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Multi-Criteria Assessment of Biogas Feedstock

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Abstract : Targets have been set in the EU to increase the share of renewable energy consumption to 20% by 2020, but developments have not occurred evenly across the member states. Northern Ireland is almost 90% dependent on imported fossil fuels. With such high energy dependency, Northern Ireland is particularly susceptible to the security of supply issues. Linked to fossil fuels are greenhouse gas emissions, and the EU plans to reduce emissions by 20% by 2020. The use of indigenously produced biomass could reduce both greenhouse gas emissions and external energy dependence. With a wide range of both crop and waste feedstock potentially available in Northern Ireland, anaerobic digestion has been put forward as a possible solution for renewable energy production, waste management, and greenhouse gas reduction. Not all feedstock, however, is the same, and an understanding of feedstock suitability is important for both plant operators and policy makers. The aim of this paper is to investigate biomass suitability for anaerobic digestion in Northern Ireland. It is also important that decisions are based on solid scientific evidence. For this reason, the methodology used is multi-criteria decision matrix analysis which takes multiple criteria into account simultaneously and ranks alternatives accordingly. The model uses the weighted sum method (which follows the Entropy Method to measure uncertainty using probability theory) to decide on weights. The Topsis method is utilized to carry out the mathematical analysis to provide the final scores. Feedstock that is currently available in Northern Ireland was classified into two categories: wastes (manure, sewage sludge and food waste) and energy crops, specifically grass silage. To select the most suitable feedstock, methane yield, feedstock availability, feedstock production cost, biogas production, calorific value, produced kilowatt-hours, dry matter content, and carbon to nitrogen ratio were assessed. The highest weight (0.249) corresponded to production cost reflecting a variation of £41 gate fee to 22£/tonne cost. The weights calculated found that grass silage was the most suitable feedstock. A sensitivity analysis was then conducted to investigate the impact of weights. The analysis used the Pugh Matrix Method which relies upon The Analytical Hierarchy Process and pairwise comparisons to determine a weighting for each criterion. The results showed that the highest weight (0.193) corresponded to biogas production indicating that grass silage and manure are the most suitable feedstock. Introducing co-digestion of two or more substrates can boost the biogas yield due to a synergistic effect induced by the feedstock to favor positive biological interactions. A further benefit of co-digesting manure is that the anaerobic digestion process also acts as a waste management strategy. From the research, it was concluded that energy from agricultural biomass is highly advantageous in Northern Ireland because it would increase the country's production of renewable energy, manage waste production, and would limit the production of greenhouse gases (current contribution from agriculture sector is 26%). Decision-making methods based on scientific evidence aid policy makers in classifying multiple criteria in a logical mathematical manner in order to reach a resolution.

Keywords : anaerobic digestion, biomass as feedstock, decision matrix, renewable energy
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