

DELOS: An e-learning training platform for the operation and management of biogas production plants

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Abstract

Biogas technology constitutes an integrated system of resources utilization, recycling of nutrients, organic wastes treatment and renewable energy production. Biogas is a clean and renewable energy source which can be converted into heat and electricity, or it can be used as transport fuel and injected to the grid for energy saving purposes, in compliance with European Directives for less greenhouse gas emissions, sustainability and a more circular economy. In the framework of DELOS project, an e-learning training platform was developed concerning biogas units, seeking to foster the development of certain skills and transfer innovation and know-how between relevant stakeholders. The developed e-learning material consists of thirteen modules, covering basic areas of biogas production, both theoretical and technical. An emphasis is given on agro-industrial wastes used as substrates, because of their extended production worldwide, including many Mediterranean regions. Through DELOS courses, trainees will gain insight into the basic principles of anaerobic digestion which will help them become more effective in dealing with challenges that may arise in the working field.

Keywords : Anaerobic digestion, agro-industrial wastes, biogas, e-learning, training

Introduction

An effective way to prevent pollution is **anaerobic digestion**, an established waste treatment technology which offers a number of environmental benefits. Anaerobic digestion is a biological process which occurs when organic material decomposes in an oxygen-free environment, in the presence of a microbial consortium (Pain & Hepherd, 1985). The final products of the process are **biogas**, a renewable energy source mainly consisting of methane and carbon dioxide, and **digestate**, a nitrogen-rich residual mixture, which can be used as fertilizer or further valorized. Anaerobic digestion constitutes an integrated system of resources utilization, recycling of nutrients, organic wastes treatment and renewable energy production (Holm-Nielsen et al., 2009). The produced biogas can be converted into heat and electricity using CHP engines, as well as for transport and injection to grid after upgrading, replacing the energy provided by fossil fuels in compliance with European Directives for less greenhouse gas emissions and a more circular economy. Undoubtedly, renewable energy sources (RES) play a crucial role in the current EU policy for energy. In this regard, energy from biomass and waste is considered to be as one of the most dominant future renewable energy sources, especially due to the fact that a continuous power generation can be guaranteed unlike other types of RES, such as solar and wind energy (Appels et al., 2011). In the framework of the European project DELOS, Project No: 2013-1-ES1-LEO05-68066, an e-learning platform was developed for training all relevant stakeholders in the operation and management of anaerobic digestion plants. E-learning or Web-Based-Training is an emerging self-paced and highly interactive training method, which constitutes an alternative to traditional classroom-training. It is a type of distance learning in which educational material is delivered electronically to remote trainees via the Internet. In this way, such a system provides a valuable tool that integrates learning material and services into a single solution which effectively and economically delivers training or

educational content (Anaraki, 2004). Through DELOS courses, trainees will have the opportunity to gain insight, in both theoretical and technical level, into the basic principles of anaerobic digestion which will help them become more effective in dealing with challenges that may arise in the biogas production units. An emphasis is given on agro-industrial wastes used as substrates or co-substrates in biogas plants, due to their extended production in Mediterranean countries (Dareioti et al., 2009).

Materials and methods

The methodology followed for the DELOS project derives from three basic, strongly interrelated aspects, including the learning objective, the learning outcomes and the specific qualifications gained. These qualifications can be described as the knowledge, perception, skills and abilities which finally lead to a successful performance of employees in biogas plants. After an extensive research as well as a methodical review on the existing training material in the sector and the major training needs and gaps of the personnel occupied in the existing anaerobic digestion units of the partner countries, the material of the e-learning units was carefully selected and modified in order to meet the identified needs. For the purposes of this project thirteen modules were developed. These learning modules are provided as interactive presentations. Each learning unit consists of animated and non-animated slides, following thus a more reader attractive methodology compared for example with a conventional book or even an e-book, and ends with several exercises, 80% of which have to be answered correctly, in order to successfully complete the course. The e-learning platform is currently available in three languages, i.e. English, Greek and Spanish, through the official DELOS website (<https://elearning.delosproject.eu>). For an initial trial period (around 2 years), during which fine-tuning of the e-learning platform will take place, the use of the platform will

be at no cost. However, after the end of this testing and optimization period the cost of platform use will be priced by the DELOS partners, i.e. AITIIP (co-ordinator, Spain), Green Technologies Ltd (Greece), SciCo (Greece) and Marketmentoro Ltd (Cyprus).

Results

The theoretical training course of the e-learning platform comprises of seven modules (Table 1):

1. *Introduction of anaerobic digestion process-overview*: The objective of this unit is to establish a common knowledge base on anaerobic digestion and present the process of anaerobic treatment, its history and the basic technology which is currently applied. It also helps the trainee understand the biogas production and conceive the benefits of biogas utilization, instead of other forms of energy.
2. *Legislation issues in the partner countries and EU policies*: Through this unit, trainees become acquainted to the European and national legislation concerning anaerobic digestion and units operation. They learn key-EU Directives implemented in anaerobic treatment facilities and understand the importance of an effective operation of biogas plants, in compliance with the existing environmental policy.
3. *Design of anaerobic digesters*: This learning unit provides an overview on the configuration of anaerobic digesters, including the history, the design principles and the basic types of digesters. The purpose of this unit is to help trainees choose the appropriate digester for specific conditions and expected results of a unit, as well as becoming able to monitor the operation of reactors effectively.
4. *Microbiology of anaerobic digesters*: This unit focuses on the biotic part of the process and teaches basic principles of microbiology. Common microorganisms involved in each stage of anaerobic digestion and their interactions are presented trying to help trainees optimize anaerobic digestion and monitor the performance of microorganisms.
5. *Inhibition of the anaerobic digestion*

process: The fifth learning unit constitutes an overview on the common inhibitors which may hinder anaerobic digestion. Different types of inhibitors, as well as the interactions between different inhibitory agents are extensively described, in order to help trainees recognize the source of inhibition and find ways to counteract it. 6. *Increasing the biogas yield of a plant*: Effective ways, through which the performance of a biogas plant can be improved, are presented. Trainees will be able to evaluate the performance of such a plant and optimize the applied process. 7. *Techno-economic evaluation of a biogas plant*: In the last learning unit, the steps of the applied process, the main parts of the plant, as well as design calculations are presented. Trainees may understand the need and requirements of an extended technical feasibility and cost effectiveness study before the start-up of a biogas plant. Each learning unit consists of approximately 20 slides, for which it has been evaluated that it will take the trainee about 5-10 minutes in average to read, understand the content of a slide and acquire the knowledge which is offered. Each learning unit ends with 10 exercises with different response patterns, 8 of which have to be answered correctly. The successful completion of the exercises is compulsory in order to proceed to the next learning unit. The same principles apply also to the technical training course.

The technical training course of the e-learning platform is composed of six modules: 1. *Biogas plants components*, 2. *Selection of substrates-Co-digestion of agro-wastes*, 3. *Process monitoring*, 4. *Troubleshooting*, 5. *Safety practices for anaerobic digestion systems*, 6. *Composting of digestate*. This course has been designed for trainees, who have successfully completed the theoretical part of the e-learning platform, in order to expand on technical aspects of the topic. Doing so, a complete basis will have been established, constituting trainees ready to implement what they have learnt.

Table 1: Overview of the developed E-learning platform

Learning Unit	Unit length¹	Exercises	Training Module	Module length¹	Exercises
Theoretical part			Technical part		
Unit 1	22 slides	10	Mod. 1	42 slides	17
Unit 2	42 slides	10	Mod. 2	7 slides	7
Unit 3, 4	21 slides/unit	20	Mod. 3	8 slides	8
Unit 5	20 slides	10	Mod. 4	6 slides	4
Unit 6	19 slides	10	Mod. 5	14 slides	9
Unit 7	22 slides	10	Mod. 6	21 slides	12
Total	167slides	70 exercises	Total	97 slides	57 exercises
Duration	20.9 h	3.5 h	Duration	12.1 h	2.8 h
(about four days of training)			(about three days of training)		

¹ Cover slide and References are excluded from the length of the learning units and training modules

Conclusions

With the increasing use of the Internet, e-learning has been assessed as a valuable tool for learning and training. E-learning reduces training time and cost and helps academia and companies have well-educated and highly-performance students and workforce, respectively. Through DELOS courses, e-trainees will have a significant opportunity to learn the basic principles of anaerobic digestion of agro-industrial wastes, as well as to gain insight into more specific theoretical and technical aspects of biogas production. Furthermore, trainees will be able to assess their comprehension and repeat the course, if necessary. The target audience of this project includes companies active in the field of energy production, agricultural plants which will directly benefit from the application of the established technology, and engineers, scientists and whoever seeks to becoming involved in the sector of waste management and renewable energy production. Only through education will we manage to acquire a responsible attitude towards environment. Therefore, it is time we realized that pollution affects every aspect of

human well-being and immediate action is needed in order to establish a better quality of environment and life.

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