Utilising Northern Irelands' Agriculture Sector to Decarbonise Heat

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Background

The window in which to limit the intense and frequent climate impacts like wildfires, heatwaves and floods and to secure a "liveable and sustainable future for all" is becoming narrower (Paul, 2022).

In Northern Ireland, NIDIRECT (n.d.) emphasises that climate impacts and the associated adverse changes could lead to (1) disruption to business, services and people's daily lives, (2) an increased risk of flooding and coastal wear which will put pressure on drainage, sewage, roads, water and habitats and (3) increases in temperature, in pollution and a decrease in air quality which may bring discomfort to the vulnerable and threaten species of animals and crops, and general biodiversity levels.

So where does anaerobic digestion come in?

Biomethane production via anaerobic digestion is a promising technology for the decarbonisation of the energy system (Oreggioni et al., 2017).

Anaerobic digestion is a microbial process carried out in the absence of oxygen to break down organic matter such as livestock manure, food waste etc. to biogas and digestate. Biogas is composed of methane (50-60%), carbon dioxide and trace amounts of other gases. Biogas, when upgraded to biomethane through scrubbing technologies, consists of about 97% of methane and only 3% CO_2. It can then be transported and used wherever gas is consumed since it is indistinguishable from the regular natural gas stream (IEA, 2020).

Against this backdrop, this report presents key findings from a study submitted for journal paper publication by researchers in the Queen's University Belfast and the Agri-Food and Biosciences Institute. The study evaluated the opportunity around anaerobic digestion and secondary treatment of livestock manure and underutilised grass silage for the decarbonisation of the gas infrastructure in Northern Ireland (Mehta et al., 2022, manuscript submitted for publication).

Methods: Resource assessment and environmental impacts evaluation

For conducting resource assessment, livestock numbers and total grassland area were extracted from the Agricultural Census in Northern Ireland at a farm scale (results for June 2020). This data was plotted in a Geographic Information System (GIS) and used to quantify mass of manure produced, dry matter requirements and estimations of silage quantities that could be produced over a one-year period at a farm scale. Incorporating appropriate controls (22-week housing limit for cattle, removal of severely disadvantaged areas etc.), total mass of feedstock for anaerobic digestion in Northern Ireland was estimated for: (1) manure from housed livestock and (2) underutilised grass silage. An associated volume of biomethane could be calculated from such biomass estimations using biomethane yield conversions to provide a value for how much biomethane could be produced in Northern Ireland from these agricultural sources. Potential displacement of fossil natural gas by biomethane was then calculated using spatial annual natural gas distribution demand data (Oct 2020-Sept 2021).

Furthermore, life cycle assessment was used for appraising environmental impacts incurred during the production of biomethane. The assessment was conducted using the Ecoinvent database and following the ISO 14040 and ISO 14044 standards (Osman et al., 2021). This approach used a cradle-to-gate attributional approach excluding infrastructure processes for the three scenarios (**Figure 1**).

- **Scenario 1:** All housed livestock manure in Northern Ireland is applied to land without any treatment.
- **Scenario 2:** All housed livestock manure and underutilised grass silage is used for biomethane production via anaerobic digestion.
- **Scenario 3:** All housed livestock manure and underutilised grass silage is used for biomethane and biochar production via anaerobic digestion and pyrolysis.

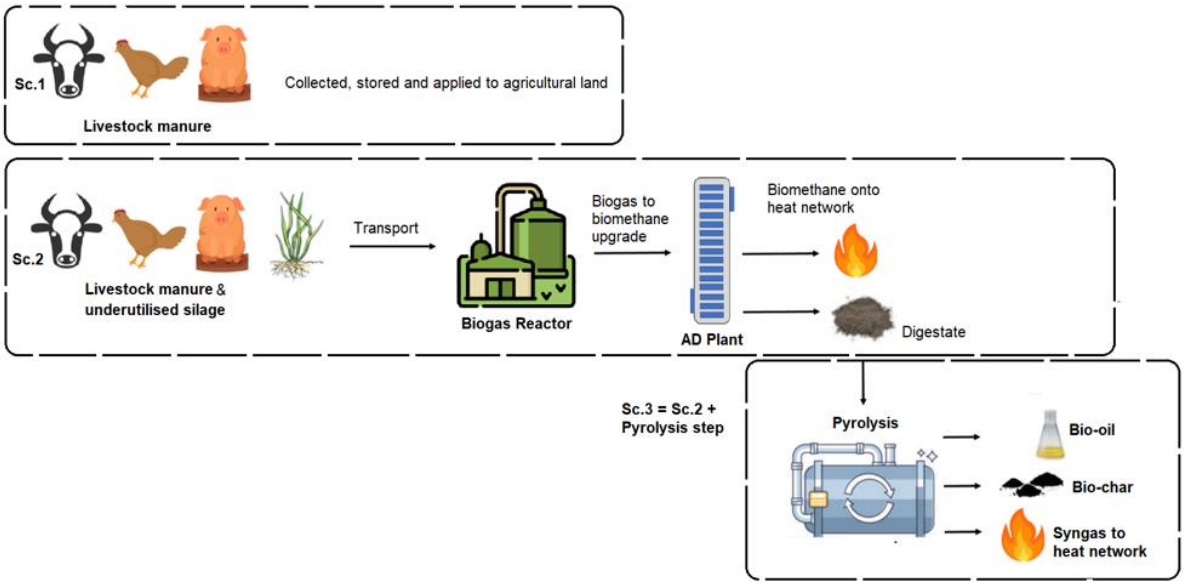

Figure 1. The three scenarios and associated processes considered for life cycle assessment.

Key findings

Total agricultural feedstock and biomethane potential per year: 9,218 kilo tonnes of cattle (housed), pig and poultry manure (1,162 kilo tonnes of total manure solids) which equates to 253 million Nm^3 of biomethane. 4,693 kilo tonnes of underutilised silage (1,374 kilo tonnes of silage dry matter) which equates to 500 million Nm^3 of biomethane. Total biomethane potential was therefore calculated at 753 million Nm^3.

Annual natural gas distribution energy demand in Northern Ireland (September 2020 – October 2021): 7656 GWh

- **Scenario 1:** Manure management without any treatment leads to 17.2 kilo tonnes of ammonia emissions and 109 tonnes of phosphorus equivalent eutrophication. Additionally, it was observed that the global warming potential for a 100-year time horizon was 718 kilo tonnes CO_2 equivalent, which is ~14% of total greenhouse gas emissions from agriculture sector in Northern Ireland.

- **Scenario 2:** In a scenario where all housed livestock manure and underutilised grass silage is used for anaerobic digestion, the total energy produced in the form of biomethane was modelled as 6124 GWh/year. This equates to 80% of total gas distribution network demand in Northern Ireland. Energy potential from 627 million Nm^3 of biomethane from both cattle (housed), pig and poultry manure and underutilised silage within 10 km from distribution network is 67% of gas distribution demand. The associated ammonia and eutrophication potential due to digestate spread on land was 7.0 kilo tonnes and 109 tonnes of phosphorus equivalent. The global warming potential for the entire process was observed as -845 kilo tonnes CO_2 equivalent.

- **Scenario 3:** In an integrated anaerobic digestion and pyrolysis scenario, the total energy produced in the form of biomethane amounts to 6124 GWh for a year. This equates to 80% of total gas distribution network demand in Northern Ireland and 67% of gas distribution demand in 15 gas distribution network zones. From the pyrolysis step, 200 kilo tonnes of biochar can be produced, to be used as soil conditioner within or outside of Northern Ireland. The associated ammonia and eutrophication potential due to digestate spread on land were 6.8 kilo tonnes and 39 tonnes

phosphorus equivalent. In this scenario the amount of phosphorus returning to the land decreases and the biochar co-product represents fixed carbon and a more nutrient dense material for more efficient redistribution and export (**Figure 2**). The global warming potential for the whole process was observed as -1018 kilo tonnes CO_2 equivalent.

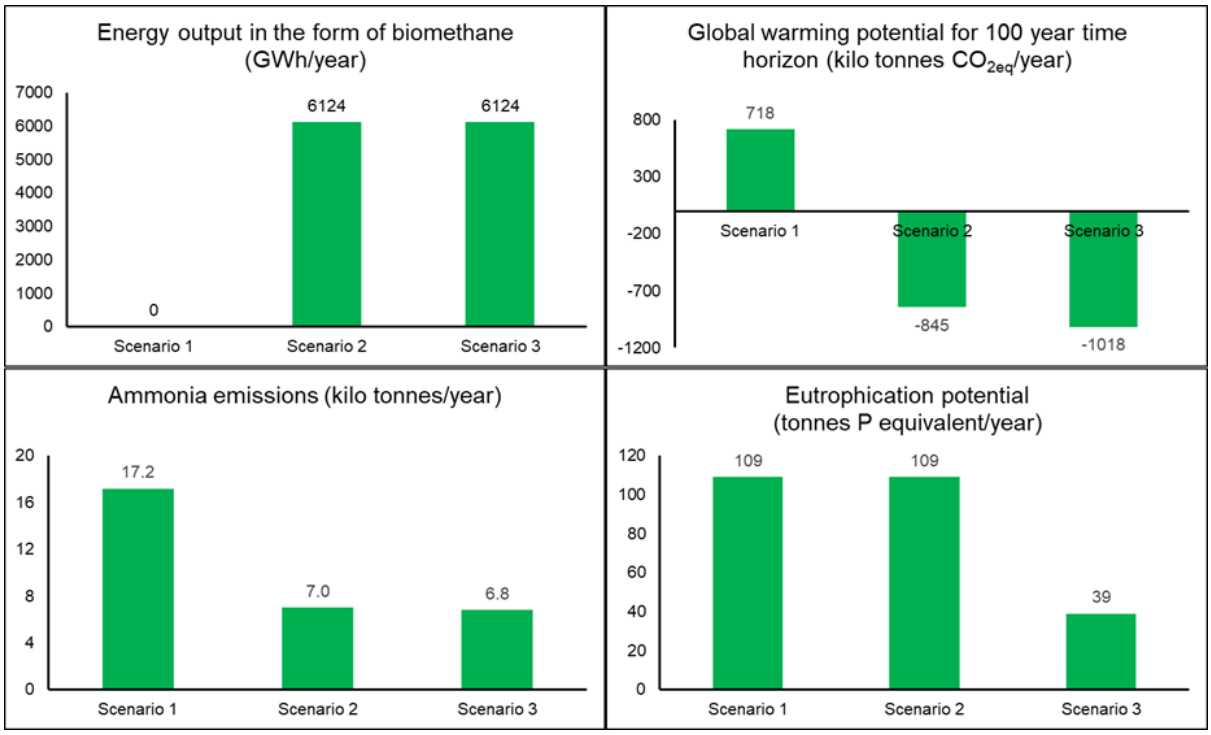

Figure 2. Environmental impacts incurred for the three scenarios. Scenario 1: No manure treatment. Scenario 2: Anaerobic digestion. Scenario 3: Integrated anaerobic digestion and pyrolysis (adapted from Mehta et al., 2022).

Acknowledgements

This work is supported by the Centre for Advanced Sustainable Energy (CASE). CASE is funded through Invest NI's Competence Centre Programme and aims to transform the sustainable energy sector through business research. Sincere thanks to: Mr Iain Hoy, Mr Jonathan Martindale, Mr Conor O'Reilly and Ms Gillian Orr for their support on GIS maps and initial CASE report (Phoenix Natural Gas Ltd); Dr James Young and Mr Stuart Dobson for analysis (EnerChem Solutions Ltd); Mr Thomas Cromie for data understanding (AgriAD Ltd); Mr David Butler and Mr Eric Cosgrove for providing shape files of the gas distribution network (SGN Natural Gas Network Ltd, Firmus Energy Ltd); Ms Kathryn Rogers, Dr Simon Murray, Mr Martin Doherty, Ms Sam McCloskey for their endless support to the researchers (CASE); Dr Beatrice Smyth and Prof Jennifer McKinley for conversations and discussions on energy and environment (Queen's University Belfast).