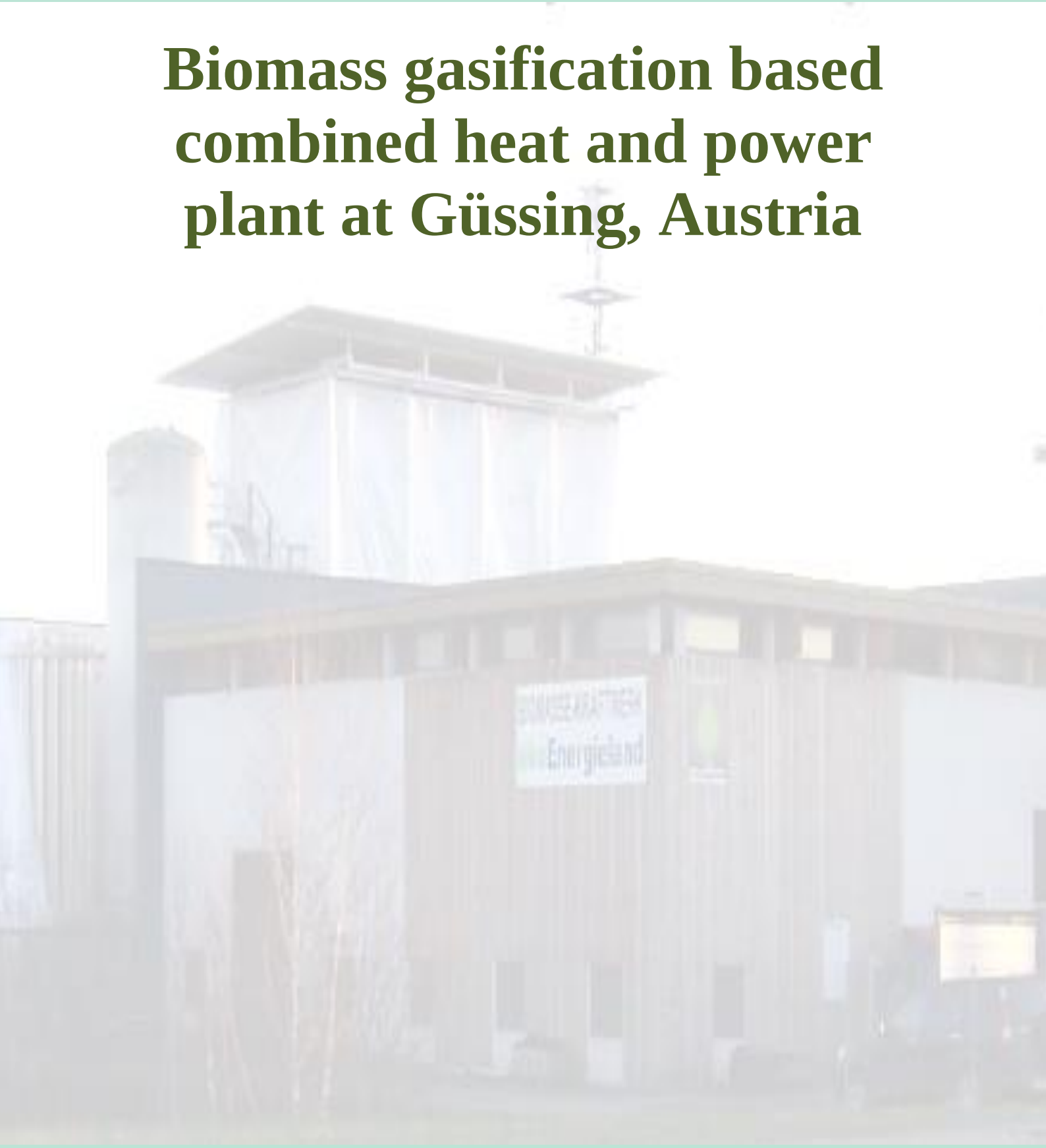
Biomass gasification based combined heat and power plant at Güssing, Austria



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Introduction

The country's primary energy demand is about 32.5 million tonnes of oil equivalent (2014) and renewable energy has a share of more than 30% in total energy demand. In Austria, the biomass has a primary role in accomplishing the energy demand in the country with contribution of 70% in the total renewable energy consumption.

Güssing is a small town located in eastern Austria and well known for its 8 MW biomass gasification plant. Due to lack of connectivity, the energy costs in the town were extremely high. Therefore, the government of Güssing decided to make the town self-sufficient in energy. Since, the biomass is abundant in the town with 40% of the region covered with wood which could provide sufficient raw material for energy generation; a biomass gasification plant was implemented in 2002. The plant has not only resulted in providing energy security but also being a carbon neutral source does not contribute in increasing CO_2 emissions unlike fossil fuels. As a result, Güssing became the first community in the European Union to cut carbon emissions by more than 90 percent.

Overview about the pilot plants

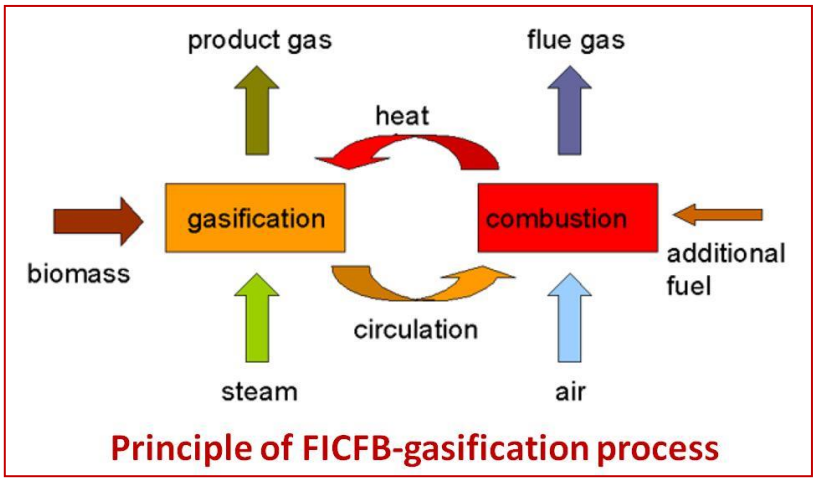
The biomass gasifier plant installed at Güssing was a joint effort of a consortium called "Renet Austria" which included: AE Energietechnik as the construction company, (ii) Institute for chemical engineering (Technical University of Vienna), (iii) EVN the regional energy utility, (iv) District heating company Güssing, (v) GE Jenbacher company, and (vi) Repotec Umwelttechnik GmbH.

Biomass based Combined Heat and Power (CHP) plant at Güssing, Austria produces 2 MW of electricity and 4.5 MW of heat for the local district heating network. The plant has an overall efficiency of 80%.

Technology configuration at Güssing plant

The technology deployed at Güssing plant is Fast Internally Circulating Fluidized Bed (FICFB) gasification system, also called as dual fluidized bed gasification, developed jointly by the Institute of Chemical Engineering (Technical University of Vienna) and by AE Energietechnik in Austria. In this system, the gasification reactor is physically separated from the combustion reactor in order to gain a largely nitrogen-free product gas.

The gasification reactor is operated as a bubbling fluidized bed fluidized by high temperature steam. In the gasification reactor, at approximately 850°C, the biomass is



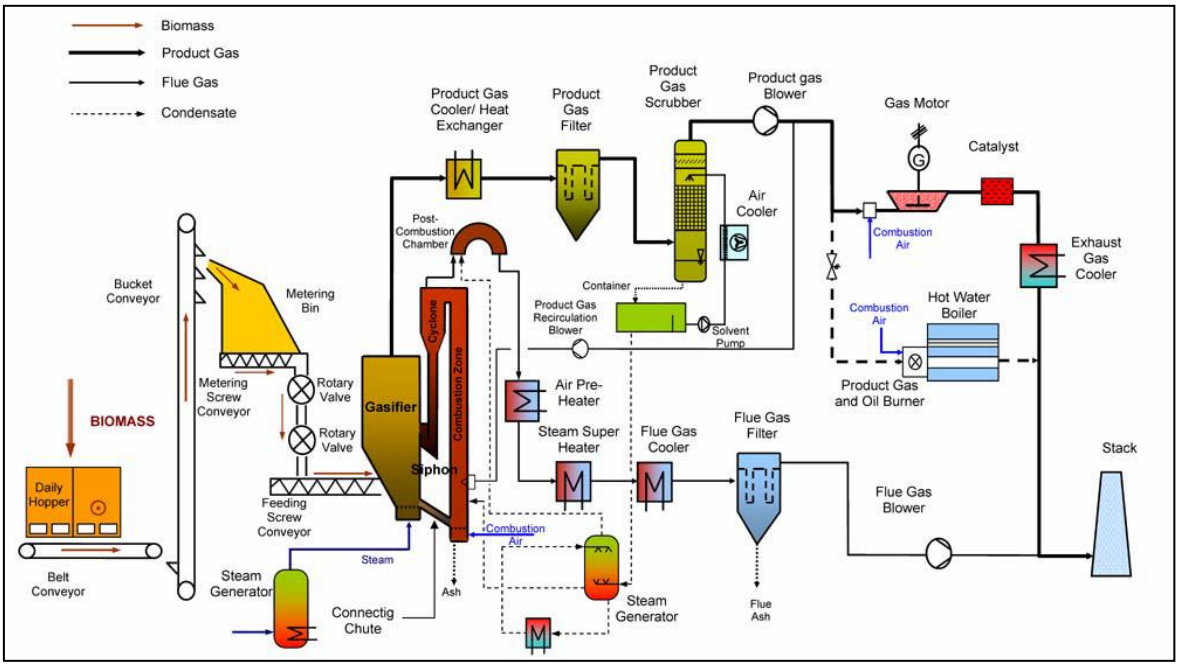
Principle of FICFB-gasification process

gasified with steam and releases a mixture of combustible gases, such as CO_2, CO, H_2, etc. and water vapours. A chute connects the gasification section with the combustion section and combustion reactor operates as a circulating fluidised bed. Bed material from the gasification chamber together with any non-gasified carbon is transported through this chute into the combustion section, where the complete combustion takes place of the biomass with the help of air. The heat generated in combustion chamber is transferred to the gasification chamber to provide the heat required for process of gasification. Combustion process is controlled by varying the quantity of supplementary fuel fed to the combustion chamber. The supplementary fuels used in the combustion are the waste products such as particulate matter and tar compounds, which are generated while doing the cleaning of the gas. The application of steam instead of air in gasification results in low tar free gas because steam gasification increases the gasifier temperature resulting in better tar cracking. The table gives the typical gas composition of the Güssing gasifier. The table gives typical gas composition for Güssing plant.

Typical composition of producer gas	
Component	**Range (Volume %)**
Hydrogen	35-45
Carbon monoxide	20-30
Carbon dioxide	15-25
Methane	8-12
Nitrogen	3-5

Cleaning and cooling of gas

Before cleaning the gas, it is cooled using a water cooled heat exchanger reducing gas temperature from 850–900°C to about 160–180°C. The cleaning of gas is a two staged process. The first stage of the cleaning system comprises of a fabric filter in order to separate the particles; and second stage is cleaning of the tar from the producer gas with the help of a scrubber. The tar scrubber uses rape oil methyl ester (RME) as solvent and reaches high tar separation efficiencies. After passing through the scrubber, the gas temperature reduces to 40°C, which is suitable for gas engine application. The gas engine used at Güssing is a turbo-charged "Otto"-type GE Jenbacher J620 engine.

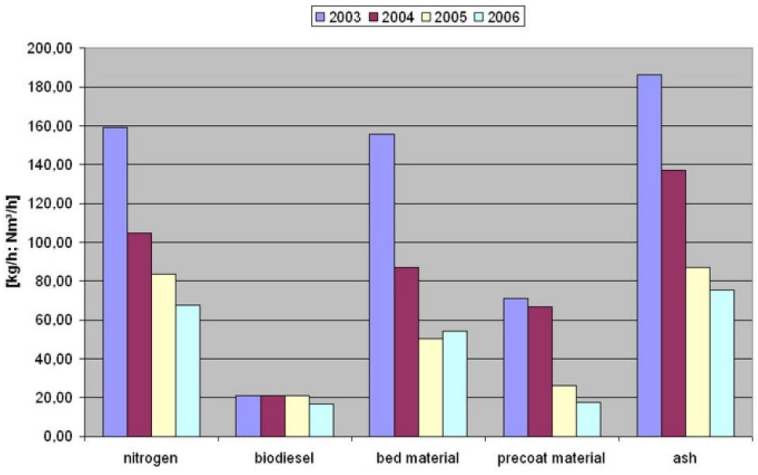


Schematic of biomass gasification based CHP plant at Güssing, Austria

Operational performance of the plant

Since the beginning of the plant operation in the year 2002, continuous improvement in the plant operation and optimisation has been done.

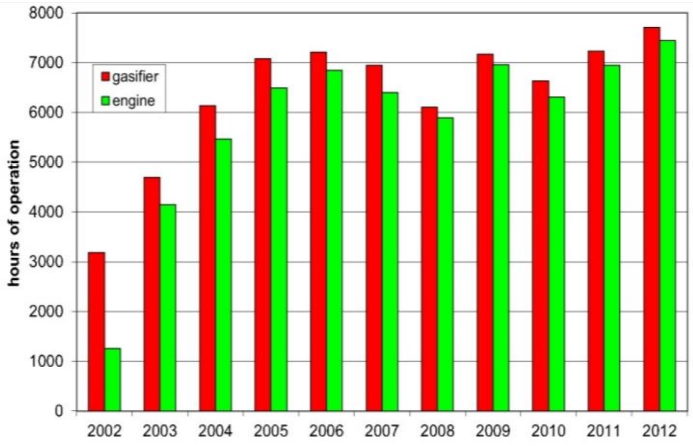
- Nitrogen is used as purge gas in the gasifier system. This is used as a precautionary measure before start of operation to identify if any gas is blocked in the gasifier to prevent firing. It is also used for removing the dust from the fabric filter in the producer gas line. For the year 2003 to 2005, optimization for nitrogen consumption was done so as to reduce the usage by 50%.
- The attrition rate of bed material in gasifier depends upon kind of bed material, the velocities of the riser and efficiency of the cyclone. In Güssing plant, based on optimization of these parameters, attrition rate has been reduced to 70%.
- The Güssing plant consists of precoated bag house filter to remove particles and an organic scrubber to precipitate tars. The precoat material is used to remove the chlorine which is present in the dust stream. By optimizing the system, the precoat material requirement is reduced to about 20% of the original amount.



- The scrubber for tar separation in the plant is RME. With this scrubber,

the overall tar in the producer gas can be removed over 90%. The spent biodiesel together with some condensate was fed into combustion chamber; this resulted in slight reduction of biodiesel to about 25%.

The Güssing plant had consistent hours of operation and continuously improved the availability of the plant. Following figure shows the operational data for about decade's operation (2002 to 2012) showing availability of gasifier and engine. It can be seen that after the initial optimization period (2002 to 2006), the system running hours both for gasifier and engine were quite consistent; about 7000 hours and more than 6000 hours per year respectively. Table summarizes the plant's design and actual performance parameters.



Characteristic performance data of CHP Plant at Gussing, 2009		
Particulars	**Design data**	**Operating data**
Biomass fuel	Wood chips	Wood chips
Moisture content	15%	25-40%
Fuel power (MW)	8	8.5-9.5
Electrical output (MW)	2	2
Thermal output (MW)	4.5	4.5
Electrical efficiency (%)	25.0%	20-23%
Thermal efficiency (%)	56.3%	45-53%
Total efficiency (%)	81.3%	65-76%

The flue gas from the gas engine and the flue gas from the combustion zone are mixed together and released via the stack to the environment. Measurements of the emissions are summarized in the table below.

There are no liquid emissions from the CHP plant at Gussing, as the condensate from the scrubber is evaporated and fed into the combustion zone, where the organic matter is combusted. The only solid residue is the fly ash from the combustion zone. Therefore the carbon content in this fly ash is very low (<0.5%) and can be handled similar to an ash from biomass combustion. This is an essential advantage of biomass FICFB gasification plant here compared to the most other gasifiers.

Characteristic performance data of CHP Plant at Güssing		
Particulars	**Raw gas**	**Clean**
Tar (mg/Nm^3)	1500-4500	10-40
Particulates (mg/Nm^3)	5000-10000	<5
Ammonia (ppm)	1000-2000	<400
Hydrogen sulfide (ppm)	Not measured	20-40

Emissions from CHP plant	
Component	**Range**
CO (mg/Nm^3)	900-1500 (without catalyst)
	100-150 (with catalyst)
NO_x (mg/Nm^3)	300-350
Dust (mg/Nm^3)	<20

Biomass supply management in Güssing

Güssing plant gets the biomass supply through the local forest. More than 40% of the area surrounding Güssing is forested. The region has variety of wood fuel species such as Pines, Aoks, Spruces, Beeches etc. The biomass power plant Güssing is supplied with wood chips with a moisture content of 20-30% from the region of Güssing (30-40 km radius from the town) mainly delivered by the forest association of Burgenland.

The quantity of fuel consumed is around 2,300 kg/hour. The strength of the Güssing system is the good integration between plant facilities' distribution and the available biomass resources.

Plant economics

Because of high fuel cost, the operation of biomass CHP plants is possible due to the high fixed feed-in tariffs for renewable energy by Austrian Government. Following table gives the typical data showing economics of the Güssing plant.

Economics of Güssing biomass CHP plant	
Particulars	**Cost**
Investment cost	10 Million Euros
Funding (EU, national)	6 - Million Euros
Operation cost/year	10 to 15% of capital costs
Price for heat (into grid)	2.0 €-cents/kWh_{th}
Price for heat (consumer)	3.9 €-cents/ kWh_{th}
Price for electricity	16.0 €-cents/kWh_e