# Exploitation of by-products from biogas plants for greenhouse heating

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Greenhouse cultivation is a growing sector in agriculture, primarily due to its ability to adapt growing conditions and optimize resource utilization, leading to increased economic advantages for producers. However, a significant concern regarding the economic feasibility of greenhouses relates to the energy expenses required for maintaining the desired temperature within the greenhouse environment. Specifically, the costs associated with heating and cooling in greenhouses may end up to 70-85% of the operational expenditures (Ahamed et al., 2019). Currently, the majority of existing greenhouses rely on fossil fuels for heating, which not only contributes to environmental pollution but also incurs substantial costs due to rising gas and oil prices (Ntinas et al., 2020). Consequently, many producers are exploring alternative energy sources to meet the winter heating requirements of greenhouses. A promising solution for cost-effective and environmentally friendly heating is the utilization of biogas derived from production plants, coupled with combined heat and power (CHP) systems. By capturing and utilizing the heat and electricity generated by the CHP system, greenhouse operators can significantly reduce energy costs. This approach offers a synergistic relationship between biogas production and greenhouse cultivation, enabling the reuse of energy and the recycling of carbon and other inorganic substances (Ntinas et al., 2021). Particularly in small-scale biogas plants, located in remote or rural areas, this symbiotic relationship proves highly attractive. For large-scale biogas plants, it is advisable to maximize heat utilization by establishing connections via pipelines with adjacent industries or residential areas (Vallios et al., 2009). Alternatively, combining the heat from biogas with other energy sources can enhance overall efficiency and optimize energy utilization.

This study focuses on the initial findings from a pilot-scale demonstration that explores the energy recuperation capabilities of a biogas plant for the purpose of greenhouse heating. Specifically, the study examines the energy requirements of a greenhouse cultivating tomato plants, along with the technical characteristics of the combined heat and power (CHP) system employed. Additionally, experiments were conducted to assess the biogas production potential of various feedstocks used in the plant, aiming to identify the most effective feed mixture that maximizes energy recovery.

Based on the available construction and meteorological data for the specific region, the pilot greenhouse being investigated, situated within the premises of BIOGAS CHALKIDIKI, exhibits a heating demand of 13.33 kW. After considering the technical specifications of the currently utilized combined heat and power (CHP) system, it has been determined that the most suitable exhaust gas exchanger for compatibility is the INNIO Jenbacher model N-25-300/2000-1H-1AX-P. This particular exchanger is designed in a horizontal configuration and possesses the capability to handle the entire exhaust gas output from the biogas plant, generating a heat output of 231 kW. Notably, the efficiency of this heat exchanger surpasses the heating requirements of the greenhouse facility.

These findings are significant in the context of energy recovery systems for greenhouse environments. The compatibility of the selected exhaust gas exchanger with the CHP system and its ability to supply sufficient heat output present promising opportunities for optimizing energy utilization. The excess heat generated by the biogas plant can be efficiently harnessed to meet the greenhouse's heating demands, resulting in enhanced energy efficiency and cost-effectiveness.Furthermore, the compatibility and high efficiency of the exhaust gas exchanger contribute to the overall feasibility of employing biogas-based energy recovery systems in greenhouse applications. The utilization of such systems can lead to significant reductions in greenhouse gas emissions, as well as reliance on fossil fuels for heating purposes. Additionally, the findings highlight the potential for scaling up and implementing similar systems in larger greenhouse facilities, considering the adaptability and efficacy demonstrated by the current pilot-scale study.

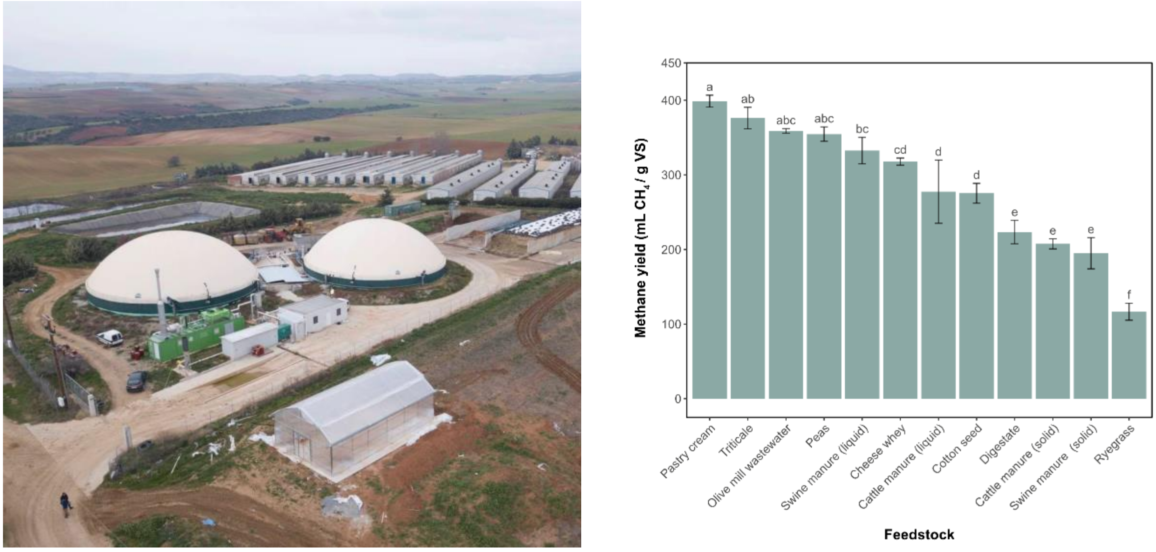


*Figure 1. Pilot-scale demonstration of symbiotic relationship of BIOGAS CHALKIDIKI plant with greenhouse (left); methane potential of different influent feedtsocks (right).*

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