Biogas2PEM-FC

Biogas Reforming and Valorisation Through PEM Fuel Cells

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SEVENTH FRAMEWORK PROGRAMME

Abstract

This deliverable provides a cumulative overview of the undertaken Project's dissemination activities that have been carried out during the first nine months of the project. These activities have been executed as main consequence of the Dissemination Plan implementation (for further information about the Dissemination Plan, please check the deliverable D6.2 "Interim/Draft plan for use and dissemination of knowledge").

Firstly, information about Biogas2PEM-FC project is provided in order to highlight main project objectives, research activities to be conducted and the S/T methodology behind the envisaged work to be performed. Information about project participants and main roles is also provided in this section.

Secondly, captions of the main dissemination tools such as project website, project brochure and project poster are included. Information about publications and events is also summarised, being possible to find the whole abstract of produced publications at the end of the document (see Annex I).

Finally, a table summarises all the aforementioned activities, providing information about the main partner involved, the target audience and the countries addressed by such a dissemination activity, being possible to have a quick idea of the dissemination activities carried out during the first reporting period of the project.

Table of contents

1. Introduction

Biogas2PEM-FC is an industrial research project that aims to develop, according to participating SMEs needs, the technologies that compose a novel and integrated solution for biogas valorisation through proton exchange membrane fuel cells (PEM). Such a solution will provide a modular, reliable, cost-effective and efficient combined heat & power (CHP) system suitable for a distributed, on-site power generation from agricultural wastes.

This project has received funding from the European Union's Seventh Framework Programme managed by REA – Research Executive Agency, http://ec.europa.eu/research/rea (FP7/2007_2013), under Grant Agreement N.314940, Capacities programme, call "Research for the benefit of SMEs". The aim of this call is to strengthen the 'innovation capacity' of small and medium-sized enterprises (SMEs) in Europe and their contribution to the development of new technology based products and markets. This funding instrument helps them outsource research, increase their research efforts, extend their networks, better exploit research results and acquire technological knowhow, bridging the gap between research and innovation.

In this context, Biogas2PEM-FC firstly came up as an answer to the needs of the Andalusian Agrarian Cooperatives Union (participating end-user FAECA). As an agrarian sector representative, FAECA is specifically searching a way to treat and valorise olive oil mill (solid and liquid) wastes. The extraction of olive oil generates huge quantities of wastes that have a great impact on land and water environments because of their high phytotoxicity. These wastes include olive pomace (SOMW), a mixture of liquid and solid wastes with 55-60% water content. Because of SOMW characteristics (higher water content and organic compound concentration such as carbohydrates, pectins and polyphenols), a huge disposal and potentially pollution problem for the industry is generated.

Additionally, olives are cleaned producing washing wastewater containing emerging pollutants like pesticides, and olive oil produced is centrifuged producing oil washing wastewater (OMW) representing high pollution impact because of its acidity, high salinity and organic load. As a consequence, wastewater discharge into public wastewater collectors and/or use for crop land irrigation is limited. Then, the extensive practice for management of both types of wastes (solid and liquid) is the disposal into vessels. When vessels are filled up, the need for new vessels creates new problems such as increase of land use, overflowing, economic sanctions and activity, stop-up of industrial production, atmospheric pollution (odours), insect plagues and other problems in locations with high pluviometry. Several studies have proven the negative effects of these wastes on soil microbial populations, on aquatic ecosystems and even in air medium. Therefore, there is a need for guidelines to manage these wastes through technologies that minimize their environmental impact and lead to a sustainable use of resources. For many years, olive oil mill wastes has been the most pollutant and troublesome waste produced by olive mills in all Mediterranean countries, being very difficult to be treated and valorised.

1.1 SMEs needs to be covered

Biogas2PEM-FC project creates a framework where SMEs show their needs for advanced research in order to obtain a novel, cost-effective, efficient and integrated system to jointly valorise the aforementioned SOMW and OMW:

- FAECA needs the development of an olive mill waste bioremediation and valorisation system
- INGENOSTRUM needs a cost-effective integrated modular system for energy and heat production from biowastes
- HELBIO needs to go deep into biogas reforming through the development of new catalysts, new reactor designs looking for the maximization of process efficiency for biogas conversion to hydrogen

- POWERCELL needs the development of a novel and efficient PEM-FC able to accept hydrogen impurities at least in some degree in order to be fed by hydrogen from reforming technologies

1.2 Project objectives

In order to overcome the aforementioned SME needs and thus a marketable solution, some project objectives in each of the corresponding areas are expected to be achieved.

- Regarding anaerobic digestion, an optimization of the process should be carried out, so an objective of around 0,005 m^3 of biogas/kg olive mill waste in co-digestion is expected and realistic.
- As for the reforming process, the developed reformer should consume around 0.45 Nm^3/h of biogas (assuming composition of ~65% CH_4) in order to produce 1 Nm^3/h of hydrogen (in reformate gas) demanding no more than 0.8kW. The latter is produced by burning biogas in the combustion side of the reformer (also the unreacted reformate from the fuel cell can be recycled and directed it in the burner, reducing the biogas needed for the combustion).
- As for the PEM-FC, membranes suited to the reformate hydrogen while providing service life of about 40.000 hours are also advisable.
- Last but not least, the system to be developed should integrate all the aforementioned technologies in a modular, robust and easy-to-install&operate way, also taking advantage as much as possible of heat&energy recovery.
- An overall efficiency of up to 80% (electricity + thermal) is expected. The objective price of the overall solution in a commercial format should not exceed 20.000 €/kW installed in order to achieve a return on investment (ROI) of about 10 years.

1.3 Research strategies

In this context, Biogas2PEM-FC project will conduct research in order to achieve the aforementioned project objectives, specifically, the following research will be conducted:

- Research for the increase of biogas production yield, using physic-chemical and biological pre-treatment technologies at laboratory scale for enhancing anaerobic digestion effectiveness. After optimization of pre-treatment technologies, different inoculates and co-substrates will be investigated and used in laboratory experiments for maximization of biogas production: high methane and hydrogen content with minimum CO_2 and CO production ratio.
- Development and optimization of current biogas reforming technologies: new catalysts for an efficient conversion of biogas to hydrogen.
- Research for the integration of PEM technologies using hydrogen produced from biogas.
- Construction and field tests of a pilot plant located in a selected olive oil mill exploitation.
- Techno-economic and environmental evaluation of power generation using integrated Biogas2PEM-FC technology.
- Dissemination and exploitation activities of Biogas2PEM-FC project results for the feasibility demonstration of low cost biogas reforming and power generation.

Moreover, the project objectives are not restricted to olive mill waste valorisation. Once they are achieved, project results could be extrapolated to the valorisation of other agricultural wastes just with little technological modifications, making the project potential impact and interest of European and international SMEs bigger.

1.4 Participating RTD performers

According to the "Research for the benefit of SME" programme definition, the selected project objectives require research and development activities that the SMEs cannot afford by themselves, both technically and economically (since usually only well specialised RTD performers have the resources to conduct such activities). This is why first-class RTD performers where searched in order to be subcontract by the participating SMEs. Specifically, next RTD performers are going to participate in Biogas2PEM-FC project:

- IDENER, research SME specialized in systems integration and control optimization formed by a leading systems and automation R&D University group that will focus on the development of the modular system of valorisation and the reforming research tasks
- LEITAT, non-profit research centre that will focus on anaerobic digestion tasks.
- KTH, Royal Institute of technology, public university with wide experience in PEM-FC research studies

1.5 S/T methodology

In order to accomplish the main objectives defined in section 1.2, a work plan broken down into seven work packages (WPs) has been established. The WPs also include management tasks and assessment of progress and exploitation of results:

WP1.Biogas generation from olive mill wastes. This WP will perform research about yields of methane generation using co-substrates like olive mill wastes and manure. This is the key for the whole process, because it is the start point for the power generation and waste valorisation.

WP2. Optimization of reforming technology and development of a novel fuel processor unit. This WP will design an optimized and cost-effective fuel processor unit that will assure an efficient conversion of biogas to hydrogen, focusing on improved catalysers and heat recovery.

WP3. Development of PEM-FC membranes adapted to H_2 generated from biogas. This WP will research on novel PEM-FC membranes that will make possible the integration of this technology in hydrogen reformate steam.

WP4. Modular system development. This WP will research on the overall subsystem integration, allowing as much heat recovery as possible and allowing a robust, automatic and efficient system operation.

WP5. Field tests of a pilot plant. This WP will provide evidence of the feasibility of the project as a possibility for valorising olive mill wastes by implementing a pilot plant in a real facility provided by FAECA, the Andalusian Agrarian Cooperatives Union .

WP6. Exploitation and dissemination. This WP will ensure the proper dissemination and exploitation of project results so that a right flow of knowledge can flow from RTD performers to SME.

WP7. Project management. This WP will ensure that project objectives are achieved by coordinating the consortium, managing tasks and developing financial administration.

The Pert diagram included below summarises all the aforementioned WPs and their interdependences.

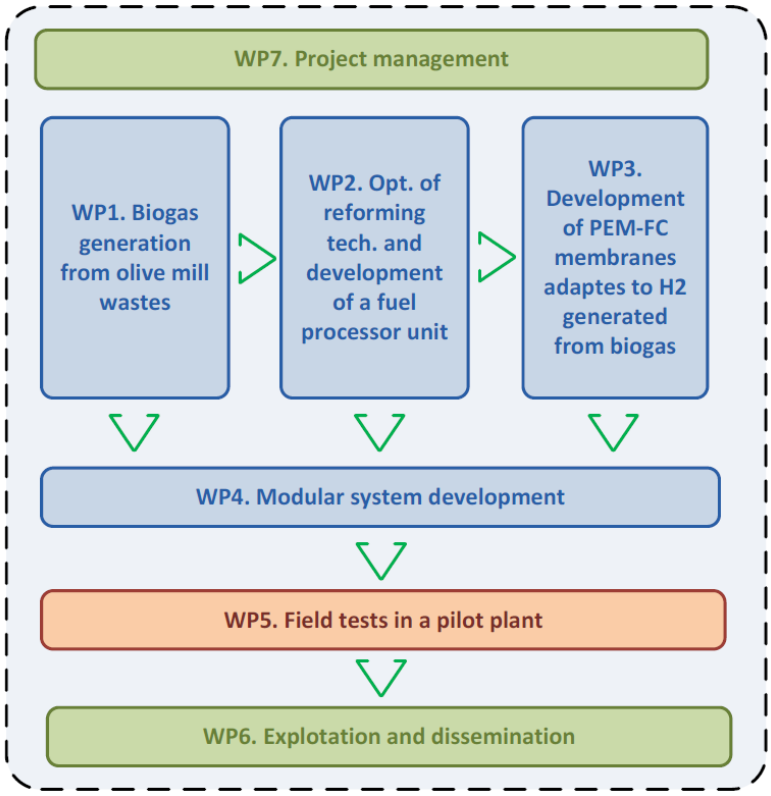

Fig 1: Biogas2PEM-FC Pert diagram

Furthermore, the following figure shows the main areas where research will be conducted as well as the partners involved. The flow of knowledge exchange is also represented (from the RTD performers to the SMEs, adopting the "Research for the benefit of SMEs" approach).

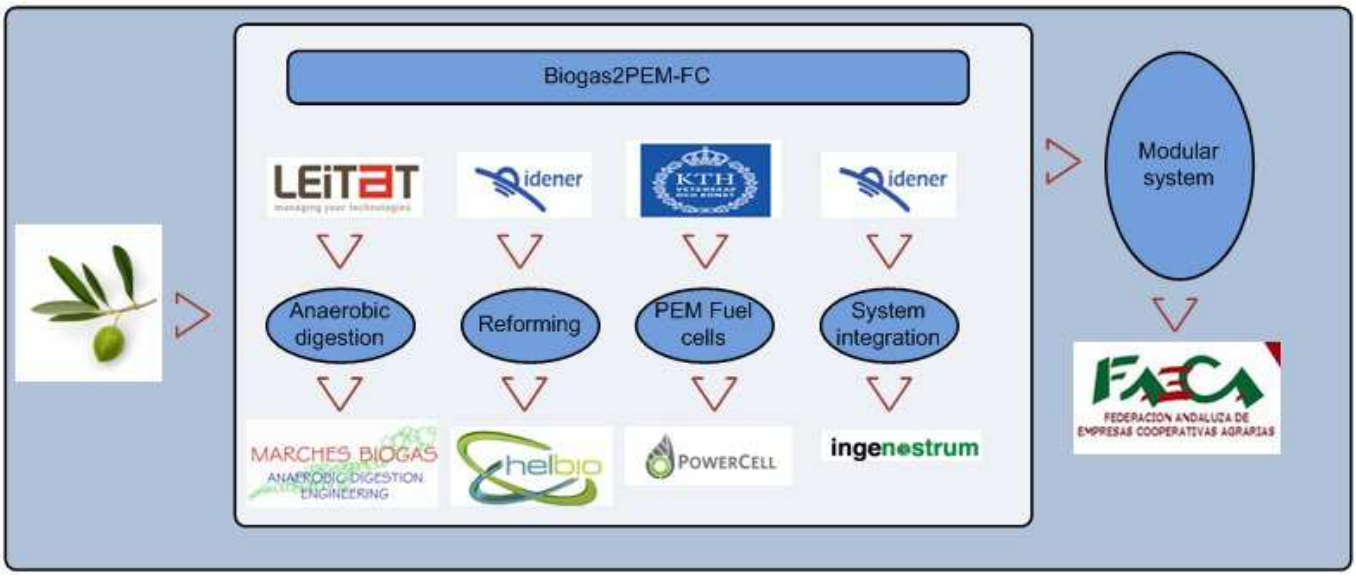

Fig 2: Biogas2PEM-FC S/T methodology

2. Activities performed in the project's first nine months (November 2012 – July 2013)

The activities of the first nine months of the project have been consistent with the Dissemination Plan as well as with the originally planned dissemination activities of the project proposal. Further information and a detailed description of the aforementioned plan can be found in D6.2 "Interim/draft plan for use and dissemination of knowledge". The partners, as depicted in Table 1 from the Summary section, have used an array of mediums and tools in order to successfully disseminate the project to the relevant audience. Since at this early stage of the project the amount of generated project results and/or knowledge is limited, main dissemination activities have been related to spreading project main idea and the potential of the results to be obtained as an innovative way of valorising and manage olive mill waste.

In order to raise this public awareness of the proposed technology, the partners have performed pre-marketing activities, including publications, project website launching, presentations and conference papers and the distribution of project promotional material.

2.1 Project logo and graphical identity

The graphical identity is in line with the public website and the general brochure and poster. It is important to follow the graphical identity, since good use of it will help to consistently communicate and disseminate the project. Guidelines and templates will also save time and effort for the members of the consortium, since no further design work will be necessary.

An important item to establish the project's identity is the project's logo. This logo was created by project partners and is usually included in all presentations, reports, documents, etc., of the project. The logo is shown in the below figure.

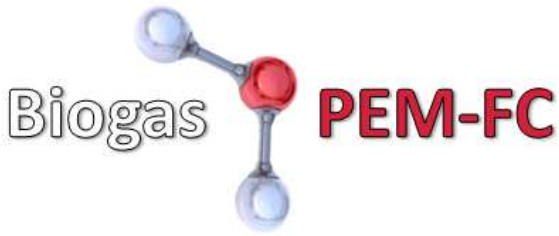

Fig 3: Biogas2PEM-FC project logo

2.2 Project reports

Dissemination of projects results by making deliverables publicly available is regarded as one of the most important means to publish results. For that reason this project consortium team is considering to review the dissemination level of deliverables (after the end of the project) in order to have more public reports published on the project website. Additionally, it is under consideration the possibility to have, during the lifetime of the project, a public version of documents that contain confidential information. These documents will be published on the projects website.

As for the reports and in order to maintain the project graphical identity, a template was provided to the partners using the Alfresco share tool linked to the project website private area.

2.3. Project presentations

In line with aforementioned idea of keeping an identity in order to make easier for target audiences to identify the project and as well as to provide uniformity when presenting project ideas, results or facts in a meeting, a template for a presentation has also been created and distributed to the partners through the above-mentioned internal sharing tool.

A caption of the main slides from the presentation template is included next.

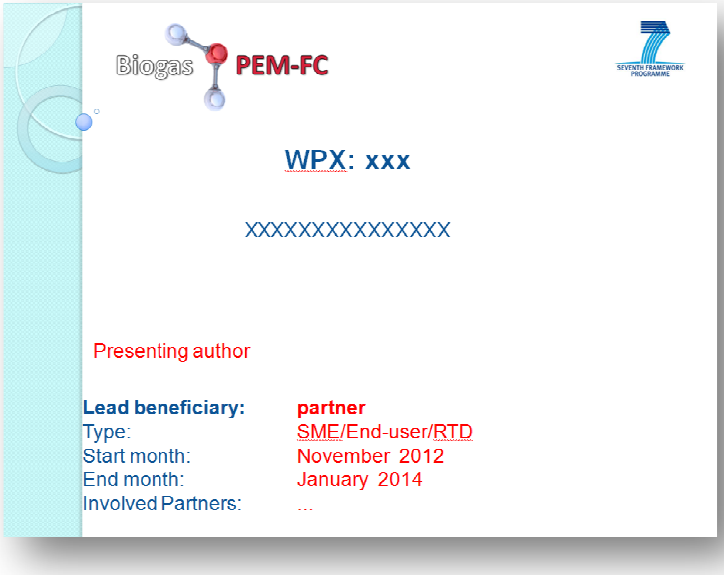

Fig 4: Biogas2PEM-FC presentation template

2.4 Brochures

For the purposes of effectively disseminating the project, a three-fold project brochure has been created. The brochure describes the main innovations that will be developed within the project and provides main contact details from project coordinator. In addition, all project participants logos are included as well as a reference to the EU funding. In order for the brochure to have a maximum effect on targeted audiences, one brochure per partner can be produced changing the partner profile, whereby a whole page is devoted to the description of that specific partner and their role within Biogas2PEM-FC. In this way, it will prove much more efficient to attract local audiences and be particularly customized to be used nationally. The brochure is user-friendly, compact and easy to understand, being included as part of the Dissemination Plan. a caption of the aforementioned document can be found next.

Fig 5: Biogas2PEM-FC brochure (outside)

Fig 6: Biogas2PEM-FC brochure (inside)

2.5 Poster

The project poster was developed in order to provide basic information about the project main goals, the technical approach, the expected achievements and a list of project participants and its consortium. This will serve as the project's *"business card"* and will be distributed, by the project beneficiaries, as widely as possible in any appropriate occasion. This document is available on the public website so all the audiences as well as partners can have access to it. A caption of such a document can be found next.

Fig 7: Biogas2PEM-FC poster

2.6 Events

The first nine months of the project were noted with overall success in relation to the participation of the partners in conferences, since a poster related to the proposed technology and an oral presentation about the first stage of the proposed solution (the one related to anaerobic digestion) have been selected for the Wastes 2013 congress to be held in Braga in September 2013. The technology of the project will be presented thoroughly and throughout this event, with the partners aiming at maximizing the visibility status of the project results foreseen. Moreover, an abstract concerning the PEM-FC research area has also been accepted for the European Fuel Cell conference to be held in Rome in December 2013 (a copy of the aforementioned abstracts and documents can be found at the end of this deliverable, see Annex I). In addition, new events are often looked for, in order to increase this project impact.

Specific mention must be made in relation to the type of audience each event can be targeted, since the dissemination activities performed approached an array of interested parties, coming from different fields and areas of interest. Universities and academic institutions, technology institutes and potential end-users are some examples of the type of audience the dissemination activities aimed at. Specifically for end-users, the main link between the project's core and them will be FAECA, the Spanish cooperative of Andalusian agrofarms.

As it can be depicted from Table 1 above, all events had a wide geographic approach, targeting audiences in Europe. All events took place over the entire time span of the project's first nine months, thus maintaining a dynamic momentum of interest at a constant pace.

As far as project meetings are concerned, the partners met two times, as prescribed within the project proposal. The first meeting (kick off meeting) took place in Göteborg (Sweden), in December 2012, where the partners had the opportunity to present their organizations and further define and describe their involvement in the project. The second meeting (M6 meeting) was held online using Webex in May 2012. The partners had the opportunity to comment on the work progress and establish internal deadlines. Several telephone conference and technical meetings between the partners served as a follow up to ensure that all aspects of dissemination and exploitation activities are carefully taken into consideration. The third meeting (M12 meeting) will took place in November 2013 where partners will have the opportunity to review the work progress during the first part of the project.

2. 7 Publications

Publications, either in the form of Press Releases or as scientific papers with the intention of being published and/or in the process of being published, have played a significant role in the dissemination of the project during its first months and are elevated at an equal bearing as any other type of activities performed during this time.

The project has been disseminated in various newspaper articles mainly on the internet (see Table 1), such as Tierra cooperative and chil.org, both Spanish publications. Press Releases were aimed primarily at the local audience, particularly end-users such as small and medium agriculture cooperatives who usually deal with the problems related to olive mill waste valorisation and management. This medium has proved particularly useful since it has disseminated the project at large to a wide public which would not be easily identified via standardized methods of dissemination such as events and scientific conferences.

In addition, links to these publications have been disseminated using new tools such as twitter, specifically from the account of @red_chil, the media account from chil.org.

2. 8 Website

The project website (www.biogas2pemfc.eu) acts as a dissemination platform with the aim to establish an efficient and effective dissemination and communication tool for the Biogas2PEM-FC consortium for the duration of the project. The website construction consists of one of the main dissemination tools of the project, which will ensure the successful use of project results and non-confidential information to the widest possible audience (including the industrial, academic community and potential end-users).

Fig 8: Biogas2PEM-FC project website

The website has a clear structure with two types of webpage navigation depending on the type of user i.e. visitor (public) or Consortium member (private area). The potentials for navigation, document uploading and website alterations differ for each type of user. The aim of the website is on one hand to inform general public about the project and on the other hand to constitute a tool to communicate and to exchange information on the project between partners. Project website is often updated through the insertion of news, new data and events and activities that are related to the project area and could be interesting for website visitors. More detailed description of the project website is given in D6.1 "Website".

Concerning project website updates, information has been added to the website often (a summary of website updates can be found in section 3 Summary).

In addition, some partners have also added a web link to the project on its organization's website, such as Ingenostrum, FAECA or Helbio.

3. Summary

The following table includes a detailed list of all dissemination activities (publications, conferences, web sites/applications, press releases, and flyers, articles published in the popular press, media briefings, presentations, and posters) that have been carried out during the first nine months of the project.

Type of activities	Main partner involved	Title	Date	Type of audience	Countries addressed
Project website	FAECA	www.biogas2pemfc.eu	M3	All	Europe
Project website update	FAECA	Biogas2PEM-FC project starts	M1	All	Europe
Brochure	FAECA	Biogas2PEM-FC Brochure	M3	All	Europe
Poster	FAECA	Biogas2PEM-FC Poster	M3	All	Europe
Logo	FAECA	Biogas2PEM-FC Logo	M3	All	Europe
Publication	FAECA	"Tierra cooperativa" magazine http://www.faeca.es/index.php/comunicacion/revista-tierra-cooperativa.html	M2	End-users	Spain
Project website update	FAECA	Biogas2PEM-FC Kick-off meeting in Sweden	M2	All	Europe
Publication	FAECA	*chil. org* ,	M4	End-users	Spain
Project website update	FAECA	Arrangements for samples collection started	M3	All	Europe
Abstract accepted	KTH	European Fuel Cell Conference 2013 (Rome, Italy)	M8	Scientific and academic audience	All
Abstract accepted	LEITAT	Wastes 2013 (Braga, Portugal)	M9	Scientific and academic audience and end-users	All
Abstract accepted	IDENER	Wastes 2013 (Braga, Portugal)	M9	Scientific/academic audience & end users	All
Website publication	Helbio	`Publication of Biogas2PEM-FC participation and link to project website in Helbio website	M4	All	All
Project	FAECA	First interesting results regarding Olive	M5	All	Europe

website update		Mill waste valorisation have been produced			
Publication	FAECA	Chil Innova	M4	End-users	Spain
Website publication	Ingenostrum	`Publication of Biogas2PEM-FC participation and link to project website in Ingenostrum website	M4	All	Spain
Link to publication	FAECA	Twitter account @red_chil	M4	End-users	Spain
Project website update	FAECA	Dissemination activities	M8	All	Europe

The status of the Biogas2PEM-FC project developed Dissemination Plan up to month 9 has been presented. Although at this early stage of the project there are not a lot of sounding results, dissemination is progressing well. The project website is up and running and partners have been provided with the required material as for starting their own dissemination activities.

ANNEX I. Abstracts and publications

EUROPEAN FUEL CELL CONFERENCE, Rome (Italy), December 2013

Abstract

REFORMATE FROM BIOGAS USED AS FUEL IN A PEM FUEL CELL

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Biogas is a renewable source that may be produced from many different raw materials such as industrial waste from wood and food industry, and sewage from wastewater treatment plants. Apart from traces of different impurities, the biogas also contains large amounts of methane and carbon dioxide and is a good feedstock for hydrogen production. By processing the biogas in a steam reformer a gas containing about 65-69% of hydrogen will be produced. However, the hydrogen is also accompanied with 26 – 29% of carbon dioxide and small amounts of impurities, mainly carbon monoxide and hydrogen sulfide.

The proton exchange membrane fuel cell (PEMFC) is seen as an attractive alternative for clean electricity production for transportation as well as for stationary power production. The PEMFCs possess advantageous features such as high efficiency, high power density and low emissions, making them competitive with e.g. the internal combustion engines in many applications. The best efficiency of the fuel cell is obtained when running the fuel cell on pure hydrogen and pure oxygen for the anode and cathode respectively.

In this project, olive mill wastes are digested to produce biogas that will in a later step be reformed to a hydrogen rich gas. That reformate gas will be used as anode gas in the PEM fuel cell producing electricity, and some heat, for the mill. For the cathode gas, air will be used. The aim of the present investigation is to study how the presence of different impurities will affect the performance of the fuel cell. Since the fuel cell will be placed in an agricultural area, not only impurities in the reformate used for the anode are of interest, but also possible contaminants such as ammonia or nitrogen oxides present in the air are investigated. Since the reformate will contain at least one third of carbon dioxide, known to be a problem when using Pt catalyst on the anode, also the influence of CO2 on the anode is studied.

WASTES 2013, Braga (Portugal), September 2013

Abstract, selected for oral presentation

DEVELOPMENT OF PRE-TREATMENT TECHNOLOGIES FOR THE ENHANCEMENT OF BIOGAS PRODUCTION FROM OLIVE OIL RESIDUES

Sergio Martínez-Lozano[1], Elena Genescà[1], Julia García-Montaño[1] Lorenzo Bautista[1], Jordi Mota[1], Jose García-Torres[1].

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The olive oil industrial sector produces solid residues (Solid Olive Mill Wastes, SOMW) and wastewater (Olive Mill Wastewater, OMW) that are currently considered an environmental problem to be targeted. Because of their high organic load such as carbohydrates, pectins and polyphenols –the last with non biodegradable nature-, they are difficult to be managed and treated through conventional management technologies.

Spain, together with Greece and Italy, covers 70% of world olive oil production. According to real data, a total amount of 2.5 millions tones of OMW and olive washing wastewater, 4.1 millions of tones of two-phase SOMW and 0.4 millions of tones of three-phase SOMW are yearly produced only in Spain.

This study investigates the application of different pre-treatment technologies for the enhancement of Anaerobic Digestion (AD) technology and the co-digestion of Solid Olive Mill Waste (SOMW) and Olive Mill Wastewater (OMW) at laboratory scale. Ozonation, Sonication and biological pre-treatment technologies are being developed and optimised for the enhancement of biogas production in the frame of Biogas2PEM-FC project (7FP Capacities, SME-2012-1), which aims to develop a novel and integrated solution for the efficient valorisation of both OMW and SOMW by integrating enhanced AD technology with further biogas reforming and proton exchange membrane fuel cells (PEM) technologies.

An optimal SOMW and OMW ratio has been selected after preliminary biogas experiments testing different SOMW:OMW ratios (defined according to original physic-chemical properties). From these results, total polyphenol was considered as one of the most important AD inhibitors conditioning biogas generation.

Operating parameters such as pH, ozone dosage and reaction time have been optimised for ozonation pre-treatment technology under optimal SOMW/OMW ratio. First optimisation tests demonstrated that 47% of phenolic concentration could be reduced after 30 minutes. Regarding sonication technology, total polyphenol reduction was comparable to that obtained by using ozonation technology while optimizing parameters such as frequency, energy and reaction time.

Finally, *T.versicolor* has been selected as a biological pre-treatment for its capacity to degradate polyphenol. Different dilutions of the optimum SOMW:OMW mixture have been plated as a nutrient source while the growing capacity of *T.versicolor* has been tested. It has been found that *T.versicolor* is able to grow under SOMW:OMW mixture at 50% or higher dilution with either clean water or pig manure (co-sustrate). The polyphenol concentration after pretreatment is currently being evaluated.

AD tests at laboratory scale for the co-digestion of SOMW and OMW after different pre-treatment technologies are demonstrating promising results. Mesophilic and thermophilic anaerobic digestion conditions are being compared. The use of additional co-substrates such as pig manure and additional specialised inoculates contributes to the C:N:P ratio balance and final biogas production yields, demonstrating its potential industrial viability. A feasible integration with further biogas reforming and PEM technologies is also foreseen.

Abstract, selected for poster

DEVELOPMENT OF A ON-SITE POWER GENERATION MODULAR SYSTEM FOR AGRICULTURAL WASTES VALORISATION

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Agricultural wastes management has become a big issue of concern nowadays. Particularly, a lot of effort has been focussed on finding the best available technology for the management of the waste generated from the extraction of olive oil, one of the most important agricultural wastes especially in Mediterranean countries where around a 70% of the total world olive oil production is covered.

Specifically, these wastes include olive pomace (SOMW, Solid Olive Mill Waste), a mixture of liquid and solid wastes with 55-60% water content, and washing wastewater from olive oil mill (OMW, Olive Mill Wastewater) [1].

Because of SOMW characteristics (high water content and organic compound concentration) and pollutant content in OMW like pesticides, a huge disposal and pollution problem is generated [2]. Currently, the extensive

practice for management of both types of waste is the disposal into vessels, thus creating problems such as increase of land use, odours and insect plagues in low pluviometry locations [1].

As an answer to this issue, a group of key European RTDs and SMEs joined efforts to conduct the project "Biogas2PEM-FC: Biogas Reforming and Valorisation Through PEM Fuel Cells", carried out under the EU Seventh Framework Programme, a tool from the European Union devoted to provide funding for the research and development of promising technologies.

Concretely, Biogas2PEM-FC is an industrial research project aiming to develop the technologies that compose a novel and integrated solution for the aforementioned waste valorisation. The proposed solution that brings together environmental remediation and energetic valorisation has, as first step, biogas production through anaerobic digestion (AD). Then, this biogas is valorised through catalytic reforming technologies coupled with a proton exchange membrane fuel cell (PEM). Such a solution provides a modular, reliable, cost-effective and efficient combined heat & power (CHP) system suitable for a distributed, on-site power generation from agricultural wastes.

Main project objectives are briefly detailed next:

- Regarding AD, an objective of around 0,005 m^3 of biogas/kg olive mill waste in co-digestion is expected to be achieved.

- As for the reforming process, the developed reformer should consume around 0.56 Nm^3/h of biogas in order to produce 1 Nm^3/h of hydrogen demanding no more than 0.8kW.

- As for the PEM-FC, membranes suited to the reformate hydrogen with a service life of about 40.000 hours are advisable.

- The system to be developed should integrate all the aforementioned technologies in a modular and easy-toinstall& operate way with an overall efficiency of up to 80% (electricity + thermal).

In order to develop the above mentioned valorisation technology and reach the detailed objectives, research activities are conducted in the following areas:

- Research for the increase of biogas production yield, using physic-chemical and biological pre-treatment technologies and investigating different inoculates and co-substrates.

- Development and optimization of current biogas reforming technologies: new catalysts for an efficient conversion of biogas to hydrogen.

- Research for the integration of PEM technologies using hydrogen produced from biogas.

- Construction and field tests of a pilot plant located in a real olive oil mill exploitation.

- Techno-economic and environmental evaluation of power generation using integrated Biogas2PEM-FC technology.

Finally, not only limited to olive mill waste valorisation, Biogas2PEM-FC technology can also be extrapolated to other agricultural wastes. Additionally, this technology can be used to valorise biogas produced from other processes such wastewater treatment plants, landfill gas installations, and industrial biowaste processing facilities.

[1] Characteristics of soil after pollution with wastewaters from olive oil extraction plants. Paredes, M.J et al.1987, Chemosphere 16 (7), 1557–1564.

[2] An overview on olive mill wastes and their valorisation methods. A. Roig et al. Waste Management 26 (2006).