LIFE CYCLE ASSESSMENT OF BIOGAS CATALYTIC AND ELECTRO-CATALYTIC PROCESSES UTILIZATION

Nikolaos D. Charisiou[1,2], Vagelis G. Papadakis[2] and Maria A. Goula[1,*]

[1] *Technological Educational Institute of Western Macedonia, Pollution Control Technologies Department, Laboratory of Alternative Fuels and Environmental Catalysis (LAFEC), Koila, 50 100 Kozani, Greece*

[2] *University of Western Greece, Department of Environmental & Natural Resources Management, Agrinio, Greece*

(*) corresponding author: E-mail address: mgoula@kozani.teikoz.gr

INTRODUCTION

- Biogas production utilizes organic waste from renewable resources, and can be used in both small (<500 kWel) and large-scale (>500 kWel) energy generation plants and in decentralized energy generation.

- If sustainably managed, biogas could make significant contribution to energy security and mitigation of the GHG emissions.

- This study aims to provide a life cycle assessment of biogas utilization through catalytic and electro-catalytic processes. Furthermore, the paper compares the environmental impacts, across a broad range of impact categories, and the utilization of biogas for either CHP, or injection to the gas grid for end use as either transportation fuel or domestic heat.

LIFE CYCLE ASSESSMENT

- Life Cycle Assessment (LCA) is increasingly been adopted as an analytical tool that is able to capture complexity and inter-dependencies, thus providing a comprehensive and objective environmental balance, helpful to address sustainability of bioenergy chains.

- However, methodological assumptions might distort the results or render comparisons nearly impossible.

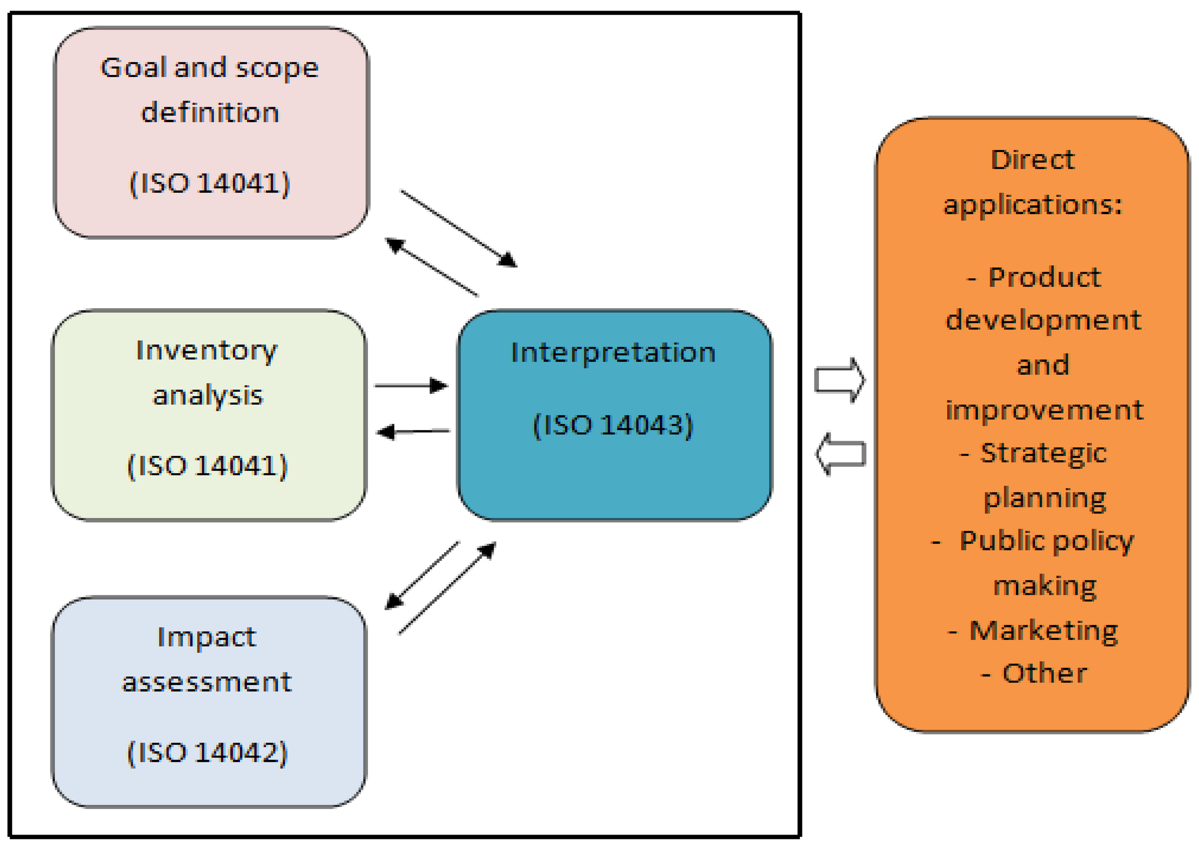
- LCA studies should systematically and adequately address the environmental aspects of products/systems.

- The depth of the details and time frame of an LCA study may vary to a large extent, depending on the definition of goal and scope.

- The scope, assumptions, description of data quality, methodologies and output of LCA studies should be transparent.

- LCA methodology should be amenable to inclusion of new scientific findings and improvements in the state-of-the-art of the technology

Life cycle assessment framework



RESULTS AND DISCUSSION

- The end use of the biogas has a major impact on the overall environmental performance.

- The results indicated that biogas utilization with fuel cell technology may be viable both with respect to energy balance and to mitigation of environmental emissions.

- Electricity generation using fuel cell coupled with external heat utilization could enhance environmental performance by up to 90%, compared to electricity generation in base case.

- Fuel cell conversion pathway coupled with heat utilization generated, on average, 85% less CH4,fossil emissions than the scenarios for upgrading und purifying biogas to biomethane. This was mainly attributed to the fact that fuel cell technology does not create greenhouse gas (GHG) emissions during biogas conversion and attractive combined efficiency of thermal and electricity for fuel cell technology (hel= 50%, hth= 40%).

- Fuel cell combined with waste heat utilization was the only biogas utilization pathways to achieve NOx environmental benefits (cumulated -9.5 g t-1). This could be attributed to the marginal NOx emissions of fuel cells per MJ energy.

- Fuel cell technology considered is still at experimental stage and the accurate potential will be clearer after commercialization.

USE OF LCA IN BIOGAS STUDIES

- Environmental performance of various biogas infrastructures have been evaluated using the Life Cycle Assessment (LCA). However, many of the studies involving life cycle approaches to assessing or comparing biogas systems concentrate on energy balances or a combination of energy balance and emissions.

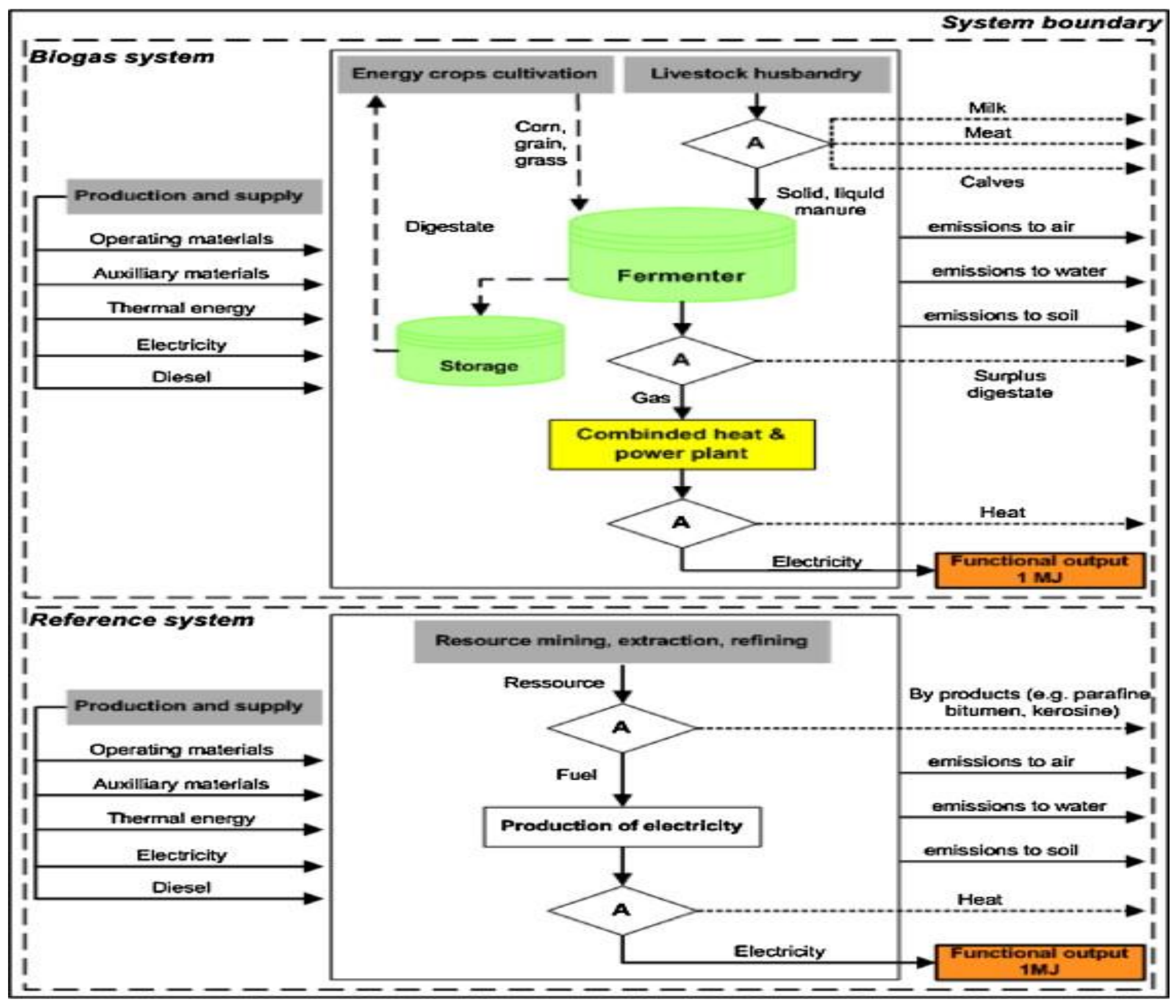
- Studies also tend to focus on either specific feedstocks, specific biogas technologies, waste management strategies at various geographic scales or specific biogas end uses.

METHODOLOGY

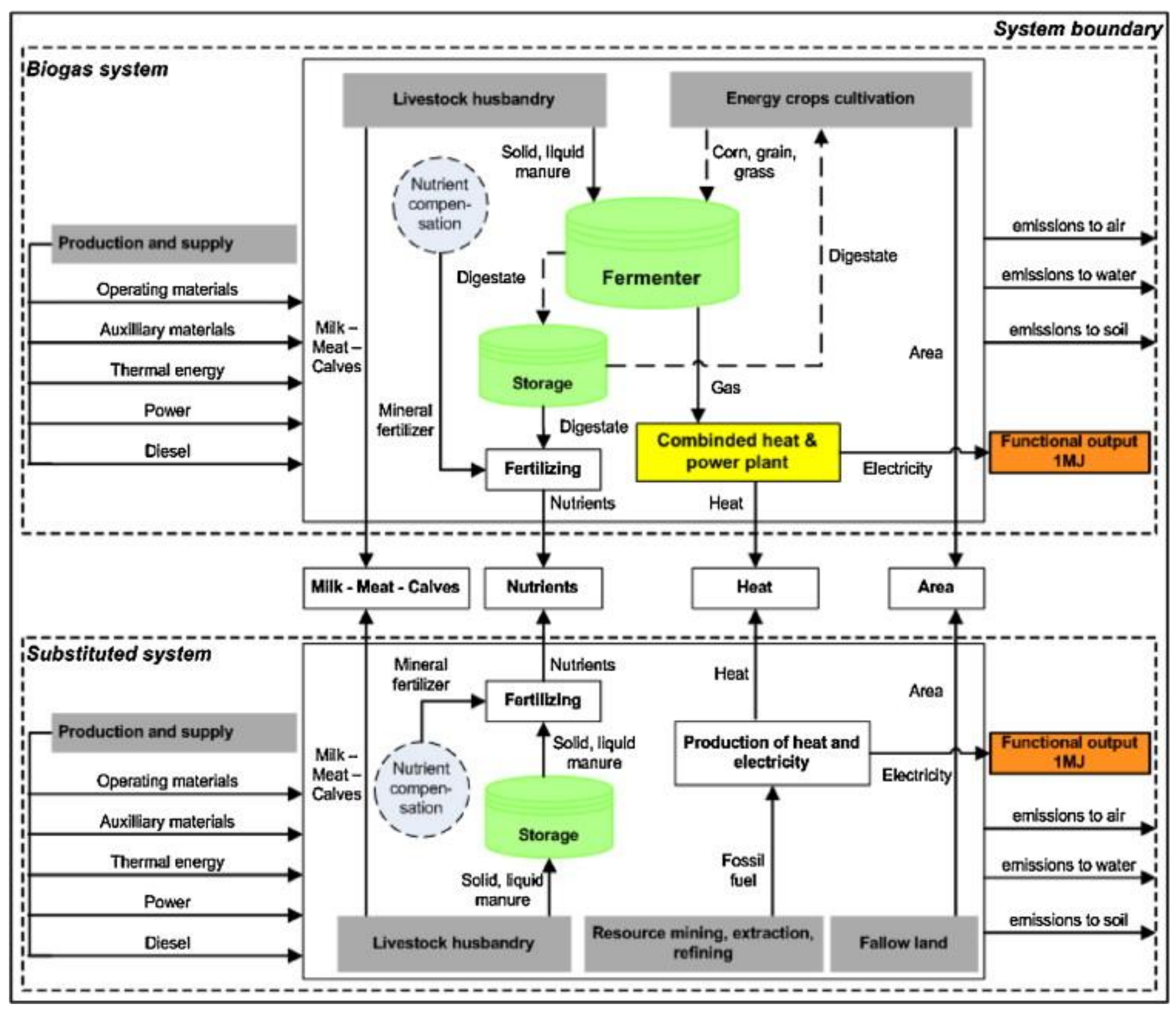
- Environmental impacts were calculated using a life cycle assessment (LCA) approach, in accordance with European guidance (BS EN ISO 14040, BS EN ISO 14044)

- Life Cycle Assessment modeling was undertaken using SimaPro v7.2 software (PRè Consultants b.v.) utilising the ecoinvent database v.2.1

System boundary, energy, material and emission flows for attributional life cycle assessment (aLCA) of a biogas system



System boundary, energy, material and emission flows for consequential life cycle assessment (cLCA) of a biogas system



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