

Abstract

This dissertation examines the potential utilization of agro-livestock residues for bioenergy production aimed at greenhouse heating, within the framework of circular economy and sustainable natural resource management. The research focuses on the study and analysis of various biomass conversion techniques, with particular emphasis on anaerobic digestion for biogas production, while also investigating its energy efficiency and contribution to the sustainability of the agricultural sector.

The study is based on an extensive literature review regarding modern methods of agro-livestock waste management, the energy efficiency of different greenhouse heating systems, and the environmental impacts of applying renewable energy sources to agricultural production. The analysis includes the recording and classification of agricultural and livestock residues that can be used for biogas production, while also examining the calorific value of different types of biomass and their efficiency in conversion into useful thermal and electrical energy.

The methodological approach is grounded in empirical research and quantitative data analysis, with a particular focus on Thessaly as a case study. Primary and secondary data are utilized to estimate the quantity of available agro-livestock residues, analyze the biogas production potential, and assess the energy requirements of greenhouses. In parallel, two methods are applied to calculate the annual heating energy demand of greenhouses: the degree-hour method and the consumed heat method. These approaches take into account the geo-climatic conditions of the region, the monthly heating requirements, the greenhouse covering material, and the optimal thermal conditions for crop growth, as well as the average daily and nocturnal outdoor temperatures, day–night duration, and incident solar radiation on a horizontal surface. The analysis is implemented in two distinct regions—climatic zones of Greece, Florina and Trikala—which exhibit different minimum winter temperatures and are located at different geographical coordinates.

The research findings indicate that biogas utilization, as an alternative energy source for greenhouse heating, can constitute an economically and environmentally sustainable solution. The production of biogas from agro-livestock residues contributes to reducing dependence on conventional fossil fuels, limiting greenhouse gas emissions, and promoting the energy self-sufficiency of agricultural enterprises. Furthermore, the economic data of the study demonstrate that the implementation of a combined heat and power (CHP) system can ensure a significant return on investment, particularly in regions with high concentrations of livestock and agricultural activities.

The dissertation concludes that applying circular economy principles in the primary sector, through the utilization of agro-livestock waste for energy production, represents a realistic and effective mechanism for enhancing sustainability and environmental protection. The research findings provide significant expertise and practical guidelines for shaping energy-efficient and environmentally responsible policies in the agricultural sector.