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UNIVERSITÀ DEGLI STUDI DI PERUGIA

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FUTURE TECHNOLOGY

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WASTE TO ENERGY WITH AN SOFC GENERATOR SYSTEM - PILOT PLANT EXPERIMENTATION

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***Abstract* - A dry anaerobic digester pilot plant was adopted to produce 0.5 - 1 Nm^3/h of biogas from OFMSW. This biogas was processed, filtered and stored in bottled gas prior to feed the reformer and the SOFC stack generator. PTR-MS instrument was adopted as a Direct Injection Mass Spectrometry technique able to monitor rapidly and reliably the trace compounds contained in the biogas. Hydrogen sulfide and siloxane compounds were the most dangerous compounds for SOFC detected and monitored, with concentrations that range from 2 - 73 ppmv for H_2S, and 100 - 400 ppbv for D4. A constant electrical power of 1900 W was achieved from the generator, with an electrical efficiency of 64% at nominal conditions.**

***Index Terms* - SOFC, biogas, PTR-MS, Gas cleaning section**

I. Introduction

The conversion of biomass into energy can be attained through different technologies. Among them the anaerobic fermentation of organic matter has interesting aspects [1–3]. The most common anaerobic digestion (AD) biogas contaminants are sulfur compounds, terpene and carboxyl compounds [1]. These compounds affect strongly fuel cell performance [4–7]. A specific combination of impurity removal methods has to be used to ensure a fuel gas with the quality that meets the fuel cell tolerance defined by the manufacturer [3,8–11]. two or at a maximum three steps are required: a primary clean-up step, in which a condenser and a first sorbent bed are inserted, followed by a fine guard bed before the biogas is delivered to the fuel cell system. The use of a condenser appears to be useful, essentially to remove water. The goal of the present work has been to build and to test an experimental pilot plant for energy production exploiting organic waste with SOFCs. Three main research sections on biogas exploitability are reported: (1) starting from biogas production from an OFMSW anaerobic dry digestion process through (2) a pilot gas cleaning section with commercial sorbents to feed (3) a 2500 Wel SOFC stack.

II. Material and Methods

The anaerobic digester adopted for the biogas production was described elsewhere[1,3,10,12]. The biogas produced from organic waste was 0.5-1 Nm^3/h. A gas cleaning section was built according to our previous work [12]. A Solidpower 2.5 kWe Engen was adopted and coupled to the experimental plant, see Fig.1.

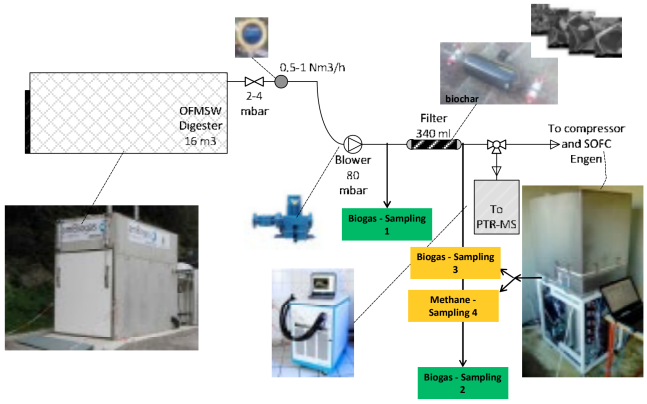

Fig. 1. Pilot plant – dry anaerobic digester of OFMSW, gas cleaning section, PTR-MS monitoring section, ENGEN SOFC stack.

III. Results

Trace compounds monitored along the biogas production process were analysed. Biogas produced has the following composition:

TABLE I
BIOGAS COMPOSITION

Compound	Concentration range (ppmv)
Hydrogen sulfide	40-110
Butanethiol	10-80
2-butanone/butanal	0-800
2-Pentanone/Pentanal	0-30
p-Cymene	0-50
Monoterpenes	0-300
Toluene	0-900
D4	0.07-0.12

The main concentration is related to sulfur compounds, carbonyls, aromatic and terpenes. These concentrations are strongly reduced with the gas cleaning section. The sulfur concentration is about 100-500 ppbv, while carbonyls and carboxyls have a concentration around 0.75-3.5 ppmv. Terpenes and aromatic compounds have a concentration around 1 ppmv. Such biogas composition feed SOFC energy generator with a

direct coupling. In the following figure is described the voltage produced; the steam to carbon ratio and fuel flow used. When the temperature is below 500 °C the fuel flow is switched from biogas to pure methane. The operating temperature was about 600 °C.

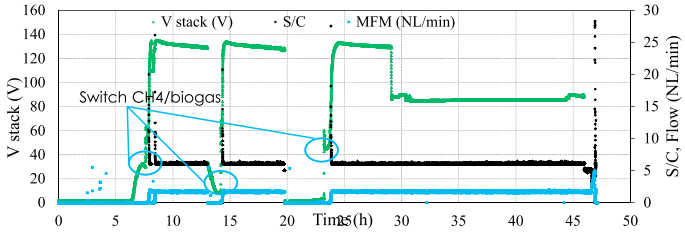

Fig. 2. Voltage, steam to carbon ratio and fuel flow of the ENGEN.

The voltage and power produced is quite stable along the process, except when the temperature of the stack decrease due to biogas composition and flow. The stable power produced was able to ensure an electrical efficiency around 64%.

IV. Conclusion

In this work the SOFC Engen (2.5 Kwe) was fed directly with the biogas produced treating organic waste. The electrical power produced was stable along the process for more than 50 h with an electrical efficiency of 64% and a temperature around 600 °C.

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