Co-funded by the Erasmus+ Programme of the European Union

Project-N° 2019-1-CZ01-KA202-061409

LEARNING SCENARIO	BIOGAS
MODULE 2	INTRODUCTION

COLOPHON

Authors

This module is part of the Learning Scenario *Biogas*. It is developed in the frame of the European project “BioComp”.
The authors are Jens Hofmann, Marek Botek, Delia Mela, and Elizabeth Ninou.

This document has been prepared for the European Commission however it reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Copyrights

This Learning Scenario is a non-commercial production. It can be used for educational purposes.

Co-funded by the Erasmus+ Programme of the European Union

PREFACE

The learning scenario Biogas has been developed as part of the Erasmus+ project BioComp. In that project, the most relevant competences for professions in the sector BBE are analysed, described and ranked. See https://navigator.biocompetences.eu/. Based on these competences this learning scenario has been developed for EQF-level 3-4. The focus is on technical competences.

Nr	Competences, ranked according importance	Modules
B1	Management - Identifying needs and mechanisms of the overall management of the biogas production process.	1, 2
B2	Operate biogas plant - Operate equipment, which treats energy crops and waste from farms, called anaerobic digesters. Ensure the equipment functions correctly in the transformation of biomass to biogas, which is used for the generation of heat and electricity.	1
B3	Resolve equipment malfunctions - Identify, report and repair equipment damage and malfunctions; communicate with field representatives and manufacturers to obtain repair and replacement components.	4
B4	Composting of organic waste (Biomass) - Identifying needs and technological responses: to know the types of bio-waste, the recovery routes (composting, digestion, incineration).	5
B5	Recycling - Identifying needs and technological responses - To know the circular economy, compost processing and the use of fermentation.	1, 3
B6	Composting of organic waste (Biomass) - Identifying needs and technological responses: to know the chemistry and biological processes of composting.	1, 5
B7	Bioconversion process - Identifying needs and technological responses - To assess needs and to identify, evaluate, and control the heating process of biological material, control the combustion process, know and be able to analyse the chemical, thermal, and biochemical methods.	3, 5
B8	Composting of organic waste and management - Identifying needs and technological responses - To assess needs and to identify, evaluate, and control the heating process of biological material, control the combustion process, know and be able to analyse the chemical, thermal, and biochemical methods.	5

These 8 most relevant competences are covered by the following 6 modules:

1. Circular economy
2. **Introduction**
3. Health and Safety
4. Maintenance
5. Malfunctions
6. Composting and disposal

Apart from these 6 text documents, the scenario also has a trailer and a WIKI with background information. To support the teacher, didactic guidance is available. It can be used for all scenarios and also includes suggestions for learning activities to develop personal and transversal competences. For this guidance, see the *Pedagogical Guidelines* in the Navigator.

CONTENT

Module 2 contains the following topics:

Co-funded by the Erasmus+ Programme of the European Union

1. Introduction to the module

Introductionary video - working of a biogas plant:

https://www.youtube.com/watch?v=5RswjCWaR6I

Biogas is an energy source created from an organic source. Therefore, it is an important component supplying relevant amounts at any time from a degradable, green source. It can always step in when it is dark and there is little wind. Biogas can not only generate electricity, but also heat and fuel. Along with energy from wind and solar, biogas creates the trinity of greening energy production.

Biogas is one of the simplest chemical compounds in nature. It can be produced from agricultural waste, food waste, and sewage. It is created from the breakdown of organic matter in the absence of oxygen.

The most important component of biogas is combustible methane (CH_4). Depending on the substrates used, the methane content varies between 50 and 65 %. In addition, carbon dioxide (CO_2) occurs in a proportion of 35 to 50 %, and other ingredients such as nitrogen, water, oxygen, and hydrogen sulphide in low concentrations.

Co-funded by the Erasmus+ Programme of the European Union

Advantages of biogas:

1. Biogas replaces fossil sources and reduces greenhouse gas emissions.
2. The combustion of biogas only releases as much CO_2 as the plants previously absorbed during growth. This makes biogas one of the CO_2-neutral fuels.
3. Biogas is available without fluctuations and can be stored without any problems.
4. Organic waste from industry and households is recycled in an environmentally friendly manner using biogas.
5. Less odour nuisance when spreading liquid manure in the fields: fermented liquid manure smells considerably less than normal liquid manure and the smell wears off faster.
6. Plants absorb the fermentation substrate better than normal manure, which can increase the yield in the fields.
7. The cost of artificial fertilizers can be reduced, and environmental pollution avoided.

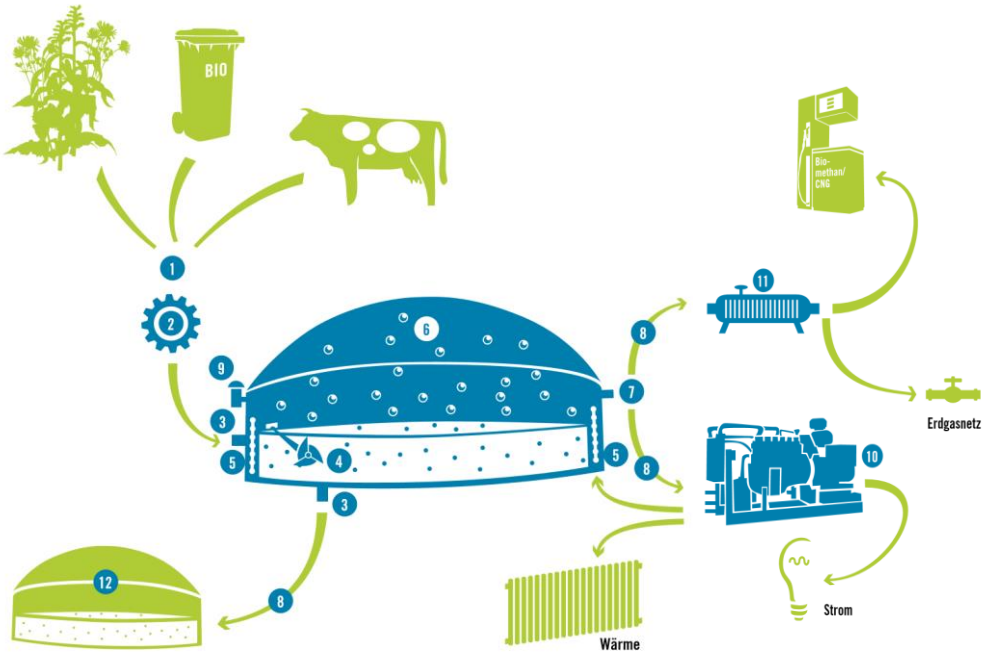
Biogas in larger quantities is normally produced in biogas plants.

2. What is a biogas plant?

The continuous creation of biogas from biodegradable sources is carried out in biogas plants. These plants represent technical systems to control processes of fermentation, biogas collection, and transformation into energy and heat.

A biogas plant consists of the following components:

Picture 1. A schematic presentation of a biogas plant



Source: https://www.biogas.org/edcom/webfvb.nsf/id/DE-So-funktioniert-eine-Biogasanlage

1 – Storage for biodegradable sources (substrate)

2 – Sorting or cleaning

3 – Pumps for transporting the biomass to/from the fermenter

4 – Agitator mixes the bacteria in the fermenter with fresh biomass

5 – Heater for reaching usual fermenting temperature of 40°C

6 – Biogas storage

7 – Gas cleaning (desulfurization and dehydration)

8 – Pumps for transporting the fermentation substrate and the biogas

9 – Security technology: pressure protection, pressure valves

10 – Cogeneration unit for the production of energy and heat

11 – Processing technology for the transformation of biogas to biomethane

12 – Storage container for the digested fermentation products

Different materials or substrates result in various methane contents. Biomass with a high-water content, which cannot be directly thermally utilized, is particularly suitable as a substrate. In contrast, biomass rich in cellulose (e. g. straw) and lignocellulose (wood) is difficult to access for microbiological degradation and therefore not suitable as a substrate for biogas production.

The methane content is increased by a substrate, which is low on water and low on inorganic components. To estimate the gas formation potential, the methane yield is related to the organic portion of the dried input mass (fresh mass minus water content).

The table below presents different substrates and the methane contents. Manure and biowaste have higher methane contents as well as less space in terms of volume required than, for example, corn or grass silage.

Table 1. Summary of the different substrates used in a biogas plant and the different methane contents produced

Material	Biogas yield /m^3 (fresh mass)	Methane content
Corn silage	202	52 %
Grass silage	172	54 %
Rye fill plant silage	163	52 %
Suger beet pulp	125	52 %
Bio waste	100	61 %
Chicken droppings	80	60 %
Pig manure	28	65 %
Cattle manure	25	60 %

Source: https://de.wikipedia.org/wiki/Substrat_(Biogasanlage)

3. Are there different biogas plant types?

Due to the different organic sources, specific biogas plant types exist. They can be mainly characterized by the main "feeding" sources. These vary from green sources like corn and cereal to liquid manure and organic waste on landfills (see below).

Table 2. The different types of biogas plants

Only green sources	(Liquid) organic waste	Mix of green + liquid organic waste	Landfill
Fermentation plant Plants from food technology	Digestion plant Treatment of sewage sludge	Agricultural biogas plant Mix of renewable raw materials and liquid manure	Landfill biogas plant 100% organic waste converted by bacterias into carbon dioxide and methane
Renewable raw material plant Mind. 80% corn, cereal, grass, sunflowers	Anaerobic plant Anaerobic treatment of waste water		
Waste biogas plant 100% waste from food production (leftovers, vegetables etc.)	Cofermentation plant Use of waste, liquid manure or sewage sludge		
	Liquid manure plant Mind. 80% liquid/animal waste (swill, excrement, ...)		

Source: https://www.archea-biogas.de/BiogasAZ/Anlagentypen/index.htm

Each plant type results in completely or partly different operating procedures. The treatment of corn results in a different energy supply of the fermenter and gas cleaning than the use of sewage sludge for biogas production does. In addition, the plant size, which results from the quantity and quality of available biodegradable sources, has a strong impact on the management of the plant operation.

To obtain a general understanding of the biogas plant types, three of them are presented below.

I. Waste biogas plant
II. Agricultural biogas plant
III. Landfill biogas plant

Type	Agricultural biogas plant	Waste biogas plant	Landfill biogas plant
Sources	Animal droppings / manure and corn or grass silage to produce biogas	Food waste (like food leftovers, vegetables) or waste from fuel production (e. g. glycerine) or waste from Slaughterhouses or Breweries (brewer's grains)	Solid waste, sewage, or waste water
How	Corn silage and manure are used only in the beginning in the fermenter. Methanisation: 65% use of pig droppings, 25-40% use of cattle droppings (both sources create different H2S amounts)	Food waste, etc. are used in a fermenter to produce biogas. Methanisation: 40-70%	Anaerobic digestion by bacteria of solid waste Biogas content 40-60%, CO_2, water vapour and other gases like H2S
Where	in the countryside or in sufficient distance to settlements (odour!)	in the countryside or in sufficient distance to settlements (odour!)	Numbers decreasing due to landfill restrictions
Benefits-Problems	Preferable for bigger agricultural farms. Effective way to use slurry and corn. Legislation and investments costs have to be taken in account and availability of amount of raw materials to feed fermenter daily.	Close to cities to ensure a constant supply of waste.	Gas collection system can by plugged by rain infiltration. Accidental disposal of further waste streams (e. g. hazardous waste).

4. Create your own biogas plant: Home-made bio-reactor

The principle of a biogas plant can be experienced on-site or in the classroom on a much smaller scale.

The only materials you need are:

- a balloon

- a plastic bottle

- Fermentation material (e.g., organic household waste, corn silage, slurry)

- Water

Processing:

- Fill the bottle up to ¾ with the fermentation material

- Add slurry to it

- Add enough warm water so that the whole mixture becomes a little more liquid and comes up to temperature

- The bottle is then closed with a balloon and placed in a darkened, warm place. The bottle should be shaken gently once a day if possible.

- Wait a few days until the balloon is inflated

Picture 2. A simple experiment to produce biogas at home. [1]

Source: https://www.friedrich-verlag.de/fileadmin/bildung_plus/Friedrich_for_Future/Material_Biogasanlage.pdf

5. Quiz

This module contains a quiz. The quiz can be answered on-line, by using QR code below. The student receives per question an answer of either **correct** or **incorrect** and has to correct each wrong answer before proceeding to the next question.

(Scan with your Smartphone camera / QR Code reader app to access the quiz)

1) Biogas and biomethane are the same:

a. Yes
b. No

Answer: b

2) There is only one specific type of biogas plant:

a. Yes
b. No

Answer: b

3) Biogas production increases CO_2 emissions:

a. Yes
b. No

Answer: b

4) All biogas plants work the same:

a. Yes
b. No

Answer: b

5) The waste at a biogas plant (plant, plant silage) produces less methane than an agricultural biogas plant (plant silage, and manure):

a. Yes
b. No

Answer: a

6. Sources

[1] Built your own biogas plant - https://www.friedrich-verlag.de/fileadmin/bildung_plus/Friedrich_for_Future/Material_Biogasanlage.pdf (accessed: 11.02.2021)

[2] Plant types - https://www.archea-biogas.de/BiogasAZ/Anlagentypen/index.htm (accessed: 30.01.2021)

[3] Structure biogas plant - https://www.biogas.org/edcom/webfvb.nsf/id/DE-So-funktioniert-eine-Biogasanlage (accessed: 09.09.2021)

[4] Substrate biogas contents: https://de.wikipedia.org/wiki/Substrat_(Biogasanlage) (accessed: 11.02.2021)