Applied Energy 228 (2018) 1046–1056

Contents lists available at ScienceDirect

Applied Energy

journal homepage: www.elsevier.com/locate/apenergy

Can power to methane systems be sustainable and can they improve the carbon intensity of renewable methane when used to upgrade biogas produced from grass and slurry?

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HIGHLIGHTS

- Increasing the slurry to grass ratio improves sustainability of biogas.
- Power to gas (P2G) can be used to upgrade biogas to biomethane.
- The carbon intensity of hydrogen is higher than the electricity it is produced from.
- P2G systems using the Irish electricity mix reduce sustainability of biomethane.
- Renewable electricity levels of 85% allow biomethane be sustainable.

ARTICLE INFO

Keywords:
Life cycle assessment
Sustainability criteria
Advanced biofuels
Power to gas
Biological methanation
Co-digestion

ABSTRACT

The recast of the renewable energy directive (RED recast) considers power to gas (P2G) an advanced transport biofuel if a 70% greenhouse gas savings as opposed to the fossil fuel displaced is achieved. Power to methane systems can store electricity as gas and the system can be optimised in sourcing CO_2 from biogas to upgrade biogas to biomethane. The crucial question in this work is whether P2G systems can be sustainable and if they can improve the sustainability of biomethane systems using traditional upgrading systems. This work evaluates a comparative lifecycle assessment of grass and slurry (50:50 wet weight equivalent to 80:20 volatile solid weight) biomethane using P2G and/or amine scrubbing as an upgrading method. The sustainability of P2G upgrading systems is heavily dependent on the carbon intensity of the source of electricity. Using a 41% decarbonised electricity mix the sustainability was reduced using P2G and would not be deemed sustainable under criterion set by the RED recast. Maintaining a maximum of 2% fugitive CH_4 emissions, using 74% slurry (wet weight) in a grass slurry feedstock, allowing for 0.6 t carbon sequestration per hectare per annum in grasslands and using an electricity mix with 85% renewable electricity the whole system including P2G upgrading could satisfy the GHG savings of 70%. However, the traditional system employing amine scrubbing had higher levels of sustainability.

1. Introduction

The transition from fossil fuels to renewable decarbonised energy needs evidence of sustainability and of a significant reduction in environmental impacts. The recast of the Renewable Energy Directive (RED recast) states that advanced biofuels should make up at least 3.6% of transportation fuels by 2030. These advanced biofuel systems must meet a threshold of 70% greenhouse gas (GHG) savings as compared to the fossil fuel displaced [1]. It is unlikely that biomethane produced from mono-digestion of crops such as maize will meet this criterion: however, maize is not considered as a source of advanced biofuel. Perennial ryegrasses are included in the list of sources of advanced biofuels, but mono-digestion of grass is unlikely to meet the strict sustainability criteria of 70% GHG savings set for transport biofuels. However, it is likely that when grass is co-digested with slurry at certain ratios sustainability may be achieved. This is due to the methane emission credit obtained by avoiding the open storage of raw manure. When slurry is stored in an open tank fugitive methane emissions occur; methane has a global warming potential (GWP) of 21 times that of CO_2 in a 100 year time frame. In anaerobic digestion systems the slurry is not open to the atmosphere and these emissions are thus avoided. When biogas is combusted it releases CO_2 (21 times less GWP than CH_4) while

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https://doi.org/10.1016/j.apenergy.2018.06.139
Received 10 April 2018; Received in revised form 7 June 2018; Accepted 29 June 2018

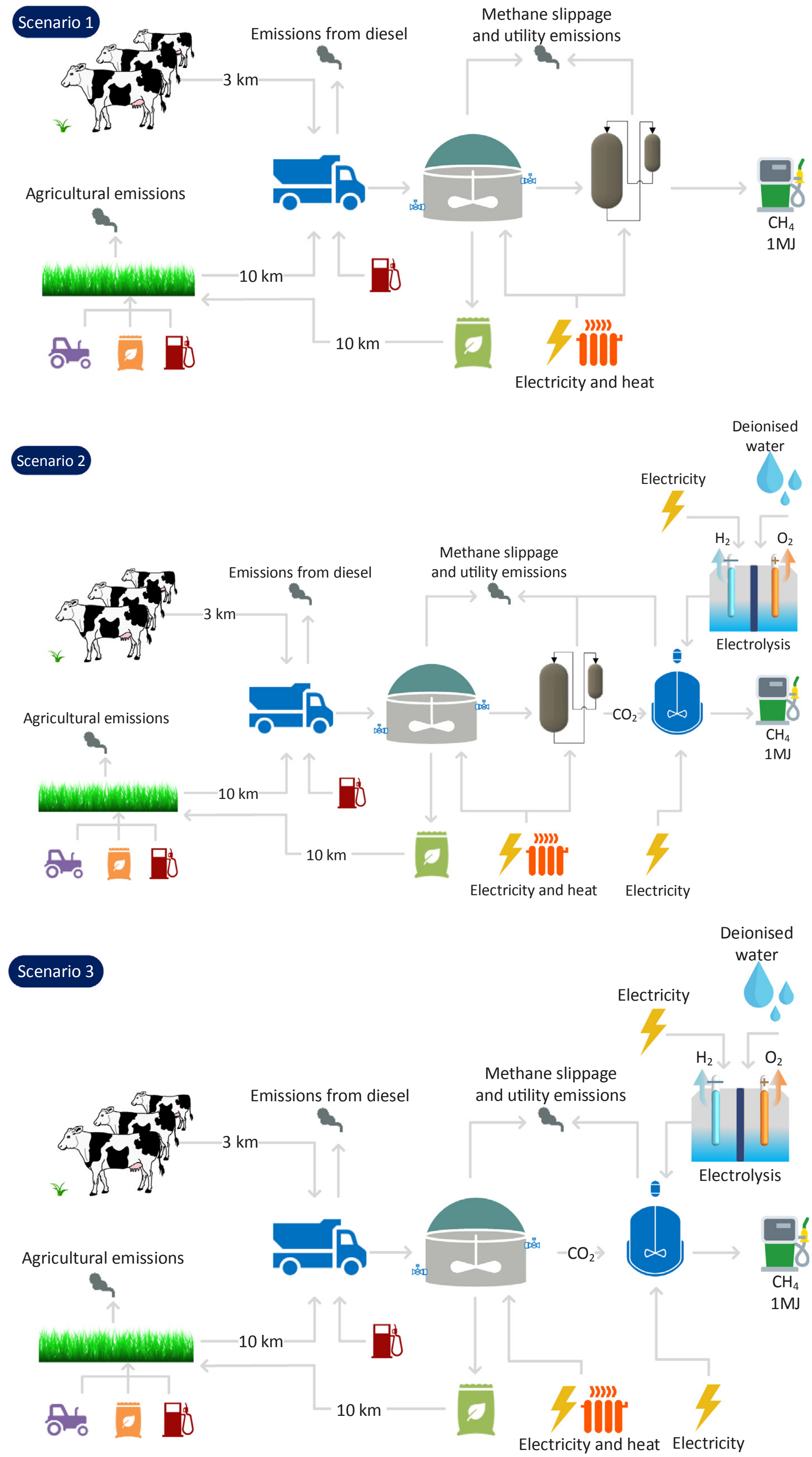

Fig. 1. System boundaries of three scenarios.

displacing the emissions from a fossil fuel. The credit for digesting manure is given as 14.6% of the methane content of the slurry stored using methodology developed by the European Commission Joint Research Centre (JRC) [2,3]. Mono-digestion of slurry is carbon negative, however, slurries have low volumetric energy content, produce a low specific methane yield and as such are uneconomic [4].