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Dynamic energy LCA-based assessment approach to evaluate energy intensity and related impact for the biogas CHP plant as the basis of the environmental view of sustainability

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Abstract

Biogas production is a promising renewable energy which can be used to achieve environmental sustainability. There are however many improvements that can still be made to the process or technology to increase energy efficiency. Dynamic energy life cycle approach integrating life cycle assessment and life cycle cost could be therefore a tool for evaluating energy intensity and related environmental impact of biogas CHP plant.

The aim of the paper is to evaluate the energy intensity of a biogas CHP system, based on energy flow and estimated associated costs. This paper provides the energy requirements in the plant identify the critical point of the digestion process and estimate the amount of CO_2 associated with the energy. The results of the study assist in 20% of heat reduction. For companies, energy LCA primarily serves to assist decision-making with a view to environmental sustainability.

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Keywords: biogas CHP plant; digester; environmental sustainability assessment; energy life cycle assessment; life cycle cost

1. Introduction

The production of biogas and other types of energy that can be produced from biogas encloses various energy flows from the production of resources for anaerobic digestion to the use of the produced energy and the utilization of the

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produced digestion. Under a variety of different conditions, it is not practicable to track and evaluate the energy (both electricity and heat). All energy flows are encompassed by life cycle analysis (LCA) which is seen as a method based on a well-established and standardized methodology [1]. LCA essentially identifies the environmental effects caused by a product over its whole life cycle. Through LCA can the larger environmental image be quantified and compared over their life cycle to find alternatives that benefit cost alike [2, 3]. As a consequence, a more efficient use of (renewable) energy can play a key role for the development of more sustainable production systems. But when dealing with analyzing each unit process treated as a complex energy system, it is difficult to translate process information into environmental objectives, incorporating environmental and economic issues of the sustainability. Limitation in the use of LCA is provided by the graphical representation, which was designed to provide separate indicators [4]. Hence, recent literature suggests the development and design of methods for environmental considerations, pointing out the opportunity to incorporate LCA into process analysis [5] or energy projects [6]. The integrated environmental sustainability approach, presented in [7] is not a long stretch from comprehensive and ambitious forms of environmental impact assessment in which "environment" is defined to include economic, components and their interactions [6]. This approach could be also extended to include energy issues as a separate component not considering in generic LCA-methodology. Usually, LCA aims to account for all material flows, direct or indirect, induced by an energy cycle. This method is also called dynamic energy life cycle assessment (eLCA) or life cycle energy assessment. This approach could be justified for energy generation.

Dynamic is expressed that the study is to determine the technical requirements and economic feasibility of an upgrade of operation of the biogas CHP on the U.S. farm in terms of eLCA and environmental Life Cycle Cost (envLCC). A target oriented of the small sized combined heat and power system (CHP) is modelled considering the future energy characteristics and presenting against the background system. With regard to this, there is no agreed methodology for assessing the energy effects and related impact for the biogas CHP system from a dynamic energy LCA-based assessment approach combining eLCA and LCC analysis so far. However, lack of clear arguments for unambiguous calculation rules for attributing CO_2 emissions to heat and electricity is currently missing [8]. Accordingly, there is a need for an assessment method to evaluate energy intensity and environmental impact as a basis for the environmental view of sustainability. Nonetheless, while the actual measurement of energy impact on environmental sustainability remains an open question, a novel approach to energy intensity assessment is being developed. The following questions then arise:

- What is the improvement potential in terms of energy of the biogas CHP plant?
- Which of environmental and inherent impacts can be causally attributed to energy?

The aim of this study is to assess the energy use by the biogas CHP farm in the U.S., based on in order to improve thermal conditions in the bio-digester.

1.1. Boundary system and methodology

This system boundary was chosen deliberately, because the energy balance is characterized by significant losses due to plant energy system. The environmental sustainability assessment of technologies was combined with eLCA and environmental LCC. This approach has been expanded to derive recommendations for an upgrade or to retrofit existing system. An extension of that approach is to consider energy minimization in LCA-based assessment by setting targets for minimum energy use while concurrently taking into account heat recovery arrangements. The following dynamic energy LCA is based on energy flow analysis and shall be regarded as an estimate of magnitude of possible impact reductions in the time span.

The scope of the eLCA-based assessment was based on energy flow analysis and related impact for CHP system as the basis of the environmental view of sustainability. It will determine the environmental impact required to perform the remediation of biogas system operation and the system`s upgrade. The system boundary includes an improvement of thermal conditions insight the bio-digester of farm plant based on heat recovery from manure rejected. The eLCA approach has been typically used to present energy flows associated with the biogas digest operation and the system`s upgrade. Hence, in this paper, the objective of the eLCA-based assessment methods is durable betterment rather than mere mitigation of significant adverse effects.

Consistent for both scenarios, the boundary of the eLCA within is shown in Fig. 1. Impacts related to the two components have been disaggregated to get the transparency of the study and to define a dominance analysis referring to the main components of the plant. The results are presented for the impact categories: greenhouse gases