The role of biogas production from wastewaters in reaching climate neutrality by 2050

This document is built together with the EBA working group "Wastewater".

Introduction

The European Biogas Association (EBA) set up a working group (WG) consisting of experts from the industry, technology providers and academia to assess the potential of biogas production from industrial liquid residues (wastewaters), towards achieving climate neutrality by 2050. The working group mapped the opportunities of producing biogas from industrial wastewaters and quantified the biogas production potential of different EU industry sectors. This work summarizes the most important outcomes highlighting **the high potential to mitigate methane emissions from wastewater whilst at the same time providing a huge potential source of renewable energy, reducing energy consumption at wastewater treatment installations, and providing needed sludge management and extra local jobs**. Finally, recommendations to untap the biogas potential from wastewaters are formulated.

Opportunities of renewable gas production from wastewaters

The collection and treatment of industrial wastewaters allow for biogas to be captured as an energy source while at the same time decreasing the GHG emissions in Europe.

Many industrial sectors such as beverage, food and paper companies produce wastewaters which are heavily loaded with organic matter (the organic load). Therefore, before discharging a purification step is required. The currently widely applied aerobic treatment (aeration) of wastewaters has a high energy consumption and greenhouse gas footprint and produces large amounts of sludge. In an anaerobic pre-treatment step a major part of the organic load can be converted to biogas. This means, introducing an anaerobic treatment step before aerobic treatment reduces the waste load of the water while producing biogas and thus reduces the need for the energy-intensive aeration as well. Renewable energy is produced and additionally, anaerobic treatment typically produced less sludge (one fifth to one tenth) compared to aerobic treatment.

When producing renewable gas from industrial wastewater, GHG emissions are saved in different ways. First, due to the reduced energy consumption in wastewater treatment installations, GHG emissions are saved. Second, GHG emissions are prevented by the replacement of fossil energy sources. Last, methane emissions are saved by bringing the wastewater in a closed and controlled environment.

(1) <u>Renewable energy production</u>

As stated above, industrial wastewaters are loaded with organic matter of which a major part can be converted to biogas. Some sectors, typically producing wastewater with high organic loads and thus high biogas potentials, are the potato industry, beer production, paper industry, food & beverage etc.

The EBA-WG demonstrated that it is possible to recover around 14 Mtoe (142 TWh) of biogas per year by valorising industrial wastewaters from the spirits, biodiesel, pulp and paper, beer, vegetable oils, ethanol, meat, and cheese sectors. The details of the calculation are given in Annex 1. According to different studies, the biogas production potential in 2050 is in the range of 87 – 114 Mtoe (1,008 – 1,326 TWh)[1]. However, most of those studies do not yet consider the large potential from industrial wastewaters, meaning biogas production potentials in Europe can even be higher than currently estimated.

[1] „Statistical report of the European Biogas Association 2020." Brussels, Belgium, January 2021.

Considering the number of anaerobic digestion facilities currently in operation in SME's (estimated around 1,000 plants in Europe), it becomes evident that market penetration at present is below 10% at EU level, which indicates that the **majority of the biogas production potential currently remains untapped.**

(2) Methane emission mitigation

Biogas production from wastewater is a methane emission mitigation technology and perfectly fits within the implementation of the methane strategy. When producing biogas from wastewater, **methane emissions are prevented by bringing the wastewater into a closed and controlled environment**.

(3) Reduced electricity consumption for wastewater treatment

Aerobe wastewater treatment plants generally have a high energy demand, especially when the organic load and thus aeration needs are high. When applying biogas production (and thus including an anaerobic treatment step) in the industrial wastewater treatment process, the organic load of the wastewater is largely reduced. This reduction of energy for the treatment is achieved by switching the waste degradation from an air-borne oxygen-based oxidation to an oxygen free fermentation process. This reduces the need of the highly energy-intensive step of oxygenation, thus largely reducing the overall energy consumption of the plant.

Aerobic treatment facilities for industrial wastewater consume up to 5-6 kWh of electricity per m^3 of wastewater, mainly for aeration. By implementing anaerobic treatment technologies, it is possible to decrease the industrial wastewaters organic load between 75% - 85%. As such, it is possible to **decrease current electricity consumption by 75%, which corresponds to approximately 3 Mtoe (32 TWh) annually at EU level.**

(4) Lower excess sludge production

Aerobic biological treatment technologies based on the widely applied activated sludge process generate large quantities of excess sludge (biosolids). Excess sludge requires treatment in form of dewatering, drying, anaerobic digestion and/or incineration and eventually becomes waste as specified in Directive 2000/532/EC and therefore requires a treatment in line with the Waste Framework Directive 2008/98/EC. When including an anaerobic treatment step, prior to or instead of aerobic treatment, the amount of sludge is significantly reduced compared to applying aerobic treatment only.

The amount of sludge produced with aerobic biological treatment technologies is calculated to be around 17 Million ton dry matter (DM) annually in Europe for industrial wastewater. By implementing anaerobic treatment technologies, it is possible to **decrease excess sludge production by up to 70-80% in most cases, meaning thus reduced cost for sludge processing as well.**

(5) Creation of local jobs

The production of renewable gas from industrial wastewaters can be economically attractive as well. According to EBA estimates, local jobs attributed to the anaerobic treatment of wastewater can grow from 1,000 direct jobs today towards **20,000 direct jobs** spread among 85,000 SME's when untapping the full potential**. Additionally, indirect jobs are created** both in the construction phase of the facilities (estimated at 14 Billion euro for plant construction at EU level), as well as in the operation of plants for e.g. the provision micro-nutrients, laboratory analysis, equipment maintenance and consumables in general.

Recommendations

To untap the full biogas production potential from wastewaters, the EBA-WG recommends the following:

1. Consider the **importance and high potential of biogas production from industrial wastewater** in upcoming European legislation and especially in the revision of the Urban Wastewater Directive and the upcoming legislation following the implementation of the Methane Strategy. And with this, **align the objectives of the Urban Wastewater Directive and the Methane Strategy with Europe's clean energy agenda.**

2. Further **incentivise the application of best practices such as anaerobic digestion** in wastewater treatment.

3. As the waste hierarchy, a **wastewater hierarchy** should be developed and implemented to ensure optimal treatment and valorisation of wastewaters. Biogas production in this respect should be strongly encouraged. EBA proposes the following wastewater hierarchy:

    1. **Prevention**: produce as little wastewater as possible
    2. **Reuse** of water in production processes where possible
    3. Treatment of wastewater **with energy recovery**
    4. Treatment of wastewater **without energy recovery**

4. Promote and prepare legislation for **centralised industrial wastewater treatment**. As the CAPEX is at present an important barrier for anaerobic treatment in small facilities, centralised industrial wastewater treatment should be incentivized, combining wastewater from different smaller companies. Hereby the economic feasibility of anaerobic treatment is increased. These centralized facilities could be installed either in industrial parks or at municipal wastewater treatment plants. The amount of biogas produced from municipal wastewater treatment plants can be increased significantly with co-processing of industrial wastewater rendering these facilities as energy and carbon neutral.

5. **Grant CAPEX support for biogas production from industrial wastewater under the European Regional Development Fund (ERDF)**. To achieve the biogas production potential from wastewaters, the enterprises need to make (potentially high) initial investments such as replacing conventional technologies. The cost (CAPEX + OPEX) for biogas production varies between bigger and smaller plants, with the bigger ones having higher potential to achieve more with less effort. As it is currently in Europe difficult to have access to funding for these investments, the EBA asks to further incentives CAPEX support granted under the ERDF by Member States.

ANNEX 1: Calculation of biogas production potential from industrial wastewater

To calculate the biogas production potential from industrial wastewater, as a first step the most important SME sectors (EU enterprises) for possible implementation of anaerobic digestion technologies were identified. Next, for each sector the yearly amount of product produced (in ton) was multiplied with the amount of wastewater (in m³) produced per ton of product, arriving at the amount of industrial wastewater produced per sector.

Next, the produced amount of industrial wastewater per sector is multiplied with the Chemical Oxygen Demand (COD) in kg COD per m³ of wastewater and further multiplied with the biogas yield in m³ of biogas per kg COD to finally arrive at the total amount of biogas produced per sector. The COD per m³ of wastewater and the biogas yield are different for each of the investigated sectors. The details of the sectors included in the calculation as well as the specific parameters used for each sector are given in Table 1.

For calculating the final amount of biogas produced from industrial wastewater in Europe a methane content of 65% percent of the biogas is assumed and a conversion factor of 10,61 kWh per m³ of methane is used. The potential biogas production from industrial wastewater for each of the investigated sectors is given in the last column of Table 1. The total biogas production potential from industrial wastewater in Europe is calculated as 142 TWh per year, equivalent to 14 Mtoe.

Table 1: Detailed calculation of biogas production potential from industrial wastewater in Europe

	Product produced (ton product/year)	Industrial wastewater produced (m³ wastewater/ ton product)	Chemical Oxygen Demand (kg COD/m³ wastewater)	Biogas yield (m³ biogas/kg COD)	Total amount of biogas produced (m³ biogas / year)	**Biogas production potential (TWh/year)**
Cheese production (37% milk)	8,202,728	13	6	0.5	319,906,392	**2.2**
Butter production (29% milk)	2,600,350	13	6	0.5	101,413,650	**0.7**
Ice-cream production (13% milk)	3,366,210	13	6	0.5	131,282,208	**0.9**
Beer production	40,593,800	3	5	0.5	304,453,500	**2.1**
Wine production	15,800,000	4	6	0.5	189,600,000	**1.3**

Spirits production	2,400,000	15	30	0.5	540,000,000	**3.7**
Ethanol production	5,505,000	15	30	0.5	1,238,625,000	**8.5**
Pulp production	36,000,000	30	9	0.5	4,860,000,000	**33.5**
Juice production	11,359,571	7	5	0.45	178,913,243	**1.2**
Tomato ketchup and sauces	2,727,000	7	6	0.45	51,540,300	**0.4**
Meat from bovine	7,590,000	7	7	0.5	185,955,000	**1.3**
Meat from pigs	22,958,000	7	7	0.5	562,471,000	**3.9**
Meat from sheep	724,000	7	7	0.5	17,738,000	**0.1**
Frozen potatos prepared	5,383,000	7	4	0.5	75,362,000	**0.5**
Potatos prepared or preserved (crisps)	2,200,000	7	5	0.5	38,500,000	**0.3**
Potato starch	1,234,000	7	5	0.5	21,595,000	**0.1**
Dried potatos, flour etc	476,000	7	5	0.5	8,330,000	**0.1**
Sugar production	18,047,000	1	5	0.5	45,117,500	**0.3**
Yeast production	1,000,000	7	30	0.35	73,500,000	**0.5**
Vegetable oils production	17,227,000	5	50	0.4	1,722,700,000	**11.9**
Biodiesel production	11,000,000	30	60	0.5	9,900,000,000	**68.3**
TOTAL						**142**