being researched and demonstrated for many decades. Despite all these efforts the technology for power generation has still not reached commercial status. This subtask describes the state of the art of small scale fixed bed gasifiers in the range up to about 1 MW<sub>e</sub>.

### **State-of-the-Art**

The state-of-the-art of fixed bed gasifiers is described in the country reports and websites like [www.gasifiers.org](http://www.gasifiers.org), [www.woodgas.com](http://www.woodgas.com) or [www.iitb.ac.in/~mech/](http://www.iitb.ac.in/~mech/).

#### *Heat gasifiers*

The most well known fixed bed heat gasifiers are Bioneer and PRM Energy, both updraft type gasifiers. About 10 Bioneer gasifiers are operational in Finland and Sweden providing heat for district heating. PRM Energy has 18 units in operation, mostly using rice husk producing heat for industrial drying applications or low pressure steam. In particular in China and India, hundreds of small gasifiers are in use for cooking purposes, drying, lime kilns, etc.

#### *Power gasifiers*

Gasification of biomass converts a solid renewable fuel to a gas that can be used in modern conversion devices, such as gas turbines or gas engines, for electricity and heat production. This opens the possibility of moving from traditional, small-scale, low-efficiency steam cycle to combined steam and turbine with higher efficiency.

A great number of small-scale fixed bed gasifiers are either in operation or under construction around the world. Since the early 90's successful applications have been seen in a.o. Denmark, N-Ireland, Belgium, UK, Germany, Austria, Switzerland. Some of these are based on old technologies (N-Ireland, Denmark) but also recent successful R&D work has been implemented (ESP < tar crackers, multi-stage gasification, etc.). Most of them are being used for CHP.

It is expected that in those countries with favourable feed-in tariffs for electricity and "green" heat regulations, new plants will be installed and new manufacturers entering the market. A selected overview of fixed bed power gasifiers is listed in Table 1.

### **Technical and Non-technical Barriers**

#### *Technical barriers*

- Sustainable feedstock supply: availability, characteristics, logistics, pretreatment, quality control, costs
- Feeding: problems with low-dense material and mixed residues with varying characteristics. There is a need for standardised fuel like sawdust, woodchips, rice husk
- Gasifier reactor: operational
- Gas cleaning: fouling and corrosion of the heat exchanger, wet/dry, tar removal/cracking, condensates, and continuous operation. Evaluation of different options is needed both technical and economical

- Tar contamination remains the main R&D subject. Promising developments are catalytic, thermal cracking and new scrubbing devices like “Olga” developed by ECN.
- Prime mover: lack of experience, allowable contamination, allowable emissions, engine, fuel cell, Stirling, turbine (specifications to producergas)
- Technology is still considered as unreliable and guarantees are lacking

#### *Non-technical*

- Permitting procedures, including lack of knowledge of the technology by the permitting authorities. Complex and time consuming, no uniform regulatory legislation
- Safety and health aspects; which directives are valid to gasifiers?
- Immuneration of electricity and heat
- Allowable emissions, which differs from country to country
- Public perception; rather negative
- Poor financial performance: high initial investments, decreasing subsidies, sustainable feedstock supply, competition with alternatives like combustion

#### **Recent/New Developments** (including new process performance data, environmental and economic assessment data).

- In general, limited data are available, see also the country report.
- Volund: updraft gasifier, wet scrubbing, wet ESP, two Jenbacher engines. Research is now concentrated on cleaning of the scrubbing water.
- Bladel, Netherlands: 60 kW<sub>e</sub> poultry litter gasifier at farm-scale with RPS (rotating particle separator), RFR (reverse flow catalytic tar reactor) and MAN engine. Problems with the RPS at high temperatures has to be resolved.
- EU project on regenerative dry gas cleaning with accumulation and recycling of tar to an open-core gasifier has been completed without promising results
- Recycling of tar (f.i. charcoal used for cleaning scrubbing water) is investigated at several places. Accumulation of specific tar components is a potential risk.
- ECN developed the “Olga” tar scrubbing technology. A pilot scale plant is installed behind the Bivkin fluid bed gasifier at ECN, Petten, the Netherlands. The tar removal principle is based on contacting the gas with an organic liquid. After separation of the organic liquid, the tar is recycled to the gasifier.
- Novel fixed bed gasifier developed by VTT: updraft gasifier with in-situ catalytic tar cracking in the upper part of the reactor. Condens Oy is marketing this gasification concept.
- Entimos Oy has constructed a new CHP plant in Tervola, which is community of ca. 2000 inhabitants in Lapland. Special features are:
  1. Two product gas lines: Gas B that is directly combusted and clean gas A, which is utilised in an Jenbacher engine
  2. Combined updraft and downdraft gasification
  3. Innovative feeding, grate and ash removal systems
  4. Adjustable in large range: 20 - 100% of nominal capacity
  5. Fuel capacity of 2 MW, generating 1.1 MWt and 450 kW<sub>e</sub>
  6. Local feedstock like sawmill and forest waste wood
- Puhdas Energia Oy located in Tampere Finland is developing a small scale CHP process based on downdraft gasification. The objective of this project is to develop a commercial unit available in capacity range 100 - 3000 kW<sub>th</sub> for farms, greenhouses and communal CHP stations. The project has focused on the R&D of the gasifier and automation of the process
- Xylowatt has built a new plant during autumn/winter 2001 on the site of the sawmill Despond SA at Bulle. The plant use the dry wood chips produce by the sawmill. The gasifier is a

further developed IISc gasifier with dry ash removal. The plant at Bulle has been in operation during spring 2002 with a total of 600 hours.

- Since June 2002, the “Viking” 2-stage gasifier of 17 kWe is operational at DTU, Denmark. The plant is used for demonstration purposes, optimizing of the engine and testing of materials.
- Two new downdraft gasifiers are under construction or in the commissioning stage in Austria, one 750 kWe gasifier by Civitas Nova and one 300 kWe gasifier by SK Industrietechnik
- In Italy two new gasifiers are being installed, a 1 MWe downdraft gasifier in Legnano by CCT based on the complex Ensofor technology and a 3.5 MWe updraft gasifier in Rossano by PRM Energy
- HoSt is building a 1 MWth Circulating Fluidised bed gasifier coupled to a steam cycle in Netherlands. The installation is designed to gasify 4,000-ton chicken manure a year. It is intended to enlarge the plant in 2 years with a gas cleaning system and a gas engine to gain a higher electrical yield.
- Xylowatt sa has constructed a 200 kWe downdraft gasifier in Regal, Belgium fuelled with SRC. The technology is a further development of the GAZEL gasifier developed at UCL, Belgium. Two similar gasifier plants is under construction near Luik and will be exploited by Electrabel.
- The largest know fixed bed gasifier of 10 MWt in Siebenlehn is closed down due to bankruptcy of the owner
- Technology belonging to Babcock Borsig Power GmbH who went bankrupt is taken over by a new company Future Energy GmbH

#### **Principal Technology Developers with Contact Details**

See country reports and [www.gasifiers.org](http://www.gasifiers.org)

#### **Achievements**

Due to the RD&D efforts the following achievements can be reported:

- Over 100 small scale fixed bed gasifiers are installed in Europe and the USA
- Hundreds are installed in developing countries, mainly for rural electrification
- Innovative concepts have been developed as an alternative to conventional moving-bed gasifiers like 2 and 3-stage process based on the ideas of De la Cotte and Kiener
- Gasifiers have been developed for “difficult” fuels like poultry litter, straw and wood chips
- New gas cleaning devices have been developed like electrostatic filters, tar crackers, rotating particle separators, scrubbers, solid bed filters, etc. including cleaning of condensate water
- Detailed characterisation of fuels for biomass gasification, like the phyllis database at [www.ecn.nl/phyllis](http://www.ecn.nl/phyllis)
- Fundamental research has improved the understanding of mass and heat transfer mechanisms of the complex gasification technology
- Complete automatic control devices have been developed for continuous and automated operation
- There is a consensus on the need for standard methods for monitoring the gasification process as indicated by the development of a standard tar measurement method
- Scale-up and demonstration of many different fixed bed gasifiers up to 10 MW<sub>t</sub> input
- Exchange of knowledge and experience by the use of internet (like [www.gasifiers.org](http://www.gasifiers.org), [www.woodgas.com](http://www.woodgas.com) and [www.gasnet.uk.net](http://www.gasnet.uk.net)) and networks (like IEA Task 33 and GasNet)

- Commercial operation of several community fixed bed gasifiers with low emissions like the Babcock & Wilcox Volund updraft gasifier for wood chips in Denmark or the Brook Hall Estate gasifier in Londonderry, N-Ireland with > 15,000 operating hours
- Gasifiers are in operation, which do not produce any condensate since the gas temperature is kept above the dewpoint
- In several countries policy measures are in place to stimulate biomass gasification. The most important market introduction measure is the governmental support in the form of subsidies on investments and guaranteed feed-in tariffs for green electricity

#### **Subtask Coordinator Concluding Comments**

- Fixed bed gasification is still a promising technology for niche markets. Exchange of knowledge, operating experience/problems is essential to “rescue” the technology. Networks like IEA and GasNet have to play an important role in this respect
- “Success stories” are needed on short-term to convince donor agents for further promotion of gasification technologies. Too many implemented plants are closing-down for distinguished reasons. Technology implemented must be mature with proven prototype models
- Implementation is hampered by many non-technical barriers
- Financial support is changing: from R&D towards Demonstration
- Subventions for R,D&D are declining in general while its difficult to attract private finance. Subsidies in the order of 20% do not really stimulate the implementation of installations.
- Fiscal instruments differ largely between countries. They are of less interest when large initial investment is needed to implement a new installation.
- Before efforts are made to commercialize small-scale power gasifiers, it is essential that the several conditions are fulfilled, see [www.gasnet.uk.net](http://www.gasnet.uk.net), under Information-Articles.
- Scale-up, demonstration, replication and optimization is essential. Based on economy of numbers (instead economy of scale) should lead to reduced capital costs. Improvements can be made from replications.
- Clear and uniform regulations are needed regarding permitting procedures and emission levels.
- Standards are needed for acceptance tests, guarantee measurements and certification.

**Table 1: Selected fixed bed gasifiers for power production**

<b>Location</b>	<b>System, supplier</b>	<b>Power MWe</b>	<b>Status</b>
Harboore, Denmark	Babcock & Wilcox Volund, updraft, chips	1.5	7500 hours since 2000 Availability is close to 100%
Viking, Denmark	DTU 2-stage for wood chips	0.017	In operation since 2002
Regal, Belgium	Xylowatt sa, downdraft, fuelled with SRC chips	0.3	Operating since nov. 2002 at farm, > 3000 hrs/yr
Gazel, Belgium	Xylowatt sa, downdraft fuelled with SRC chips	0.15	Operating since 2000
Luik, Belgium	Xylowatt sa	0.3	Two plants under construction
Eckenförde, Germany	EVN, two-zone downdraft, wood chips	0.18	Discontinuous operation since 2001
Civitas Nova, Wiener Neustadt, Austria	Modified AHT technology, wood chips	0.75	Operational since summer 2003
SK Industrietechnik, Austria	Downdraft, wood chips	0.3	Commissioning
Austria	Grübl, downdraft wood gasifiers	0.05	Several in operation at farms
Siebenlehn, Germany	Pipeline Systems, downdraft	2.3	Largest fixed gasifier coupled to combined cycle, closed-down
Espenhain	Juch gasifier	1	Closed-down
Brook Hall Estate, N-Ireland	Rural Generation Ltd. Downdraft, SRC	0.1	15,000 operating hours since three years
Blackwater Valley Museum, N-Ireland	B9 Energy Downdraft, wood	0.2	> 5000 operating hours
Beddington ZED, UK	B9 Energy technology	0,13	Operational since March
Herning, Denmark	Hollenson, downdraft gasifier, wood chips	0.4	> 7000 hrs, on hold
Legnano, Italy	Downdraft, CCT	1	Under construction
Spiez, Switzerland	Pyroforce, downdraft	0.2	Operational since 2002 > 1400 hours
Bulle, Switzerland	Xylowatt A.S, open-top gasifier	0.2	Operational since spring 2002, > 1500 hours
Camp Lejeune, USA	Thermal Technologies, downdraft	0.7	Operational
Tervola, Finland	Entimos Oy, combined updraft/downdraft	0.45	Commissioning
Gastrup, Denmark	3-stage gasifier, TK Energy	0.15	Industrial demoplant
Bladel, Netherlands	Chicken manure	0.06	Commissioning
Rossano, Italy	PRM Energy Systems, updraft	3.8	Nearing completion
Hengelo, Netherlands	HoSt, downdraft, wood chips	0.2	Operational since 2001
Petten, Netherlands	ECN, downdraft	0.1	Operational as test unit
Warrington, UK	Biomass Engineering	0.1	Operational as test unit