KEY FACTORS FOR THE SUSTAINABLE USE OF BIOGAS - LIFE CYCLE ASSESSMENT OF AUSTRIAN BIOGAS PLANTS

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ABSTRACT: This paper gives an overview on the Austrian research project "Ökobilanz Biogas". The goal is to evaluate the environmental impacts of biogas systems for different types of feedstock based on real life data from biogas plants in operation. The methodology used for the evaluation is life cycle assessment (LCA). A comprehensive LCA is performed for six different biogas systems. Besides the whole supply chain for the production and use of biogas the reference use of the agricultural area for the cultivation of energy crops, the reference use of residues and the use of digestate as fertilizer were included in the assessment. Based on the results of the LCA key factors for the sustainable use of biogas will be identified.
Keywords: biogas, environmental impact, life cycle assessment

Biogas is produced by fermentation processes from biomass resources. As a renewable energy carrier biogas may be used for heat and electricity generation or in an upgraded form as "biomethane" as fuel or to substitute natural gas.

To evaluate the environmental effects of the biogas production and to determine critical factors for a sustainable use of the biogas technology a life cycle assessment (LCA) is performed for existing biogas plants in Austria. The environmental impacts of the following processes are investigated: the production and collection of raw materials, the fermentation of the materials in a biogas plant and the use of biogas and fermentation residues. Furthermore, the LCA includes the environmental impacts of construction, operation and dismantling of all components of the biogas plants.

It was also taken into account that the raw materials or areas could have been assigned to a different use (e.g. cultivation of corn as animal feed, composting of organic residues) before the investigated biogas system was implemented.

To evaluate the environmental impact of the biogas systems they are compared to reference systems, which provide the same amount on energy for the end user as the biogas system. In this assessment conventional and renewable energy systems are considered (electricity, heat and fuel from fossil and renewable energy sources).
At the production of biogas digestate is generated as a by-product. The use of the digestate as fertilizer is also part of the LCA.

The data for the LCA is based on operational data from six Austrian biogas plants. The biogas is used for combined electricity and heat generation. In one case biogas is upgraded to biomethane and injected into the natural gas grid. Within the investigated plants mixtures of following raw materials are used:

- Energy crops (e.g. corn silage, grass silage)
- Liquid manure (e.g. cattle, pig)
- Organic residues (e.g. fruit residues, vegetable residues)

The LCA considers the following environmental impact categories:

- Cumulated fossil (primary) energy demand
- Global warming potential of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) measured in carbon dioxide-equivalents (CO_2-eq.)
- Acidification potential of sulphur dioxide (SO_2), nitrogen oxide (NO_x) measured in sulphur dioxide-equivalents (SO_2-eq.)
- Ozone creation potential of carbon monoxide (CO), non-methane volatile organic compounds (NMVOC), nitrogen oxide (NO_x), methane (CH_4) in ethane-equivalent (C_2H_4-eq.)
- Particulate emissions
- Agricultural land area demand

The LCA is performed using the model GEMIS (Global Emission Model for Integrated Systems).

The LCA results show the environmental effects of the investigated biogas plants compared to the reference systems. Based on this information the key factors for the sustainable use of biogas technology are determined. It is shown under which circumstances the environmental benefits are maximised and the environmental impacts are minimised.

Based on the project results described above a second environmental assessment of biogas is performed within the project "Virtual biogas - Ecological, economic and socio-scientific assessment of biogas". In this project the focus is the evaluation of biomethane. Biomethane is upgraded biogas in a quality comparable to natural gas, which can be injected into the natural gas grid. For ten different scenarios the economical, ecological and sociological impacts are evaluated.

The work for this paper was conducted in the Austrian projects "Ökobilanz Biogas - Erfolgsfaktoren zur nachhaltigen Nutzung der Biogastechnologie am Beispiel ausgewählter Biogasanlagen" and "Virtuelles Biogas - Ökologische, ökonomische und sozialwissenschaftliche Gesamtbetrachtung von Biogas" which are financed by the Austrian Climate and Energy Funds within the framework of the programme "Energy systems of tomorrow".