



Chapter 13

Fuzzy Logic Approach to the Management of Biomass and Biogas Energy Systems


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ABSTRACT

The critical aspects in this sense is to satisfy growing energy needs from renewable sources and one way or another, we need biomass/biogas as an alternative fuel instead of fossil fuels. The work introduces the basic concepts of fuzzy logic and its application in energy management. A framework to model complex relationships between impact parameters using fuzzy inference systems is developed in the research, enabling more accurate predictions and system performance assessments. Several biomass and biogas energy systems are taken as case studies to ascertain the effectiveness of proposed fuzzy logic approach. This chapter makes a timely and significant contribution to the renewable energy management field, in which researchers, practitioners and policymakers will find new insights about how biomass/biogas can be further integrated into global energy mix.

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1. INTRODUCTION

Management of biomass and biogas energy systems is critical today to advance sustainable energy options that will reduce our carbon footprint and save us from environmental degradation. Nonetheless, biomass and biogas energy systems are difficult to manage as feedstock availability is variable both directly feed production processes can be managed using advanced methods like automated UNF- 25IV Imaging for example –and indirectly (grown or waste derived), the biological conversion process will generate variable outputs and there exists inherent uncertainty related with biomethane. Moreover, how to incorporate fuzzy logic in management and its applications which are very important tools for policy makers who work on managing the uncertainties of biomass & biogas production is explored. The findings reported in this paper highlight important benefits of fuzzy logic-based strategies for integrating biomass and biogas energy systems management. Fuzzy logic can be used to manage such complex and uncertain systems, thereby enhancing operational efficiency, resource management or sustainability by addressing its inherent uncertainties. The results presented are designed to further explore benefits of using fuzzy logic as a powerful means in order to manage more efficiently biomass-biogas energy systems, leading to better effectiveness and reliability together with decision-making activities. This is a step in which quantifies some of the parameters that affect biomass and biogas systems including feedstock characteristics, environmental conditions and operational variables (Qian & Zhou, 2023). Many case studies indicate that the fuzzy logic approach described above is efficient for resource allocation optimization, enhanced process control and minimization of operational risks. Biogas and biomass are 2 latest type of renewable energy that is being by these industries as a source which can greatly help in reducing carbon dioxide emission (Roy & Chakraborty, 2024).

Biological systems can be more naturally described with fuzzy logic and this gives a powerful framework to manage these biological entities by also considering the uncertainty/variability characteristic for such type of processes. Fuzzy logic, unlike conventional binary logic allows for degrees of truth and this is especially useful when we are planning to make some decisions based on the output with grades like low high or medium etc in cases where quantifying an observation has complexity.

The significance of biomass and biogas energy systems lays out in their ability to ensure country's energetic self-sufficiency, as well as while there is potential for reducing greenhouse gas emissions. They provide a twofold solution by diverting waste through the conversion of organics to energy and delivering clean, renewable power. Given global efforts to move towards sustainable energy solutions, it is essential that researchers optimize these systems (Yao & Sun, 2023).

The study argues that fuzzy logic can make biomass and biogas management more efficient than the traditional control strategies and predictive models. This enables the use of multiple operating parameters, including variable feedstock and environmental conditions to achieve high system performance as well as reliability (Sahu & Sharma, 2023). With the increasing utilization of renewable energy, fuzzy logic is expected to play an important role in determining whether these systems will be effectively managed and their sustainability assured.

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