World Academy of Science, Engineering and Technology
International Journal of Mathematical and Computational Sciences
Vol:14, No:12, 2020

Combination of Modelling and Environmental Life Cycle Assessment Approach for Demand Driven Biogas Production

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Abstract : — One of the biggest challenges the world faces today is global warming that is caused by greenhouse gases (GHGs) coming from the combustion of fossil fuels for energy generation. In order to mitigate climate change, the European Union has committed to reducing GHG emissions to 80–95% below the level of the 1990s by the year 2050. Renewable technologies are vital to diminish energy-related GHG emissions. Since water and biomass are limited resources, the largest contributions to renewable energy (RE) systems will have to come from wind and solar power. Nevertheless, high proportions of fluctuating RE will present a number of challenges, especially regarding the need to balance the variable energy demand with the weather dependent fluctuation of energy supply. Therefore, biogas plants in this content would play an important role, since they are easily adaptable. Feedstock availability varies locally or seasonally; however there is a lack of knowledge in how biogas plants should be operated in a stable manner by local feedstock. This problem may be prevented through suitable control strategies. Such strategies require the development of convenient mathematical models, which fairly describe the main processes. Modelling allows us to predict the system behavior of biogas plants when different feedstocks are used with different loading rates. Life cycle assessment (LCA) is a technique for analyzing several sides from evolution of a product till its disposal in an environmental point of view. It is highly recommend to use as a decision making tool. In order to achieve suitable strategies, the combination of a flexible energy generation provided by biogas plants, a secure production process and the maximization of the environmental benefits can be obtained by the combination of process modelling and LCA approaches. For this reason, this study focuses on the biogas plant which flexibly generates required energy from the co-digestion of maize, grass and cattle manure, while emitting the lowest amount of GHG´s. To achieve this goal AMOCO model was combined with LCA. The program was structured in Matlab to simulate any biogas process based on the AMOCO model and combined with the equations necessary to obtain climate change, acidification and eutrophication potentials of the whole production system based on ReCiPe midpoint v.1.06 methodology. Developed simulation was optimized based on real data from operating biogas plants and existing literature research. The results prove that AMOCO model can successfully imitate the system behavior of biogas plants and the necessary time required for the process to adapt in order to generate demanded energy from available feedstock. Combination with LCA approach provided opportunity to keep the resulting emissions from operation at the lowest possible level. This would allow for a prediction of the process, when the feedstock utilization supports the establishment of closed material circles within a smart bio-production grid – under the constraint of minimal drawbacks for the environment and maximal sustainability.

Keywords : AMOCO model, GHG emissions, life cycle assessment, modelling
Conference Title : ICSRD 2020 : International Conference on Scientific Research and Development
Conference Location : Chicago, United States
Conference Dates : December 12-13, 2020