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BIOGAS STATIONS AND THEIR ENVIRONMENTAL IMPACTS

ELEKTRANE NA BIOPLIN I NJIHOV UTJECAJ NA OKOLIŠ

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Abstract

The article summarizes the authors' experience with environmental impact assessment in branch of biogas plants. The introductory part of the paper describes legislative obligations of the Czech Republic concerning the fulfilment of the European Union's limits as for utilization of renewable energy resources. The next parts of the paper deal with an impact analysis of biogas plants on the environment. The final part of the paper deals with experience with implementation of the environmental impact assessment process in the field of biogas plants in the Czech Republic.

Sažetak

Članak objedinjuje iskustvo autora u procjeni utjecaja na okoliš elektrana na bioplin. U uvodnom dijelu rada da obrađene su zakonske obveze Republike Češke s obzirom na ispunjavanje zahtjeva Europske unije vezano uz korištenje obnovljivih izvora energije. Sljedeći dio rada se odnosi na analizu utjecaja elektrana na bioplin na okoliš. Posljednji dio rada obrađuje dosadašnja iskustva u procjeni utjecaja na okoliš elektrana na bioplin u Republici Češkoj.

Introduction

From the legislative point of view, required utilisation of energy from biogas stations is accounted for by the Czech Republic's duty to meet the European Union limits in the sphere of exploitation of alternative energy sources (Directive No 2001/77/EC).

The targets and conclusions of the above mentioned Directive 2001/77/EC, concerning utilisation of renewable energy resources, were implemented into the State Energy Policy of the Czech Republic as well as the Czech Act No 180/2005 Coll.

The implementation of biogas stations has a positive impact in meeting the targets, making use of renewable energy sources, or fulfilment of the indicative target of a share of electricity from renewable resources in gross electricity consumption in the Czech Republic in the amount of 13 % as of 2020. Currently, within the European Union the percentage of energy production from renewable resources is anticipated in the average amount of 20 % in 2020. Some countries expect higher shares of renewable energy in total energy production (e.g. Sweden 49 %, Lithuania 42 %).

Nevertheless, the above mentioned value of 13 % (for the Czech Republic) is currently a discussion topic in the Czech Republic.

Biogas stations

According to the processed substrate (biowaste, grown biomass), biogas stations (BGS) can be classified as follows (Lapčík, 2009):

- agricultural,
- sewage treatment,
- other.

Agricultural BGS

Agricultural biogas stations are such biogas stations that process material of a plant character and dung, or bedding material. In such biogas stations it is not possible to process waste or other materials that come under Regulation (EC) 1774/2002. In the agricultural biogas stations, the following materials can be processed: *animal materials* (pig semi-liquid manure, pig dung with bedding material, cattle semi-liquid manure, cattle dung with bedding material, dung and bedding material from breeding of horses, goats and rabbits, poultry dejecta including bedding material, etc.), *plant materials* (straw of all types of cereal and oil plants, chaff and residues from cereal refining, potato haulm and peel, haulm from mangel-wurzel and sugar beet, corn straw and grains, grass biomass or hay - haylage, non-feedable plant materials – ensilage, cereal, corn etc.) and *grown biomass* (cereal in lactic ripeness [whole plants] fresh and silaged, corn in wax ripeness [whole plants] fresh and silaged, ripe corn [whole plants] fresh and silaged, fodder cabbage [whole plants] fresh and silaged, “stick” biomass – chips or shreddings from deciduous woody plants of short rotation intensive cultures, etc.).

Sewage treatment BGS

Sewage treatment BGS process only sewage sludge and make an inseparable part of wastewater treatment plants. The technologies of anaerobic digestion are used for the purposes of anaerobic stabilization of the sludge formed in the wastewater treatment plants (WTPs). Those technologies are not designed to process biowaste or for waste disposal, but function as a part of WTP sludge management as a whole. No other materials than sludge from WTPs, septic tanks and cesspits or waste water get into this facility. In case other waste under Czech Waste Act is added into such tanks for anaerobic digestion, it is a case of different kind of biogas station. The given facility is then subject to all requirements of Czech Waste Act and its implementing regulations.

Other BGS

These biogas stations process other biowaste. If BGS process animal by-products (ABP), they are subject to Regulation (EC) 1774/2002 and must comply with the conditions therein, such as hygienization of waste or other feedstock (pasteurization, high-temperature hygienization).

A biogas station is a facility which makes use of renewable resources or organic waste (see above) for the production of biogas in the anaerobic way – fermentation. Biogas is entrapped and burnt in a cogeneration unit with generation of electricity and heat. Apart from biogas, the output product of the anaerobic fermentation process is also digestate, which solid and liquid components can be separated. Both of the components are utilizable as fertilizers in agriculture. After authorized certification of the digestate as a fertilizer, the digestate is no more considered as waste by course of Czech Waste Act. However, until authorized biogas station certification of digestate as a fertilizer, it is necessary to comply with Czech Waste Act and, in particular, Decree of the Czech Ministry of the Environment (CMoE) No 382/2001 Coll.

In Table 1 the most common composition of biogas from anaerobic fermentation that is combusted in a co-generation unit is stated. (Bauer, 2007).

Table 1 Biogas composition
Tablica 1. *Sastav bioplina*

Component	Volume percentage (%)
Methane (CH_4)	40 – 80
Carbon dioxide (CO_2)	14 - 55
Nitrogen (N_2)	0 - 20
Oxygen (O_2)	0 - 2
Hydrogen (H_2)	0 - 1
Ammonia (NH_3)	0 - 1
Hydrogen sulfide (H_2S)	0 - 2

Jenbacher (concern GE – Figure 1), MAN or Deutz company units are often used as compact cogeneration units. In principle, a cogeneration unit consists of an internal-combustion engine (it has 12 or more cylinders) and a electric current generator (voltage of 0.4 kV and frequency of 50 Hz) (Bauer, 2007).

For example, a cogeneration unit of GE Jenbacher JMS 412 GS-B.LC, which has a consumption of 403 m_n^3 biogas per hour and is designed for biogas combustion with 50 to 65 % methane content, has an electric output of 844 kW and a heat output of 789 kW (the heat output is usually higher than the electric one in case of older facilities) (Lapčík, 2009). The overall efficiency of cogeneration is 81 %, calorific efficiency of a facility is 39.1 % and the electric efficiency is 41.9 % (see Figure 1 – it is an older cogeneration unit of different parameters). The consumption of electricity for the operation of a biogas station is approximately 5 to 6 % of the generated electric energy.

The given cogeneration unit is suitable for a biogas station that processes approximately below 30 000 tons of biomass or biowaste per year (Lapčík, 2009).

Figure 1 Cogeneration unit GE Jenbacher – photo by authors.
Slika 1. *Kogeneracijska jedinica GE Jenbacher – fotografirao autor.*

Environmental impact analysis of biogas stations

Assessing the environmental impacts of biogas station projects the following factors must be taken into consideration (Lapčík, 2009):

- impacts on the atmosphere,
- noise,
- impacts on the surface and ground water,
- impacts on the soil,
- impacts on the landscape and face of the landscape,
- other impacts.

Impacts on the atmosphere

The major point source of pollution in a biogas station is a cogeneration unit combusting biogas. The quantity of emissions from biogas combustion is, in the majority of cases negligible. In order to achieve maximum reduction of negative impacts of exhaust gases on the atmosphere there is a desulphurization plant for the produced gas. To calculate emissions from a cogeneration unit, emission limits for combustion sources – piston combustion engines – must be applied, the construction or conversion of which has started after 17 May 2006 by Government Decree No 146/2007 Coll. (article 2.B of Appendix 4). In accordance with CMoE Decree No 13/2009 Coll. no sulphur contents in the fuel have been determined for gases.

Among line sources of pollution there is transport of waste into the biogas station and transport of the produced fertilizers by approximately 20 trucks (daily) with bearing capacity 8 tons, as well as arrivals of cars driven by the crew and visitors (approx. 10 daily). The amount of emissions from transport is negligible.

It is odour which is assessed as one of the most disputable environmental impacts of biogas stations.

If only methane, carbon dioxide or water vapour were formed during anaerobic decomposition of organic compounds, there would be no problem with odour emissions. As this is not the case, gaseous products from other biochemical processes arise, which produce the biogas's scent. Primarily, it is the matter of hydrogen sulfide, ammonia and other gases with negative odour effects. They are the waste composition at the entry into the fermenter. This implies that various types or kinds of biogas facilities jeopardise the surroundings with odour emissions of different intensity.

The problems with odour mostly occur in *older biogas stations* or *more recent biogas stations* that were established through reconstruction of already existing facilities (e.g. of particular parts of agricultural premises). Such facilities predominantly comprise only one fermenter, a gasholder, pumped-storage reservoir, digestate's storage (in many cases it used to be a reservoir for semi-liquid manure) and cogeneration units. There is no hermetization or other equipment to reduce odour substances (hermetization of the means of transport and handling). In this case the biogas yield is approximately 50 % (Bauer, 2007).

Figure 2 A view of steel tube fermenters (top) and a concrete fermenter (bottom) – BGS Zwentendorf (Austria) - photo by authors.
Slika 2. *Pogled na čelične cilindrične fermentore (vrh) i betonski fermenter (dno) – BPS Zwentendorf (Austrija) – fotografirao autor.*

On the other hand, technically advanced biogas stations (Bauer, 2007) that function with a biogas yield of as much as 95 % mostly comprise of steel tube fermenters (see Figure 2), concrete main fermenters, secondary fermenter, gasholder, digestate's storage (concrete reservoir which may be covered) and cogeneration units. Lumpy organic waste (grass and plant residues, semi-liquid manure, food leftovers and used fat, soil water, etc.) is mainly transported into an acceptance hall. These premises are enclosed and the exhausted air from the premises is conducted into a biological filter in order to remove the odour (Lapčík, 2009).

Waste hygienization, if necessary according to the requirements of a relevant European Union Regulation (EC 1774/2002), is predominantly carried out in technically advanced facilities throughout heating up to the temperature of 70°C for one hour in double-skin stainless vessels.

The issue of odour emissions is subject to the provisions of Czech Act No 86/2002 Coll., as amended. This act is followed by Decree of the Czech Ministry of the Environment No 205/2009 Coll.

Own measuring of odours is handled by Decree of the Czech Ministry of the Environment No 362/2006 Coll. The determination of odour substance concentration is carried out by course of § 2 of the Decree No 362/2006 Coll. in stationary sources stated in the Appendix thereof, applying a procedure set by the Decree No 362/2006 Coll. and a Czech technical norm of ČSN EN 13725. The final odour situation evaluation (mostly applying olfactometric measurement) must be executed within a test run.

The majority of technically advanced biogas stations *are not sources of odour* emitted into the surroundings. Nevertheless, it must be pointed out that the working regulations of a biogas station must include a description of places of possible emergence of odour substances emissions and a description of adopted technical-organizational measures to prevent their formation and to trap odour substances emissions during ordinary operations as well as during emergencies in the facility (see article 1, letter e) of Appendix 4 to Decree of CMoE No 341/2008 Coll.).

Noise

As for noise from a biogas station it must be stated that its assessment is implemented by means of a noise study that evaluates noise level at the nearest built-up area. With regard to considerable distance from residential areas (250 metres), the noise impacts are not significant (noise level is 28 dB, noise limit is 50 dB – daytime). Moreover, a cogeneration unit is situated in a soundproof, insulated engine hall. The unit is of a compact version with an engine and generator placed on a flexible base plate. Other parts are an exhaust heat exchanger and an exhaust muffler.

The impact of noise from transportation and its changes in relation with construction and later operation of biogas stations is shown mainly during the daytime in the surroundings of the access road where transport takes place. If the calculation points (near residential areas), as for which the calculation of noise from stationary sources is carried out, are remote more than 100 metres from the road, it is necessary to describe changes in the noise situation in the noise study through changes in the equivalent noise levels in a standardized distance from roads (e.g. 7.5 m from the axis of the nearest lane) (Lapčík, 2009).

Impacts on the surface and ground water

The construction of a biogas station shall endanger neither surface nor ground water.

Process wastewater. There is no process wastewater produced during biogas production. After fermentation the digestate is processed and the service wastewater (permeate) is reused in the technological process. Its possible surplus can be applied anywhere as after two-stage reverse osmosis the water quality shall be of satisfactory indexes for service water.

Sewage.The arising soil water is mostly drained into a house wastewater treatment plant. The treated water is followingly conducted into an influent stream or the waste water drainage.

***Rainwater**.* Uncontaminated rainwater from the hall's roof is drained into an influent stream or rain water drainage.

Impacts on soil

The construction sites of biogas stations are very often situated into wearing out agricultural premises, former industrial premises or the construction is designed on a "green field" within new industrial complexes. Even in the last case not much land gets occupied as, in the majority of cases, for the construction of a biogas station a sufficient piece of land is of 4 to 5 thousand m^2 (Lapčík 2009).

At relevant processing, biogas station products (fertilizers) return nutrients back into the agricultural land. Therefore, it may be stated that operation activities of a biogas station do not affect soil (if admittedly there is no unrestrained deposition of unprocessed digestate in thick layers onto the agricultural land, which sometimes happens).

The rock environment does not get affected by the assumed activities. The impact on mineral resources is not manifested either.

Impacts on landscape

In most cases, biogas stations do not influence the face of the landscape in the negative way as they are often situated in a locality where agricultural or industrial premises are situated. In case of an alone construction, e.g. on an elevated place, an impact assessment study on the face of the landscape would be necessary (Lapčík, 2009).

Other impacts

Among other impacts it is possible to rank, for example, the issue of land used for the application of liquid and solid digestate.

Nevertheless, it must be emphasized that in all the cases a production of fertilizers, which may be implemented in a commercial way, must be preferred to a mere application of the output substances from the fermentation process on the surrounding fields.

Note: A description of remediation digestate handling, including a specific handling method of digestate made during accidents or emergencies, must be incorporated into the working regulations of a biogas station (See article 1, letter e) of Appendix 4 to Decree No 341/2008 Coll.).

The impacts on the fauna, flora and territorial system of ecological stability are negligible with regard to prevailing locations of biogas stations into already used agricultural or industrial zones.

Conclusions

As described above, in biogas stations it is odour which is one of the most controversial environmental impacts. Certain legislative measures, either in the phase of preparation or already passed, aim to reduce odour emissions in the currently operated as well as newly established biogas stations (Pastorek, 2008):

- Methodical directive No 12 of the Czech Ministry of the Environment (Department of Atmosphere Protection), on the conditions of biogas station approvals before being put into operation,
- Compulsory registration of the digestate as a fertilizer (by course of Czech Act No 156/1998 Coll., on fertilizers, as amended),
- Determination of limit odour emission values for biogas stations, apart others,
- Price decisions of the Energy Regulatory Office (ERO) privileging agricultural biogas stations,
- Decree of the CMoE No 362/2006 Coll., on the determination method of odour substance concentrations.

Unfortunately, the general public in the Czech Republic predominantly and automatically perceive biogas stations as potential sources of strong odour. This is explained by a past experience when only technologically imperfect biogas stations with no hermetization were built (mostly through reconstructions) with no odour substances reduction equipment, which led to high emissions of odour into the surroundings. Nowadays, it is very difficult to persuade the public that there are technologically advanced facilities that guarantee odour free operations at concurrent high biogas yields.

In accordance with Appendix 1 to Czech Act No 100/2001 Coll., as amended, it is possible to classify the biogas station projects into category II (projects requiring rogatory proceedings) article 10.1 *(Facility for storing, treatment and utilisation of hazardous waste; facility for physical–chemical treatment, energetic utilisation or disposal of other waste)*. The responsible authority to carry out the rogatory proceedings or the overall environmental impact assessment process is the relevant regional office.

If useful heat production of a BGS facility (cogeneration units) is over 0.2 MW, the project is at the same time an under-limit project (i.e. nominal thermal output is under 50 MW) by course of article 3.1 *(Facility for fuel combustion of a rated useful heat from 50 to 200 MW)*, category II of Appendix 1 to Czech Act No 100/2001 Coll., as amended. The responsible authority to make the decision whether fact-finding procedures will be necessary or not in case of an under-limit project (subject to amendment No 216/2007 Coll.) is the relevant regional office which may decide for the project to undergo the overall environmental impact assessment process in the following stages. At present, biogas stations projects are frequently classified into this category.

With regard to the above mentioned public attitude toward biogas stations, the environmental impact assessment process for such facilities is protracted and problematic. In the majority of cases, the overall assessment process must be taken into account (an under-limit project notification processing or a notification by course of Appendix 3a or 3 to Act No 100/2001 Coll., as amended, fact-finding procedures, documentation compilation, expert report elaboration, public hearing) despite the fact that the law hypothetically permits a mere notification of an under-limit project or subjects the project to fact-finding procedures only. This way, the officiating process is finished in the so-called accelerated proceedings or the project is not assessed at all (under-limit project).

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