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CO_2 Recovery from Biogas and Successful Upgrading to Food-Grade Quality: A Case Study

Authors : Elisa Esposito, Johannes C. Jansen, Loredana Dellamuzia, Ugo Moretti, Lidietta Giorno

Abstract : The reduction of CO_2 emission into the atmosphere as a result of human activity is one of the most important environmental challenges to face in the next decennia. Emission of CO_2, related to the use of fossil fuels, is believed to be one of the main causes of global warming and climate change. In this scenario, the production of biomethane from organic waste, as a renewable energy source, is one of the most promising strategies to reduce fossil fuel consumption and greenhouse gas emission. Unfortunately, biogas upgrading still produces the greenhouse gas CO_2 as a waste product. Therefore, this work presents a case study on biogas upgrading, aimed at the simultaneous purification of methane and CO_2 via different steps, including CO_2/methane separation by polymeric membranes. The original objective of the project was the biogas upgrading to distribution grid quality methane, but the innovative aspect of this case study is the further purification of the captured CO_2, transforming it from a useless by-product to a pure gas with food-grade quality, suitable for commercial application in the food and beverage industry. The study was performed on a pilot plant constructed by Tecno Project Industriale Srl (TPI) Italy. This is a model of one of the largest biogas production and purification plants. The full-scale anaerobic digestion plant (Montello Spa, North Italy), has a digestive capacity of 400.000 ton of biomass/year and can treat 6.250 m3/hour of biogas from FORSU (organic fraction of solid urban waste). The entire upgrading process consists of a number of purifications steps: 1. Dehydration of the raw biogas by condensation. 2. Removal of trace impurities such as H_2S via absorption. 3.Separation of CO_2 and methane via a membrane separation process. 4. Removal of trace impurities from CO_2. The gas separation with polymeric membranes guarantees complete simultaneous removal of microorganisms. The chemical purity of the different process streams was analysed by a certified laboratory and was compared with the guidelines of the European Industrial Gases Association and the International Society of Beverage Technologists (EIGA/ISBT) for CO_2 used in the food industry. The microbiological purity was compared with the limit values defined in the European Collaborative Action. With a purity of 96-99 vol%, the purified methane respects the legal requirements for the household network. At the same time, the CO_2 reaches a purity of > 98.1% before, and 99.9% after the final distillation process. According to the EIGA/ISBT guidelines, the CO_2 proves to be chemically and microbiologically sufficiently pure to be suitable for food-grade applications.

Keywords : biogas, CO_2 separation, CO2 utilization, CO_2 food grade
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