17th International Conference on Environmental Science and Technology

Athens, Greece, 1 to 4 September 2021

Quantification of feedstocks and outputs for a regional Bioeconomy using the AD Biorefinery concept.

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Abstract

Greenhouse gas emissions (GHG's) from agriculture in Northern Ireland account for over 27% of regional emissions, as opposed to 7% for the UK overall, leaving the region with challenges in meeting climate abatement targets. The development of a sustainable regional Bioeconomy has been identified as a key requirement for regional sustainability. Previous research carried out as part of the Northern Ireland Biogas Research Action Plan, had quantified the feedstock available for Anerobic Digestion (AD) in Northern Ireland, and estimated potential biogas and biomethane yields. This research builds upon and extends that work by applying the AD biorefinery concept to include both biological and thermochemical feedstocks and utilisation pathways. The research has quantified the potential feedstocks for AD coupled with gasification and has explored utilisation pathways for the outputs of the processes, including AD digestate to gasification and applications of biochar. The utilisation pathways have been evaluated for their potential in meeting GHG reduction targets and suitability indicators have been applied to a range of scenarios and a scenario analysis model developed. The limitations of this research have been identified and recommendations have been made for future research priorities.

Keywords: Bioeconomy, anaerobic digestion, gasification, biogas, syngas, biochar.

1. Introduction

Agriculture and food production is one of Northern Ireland's most important industries and the sector has ambitious targets for increased production, particularly for export (Board 2013). However, greenhouse gas emissions (GHG's) from agriculture in Northern Ireland account for over 27% of regional emissions, as opposed to 7% for the UK overall,

The potential role in the mitigation of regional GHG emissions from the generation of biogas or biomethane from the anaerobic digestion (AD) of a range of feedstocks in mitigating had been recognized as part of the Northern Ireland Biogas Research Action Plan. As part of that research, potential feedstocks for AD were quantified, regional biogas and biomethane yields and regional GHG benefits estimated (Curry, Pérez-Camacho et al. 2018).

However, this research was limited to regional biogas and biomethane yields and related GHG benefits, and did not evaluate potential utilisation pathways for digestate or possible synergies between different feedstocks, processes and products using a bioeconomy approach (House of Lords and Committee 2014).

For most AD operations, digestate is currently used as a biofertiliser of low commercial value and this has been identified as a barrier to the development of the AD industry (Edwards, Othman et al. 2015). The use of digestate as a biofertiliser is particularly significant in Northern Ireland, as the entire region is designated as a Nitrate Vulnerable Zone (NVZ) under the Nitrates Directive (91/676/EEC) (Department of Agriculture 2019).

Potential synergies from applying the AD Biorefinery approach include the potential to increase biogas yields through the addition biochar to AD (Wambugu, Rene et al. 2019)and liquid digestate use for algal production, with recent research demonstrating the feasibility of this pathway (McDowell, Dick et al. 2020).

Previous research had applied a multi-criteria approach to the assessment of feedstocks for biogas production (Feiz and Ammenberg 2017), and used these as the basis for producing assessments of feedstocks for strategic decision making (Ammenberg and Feiz 2017) and this methodology informed the generation of suitability indicators for the region.

The overall aim of the research was to evaluate and quantify feedstocks and outputs for a regional bioeconomy, using the AD Biorefinery concept (Pérez-Camacho and Curry 2018), with the following objectives underpinning this aim:

- Quantify potential feedstocks for a regional bioeconomy based on the AD Biorefinery concept.
- Quantify potential output energy carriers, materials, and nutrients.

- Compile an inventory, process flow diagram and scenario analysis model for regional bioeconomy inputs/outputs.
- Produce suitability indicators to provide an evidence-base for regional bioeconomy development; and
- Identify limitations and future research priorities.

We would highlight the use of the AD Biorefinery approach as a novel aspect of the research which supports synergies between feedstocks and processes (Pérez-Camacho and Curry 2018).

2. Methodology

2.1. Inventory

Potential feedstocks and output energy carriers, materials, and nutrients where quantified, following the methodology set out by Slade et al (Slade, Saunders et al. 2011), based on a 'hierarchy of opportunity' (theoretical, technical, economic and realistic), to allow the compilation of the inventory and regional PFD, which is illustrated in Figure 1.

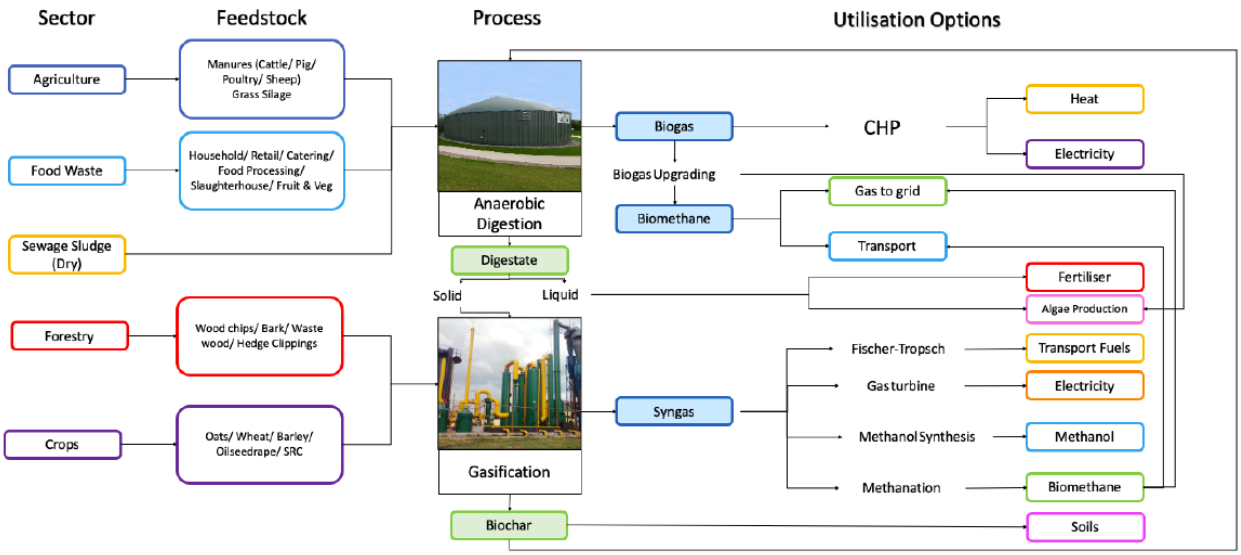


Figure 1. PFD for a regional bioeconomy.

2.2 Model

A model was developed to allow creation of bioeconomy scenarios and quantify the regional Greenhouse Gas (GHG) savings. The home page is shown in Figure 2.

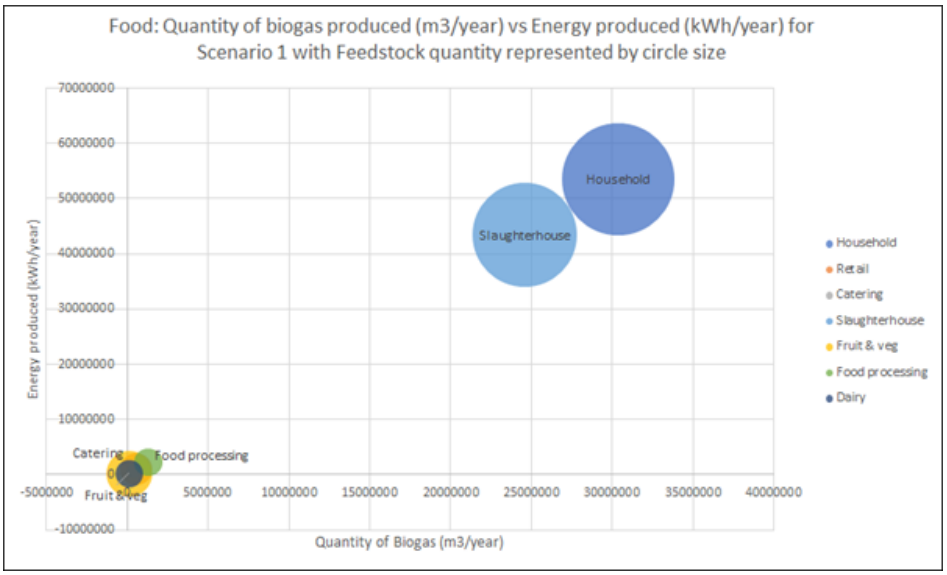
Figure 2. Scenario analysis model

Scenarios modelled included comparison of liquid digestate to algal production and biochar utilisation pathways. The presentation will include a demonstration of the model for selected scenarios and the model will be made available to other research groups.

2.2 Indicators

Suitability indicators were produced for a range of feedstock scenarios, the example of food wastes is provided in Figure 3.

Figure 3. Suitability Indicator for Food waste feedstocks to CHP



3. Conclusions and ongoing work

The outputs of the project will be presented along with ongoing research which is carrying out Life Cycle Analysis (LCA) of regional bioeconomy pathways.

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