**L16**

# BIOMASS GASIFICATION: PRODUCTION & GAS CLEANING FOR DIVERSE APPLICATIONS: CHP & CHEMICAL SYNTHESES

**Kyriakos D. Panopoulos, Christos Christodoulou, Efthymia-Ioanna Koytsoumpa**
*CENTER FOR RESEARCH AND TECHNOLOGY HELLAS*
*INSTITUTE OF SOLID FUELS TECHNOLOGY AND APPLICATIONS*

*Arkat - Mesogeion Ave. 357-359- Gr 15 231 Athens, Greece*
*panopoulos@certh.gr*

***Dr. Kyriakos D. Panopoulos*** is a Senior Researcher in the Laboratory of Alternative Fuel Technologies (LAFT) of the Institute for Solid Fuels Technologies and Applications of the Centre of Research and Technology Hellas (ISFTA/CERTH) and heads the research activities on biomass gasification and biofuel production specialized in advanced thermochmical utilisation of biomass. He participated in more than 10 EU projects and has published more than 20 papers in referred journals and numerous in conferences with over 150 citations and an H index of 9. He is invited reviewer for Journals such as FUEL, Int. J. Hydrogen Energy, etc.

Dr K. D. Panopoulos particular key qualifications to this project are:

- Being the designed and operator of the largest Biomass Gasification facilities in Greece. with numerous experimental studies of biomass gasification (agricultural residues &energy plants), heavy hydrocarbon (tars) determination, experimental investigation of fluidization quality during biomass gasification (SEM/EDS studies)
- Design of fluidized bed reactors,
- Experience in thermochemical biofuel production processes.
- Experimental research on the impact of biomass derived gas on catalytic systems operation and durability,
- Cycle modeling of integrated systems, Energy and exergy analysis of energy systems.
- Project management as Senior Researcher or Scientific Responsible (projects appointed by the EC, DG for Energy or National Programmes).

## Introduction

Biomass gasification is one of the most interesting thermochemical conversion technologies as it offers the production of a gas that can substitute fossil fuels in high efficiency power electric generation, and/or CHP applications, and can be used for the production of liquid fuels, chemicals and hydrogen via synthesis gas. Apart from the main products ($H_2$, CO, $CH_4$, $CO_2$, $H_2O$ etc) undesired trace species apparent in the raw product gas are removed with gas cleaning and conditioning unit operations before harming the end applications.

## Review

Biomass steam cycles operating in the range of 5-20 $MW_e$ are now producing most of the bio-electricity around the world. Their electrical efficiency is limited around 20% avoiding high capital costs associated with elevated steam properties and complex steam cycle integration. For even larger power plants (i.e. >20 $MW_e$) the I.G.C.C (Integrated Gasification Combined Cycle) technology is considered the most favorable with electrical efficiency up to 40%. Numerous types of gasifiers have been developed and tested in pilot and industrial scale. Although some applications are on the threshold of becoming commercial most of the applications (in particular for fluidized beds) the efficient and economic removal of tar and inorganic compounds still presents the main technical barrier to be overcome. Large biomass gasification technologies are still relative expensive.

Small scale biomass CHP systems based on gasification can use internal combustion engines or micro gas turbines with electrical efficiencies from 20 to 30% of the biomass fuel *LHV* (lower heating value). Internal combustion engines offer higher electrical efficiency with reduced co-generation possibilities and also exhibit higher pollutant levels.  More advanced proposed systems use high temperature molten carbonate salts or solid oxide fuel cells [1].

Biomass gasification is increasingly considered to produce clean syngas that can be refined and upgraded to fuels and chemicals such as substitutes for gasoline, diesel, alcohols, olefins, oxyxhemicals, synthetic natural gas (SNG), and high purity hydrogen. A key obstacle again is that raw product gas from biomass –contains $H_2S$, COS, halogen compounds, ammonia, particles, tars, heavy metals or volatile species such as arsenic and alkali aerosols which must be scavenged prior to direct use or further processing, employing cheap methods both as far as CAPEX as well as their operating costs [1][2].

Conventional gas cleaning, i.e. cold wet gas cleaning, is a proven technology but is thermally inefficient and produces waste water. Further developments are presented towards dry, warm gas cleaning. Dry hot-gas cleaning has a potential to offer higher energetic efficiencies, it is not feasible yet for all trace species and current efforts aim at the reduction of costs.

## Conclusions

This chapter summarises the biomass gasification technologies available for different applications today with special care on the traces species apparent in biomass product gas according the feedstock and biomass technology, the pathways through which these species prove detrimental for power and CHP applications and advanced fuels and chemicals catalytic syntheses. Based on the above information an attempt is made to categorise the different schemes of gas cleaning that have to be applied into gasification different schemes.

## References

1. K.D. Panopoulos et al., *Journal of Power Sources* **2006**, 159 (1), 13 September 2006, *570-585*.
2. S. Spyrakis, et al., *International Journal of Thermodynamics*,12 (4), December **2009**.