

Pyrolysis of biomass

The pyrolysis (gasification) of biomass is a very old energy technology that is becoming interesting again among various systems for the energetic utilisation of biomass. Vehicles were run on gas produced by pyrolysis of wood in times of war to replace unavailable fossil fuels. Pyrolysis has the following main advantages over conventional combustion technologies:

The combined heat and power generation via biomass gasification techniques connected to gas-fired engines or gas turbines can achieve significantly higher electrical efficiencies (22 % to 37 %) compared to biomass combustion technologies with steam generation and standard turbine technology (15 % to 18 %). Using the produced gas in fuel cells for power generation can achieve an even higher overall electrical efficiency in the range of 25 % to 50 %, even in small scale biomass pyrolysis plants and during partial load operation.

The improved electrical efficiency of the energy conversion via pyrolysis naturally means that the potential reduction in CO₂ is greater than with combustion. The formation of NO_x compounds can also be greatly reduced and the removal of pollutants is generally in most cases. The NO_x advantages, however, may be partly lost if the gas is consumed in gas-fired engines or gas turbines. Significantly lower emissions of NO_x, CO and hydrocarbons can be expected when the gas is used in fuel cells instead of using it in gas-fired engines or gas turbines.



Pyrolysis of biomass generates three different energy products in different quantities: coke, gas and oils. Flash pyrolysis gives high oil yields, but the technical efforts needed to process pyrolytic oils mean that this energy generating system does not seem very promising at the present stage of development. However, pyrolysis as a first stage in a two-stage gasification plant for straw and other agricultural materials does deserve consideration.



In the typical biomass gasification process, air is used as the gasifying agent and hence the gas has a low calorific value (3-5 MJ/m³). After cleaning it can be used in gas-fired engines or gas turbines.

Gas turbines connected to a steam turbine will burn medium calorific value gas (12-15 MJ/m³) more favourably than low calorific gas. The use of steam injection into the gas turbine combustion chamber (Cheng process) requires at the very least medium calorific value gas. The production of hydrogen or methanol from gasification of biomass or the use of producer gas in low-temperature fuel cells also require

either gasifiers that operate with highly-enriched oxygen and steam, or indirectly heated gasifiers must be used with steam as a gasification medium to generate the necessary medium calorific value producer gas with high hydrogen content.

Gasification of wood, wood-type residues and waste in fixed bed or fluidised bed gasifiers with combustion of the gas for heat production is now standard. The wood gasifiers employed primarily in the north of Europe are used almost entirely for heat generation. Much greater technical problems are posed by gasification of straw and other solid agricultural materials, which generally have much higher concentrations of chlorine, nitrogen, sulphur, and alkalis. The gasification of green biomass is still at an early stage of development. Strengthened development efforts on gasification technologies for green biomass materials are essential as the potential supply of this type of fuels is comparatively large.

Efficient cleaning of the gas and correct adaptation of the products of biomass gasification to the specific requirements of the gas combustion systems are prerequisites for use in gas-fired engines, gas turbines and fuel cells. Tar compounds can be effectively removed by increasing the gas temperature or by catalytic cracking over nickel. However, even for wood gasifiers there is still no economically viable solution of this tar problem. None of the gasifier types currently available have been successfully tested in connection with gas-fired engines in long term operation in working combined heat and power stations.



Pressurised gasification allows higher overall electrical efficiencies to be achieved, but greater technical resources are required to feed the biomass into the gasifier, and problems with gas cleaning may occur.

For power plants with integrated biomass gasification in the range 3 to 20 MW electricity, fluidised bed gasification of biomass under atmospheric pressure, coupled with gas turbines using the Cheng cycle or gas and steam turbines appear to be the most promising technology at present in technical and economic terms. For combined heat and power stations with capacities up to about 2 MW electricity, gas use in gas-fired engines is, at the moment, more attractive than gas turbines. Because of problems with fuel supply and transport, biomass gasification plants with capacities above approximately 30 MW electricity are not a viable proposition in Germany and most other European countries at the present time.

The co-firing of biomass in existing large coal power stations (< 100 MW) is currently being investigated in various countries. The integration of biomass-fuelled gasifiers in coal-fired power stations would have certain advantages over stand-alone biomass gasification plants. Most important are the improved flexibility in response to annual and seasonal fluctuations in biomass availability and the lower investment costs.