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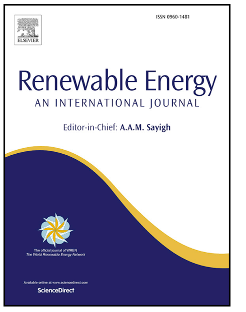

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ENVIRONMENTAL AND EXERGETIC SUSTAINABILITY ASSESSMENT OF POWER GENERATION FROM BIOMASS

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Abstract:

Power generation from biomass is mentioned as a means to make our society more sustainable as it decreases greenhouse gas emissions of fossil origin and reduces the dependency on finite energy carriers, such as coal, oil and natural gas. When assessing the sustainability of power generation from biomass, it is important to consider the supply chain of the used biofuel by conducting a life cycle assessment of the system. Besides regular sustainability assessments, such as the calculation of the environmental sustainability, attention should be paid to exergy losses, i.e. the loss of 'energy quality', caused by the system as a whole, because every process and activity is accompanied with the loss of exergy and because the amount of exergy on earth can only be replenished by capturing new exergy from solar and tidal energy. This research compares the use of livestock manure and verge grass for power generation by assessing the systems from an environmental as well as an exergetic life cycle point of view. The assessed systems are the following: combustion of bioethanol from the fermentation of verge grass, combustion of substitute natural gas from anaerobic digestion of cow and pig manure and combustion of substitute natural gas from supercritical water gasification of cow and pig manure. The environmental sustainability is assessed by calculating ReCiPe endpoint indicators and the exergetic sustainability is assessed by applying the relatively new Total Cumulative Exergy Loss (TCExL) method. The TCExL method considers all exergy losses caused by a technological system during its life cycle, i.e. the internal exergy loss caused by the conversion of materials and energy, the abatement of emissions and the exergy loss related to land use. In addition to comparing the three systems as well as both assessment methods, the influence of taking into account the system's by-products as 'avoided products' and via 'allocation' on the assessment results is investigated. The bioethanol system appears more sustainable from an environmental sustainability point of view, while the bioethanol and supercritical water gasification systems are preferred from an exergetic sustainability point of view. The indicator of the environmental sustainability assessment is largely influenced by the way of taking into account by-products, while the exergetic sustainability indicator is not.

Keywords:

Sustainability, Power Generation, Biomass, Life Cycle Assessment, Total Cumulative Exergy Loss.

1. Introduction

Renewable energy sources such as solar energy, wind energy and biomass are mentioned as a means to make our society more sustainable. They can be used to fulfil society's demand for energy carriers and to decrease the emission of carbon dioxide from fossil origin. Biomass is not only a source of energy, but also a material resource, i.e. a feedstock. When comparing different energy sources for power generation, it is important to assess these systems from a life cycle point of view, that is, to take into account the supply chain of the biomass and the construction, operation and decommissioning of the installations and equipment. By carrying out a life cycle assessment, problem-shifting between different life cycle phases and/or sustainability aspects is prevented [1].