NUI Galway
OÉ Gaillimh

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Further reading:

Opportunities for Hydrogen Energy Technologies Considering the National Energy & Climate Plans.

SEAI National Energy Projections to 2030 Understanding Ireland's Energy Transition.

Food Vision 2030 – A World Leader in Sustainable Food Systems.

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Biohydrogen coupled to biogas production from bioprocesses for decarbonisation of Ireland

Background

In 2019, 88% of the gross energy consumption in Ireland was through use of fossil fuels (coal, oil, and natural gas). The remaining 12% of energy from renewables was obtained from wind (50%), biomass and waste energy (45%), and hydropower (5%). The highest contribution from renewables was to electricity generation sector (36%), followed by transportation (8.9%) and heating (6.3%). Ireland's target for renewables participation in the energy system in 2020 was increase to 16% and from that 40% would be used for electricity generation.

An ambitious target of achieving 70% of Ireland's electricity demand from renewables has been set for 2030. To achieve this, residues from agri-food and brewery industries, crops, and the biodegradable fraction of municipal solid waste (MSW) can be used (Table 1) in a two-phase anaerobic system, producing bioH_2 in the first biodigester and biogas in the second one. This two-phase system is an alternative to the traditional one-phase anaerobic system and can achieve higher net energy, contributing to the percentage increase of renewables generating energy in Ireland. This strategy is in line with the "Mission 1: A Climate Smart, Environmentally Sustainable Agri-Food sector" of the Food Vision 2030 from the Department of Agriculture, Food and the Marine.

Table 1: Production of agri-food and brewery industries in 2020 and residue generation, and biodegradable municipal waste generated from household in 2018 (CSO Statistics, 2021; EPA Waste Data Release, October 2020; IA, 2021; Ryan and Walsh, 2016).

Sector	Product	Production 2020	Estimated Residue Generated
Meat	Cattle	633.40 ton	174.2 ton
	Pigs	66.27 ton	2.7 ton
	Sheep	320.51 ton	54.5 ton
Crops	Total Cereals	2013 x10^3 ton	604 – 1107 x10^6 ton
	Potatoes	300 x10^3 ton	82.8 – 120 x10^6 ton
	Beans and peas	66 x10^3 ton	
	Oilseed rape	45 x10^3 ton	24.75 - 29.25 x10^6 ton
Dairy	Milk	523.6 x10^6 L	
	Butter	262.6 x10^3 ton	787.8 – 1313 x10^6 L
	Skimmed milk powder	141.6 x10^3 ton	424.8 – 708 x10^6 L
	Cheese	278.4 x10^3 ton	835.2 – 1392 x10^6 L
Beverage	Beer	7100 x10^3 hL	2130 – 7100 x10^6 L
Biodegradable Municipal Waste[a]		-	137 x10^3 ton

[a] Generated in 2018 from household.

Contribution of hydrogen to the renewable energy matrix

The anaerobic digestion of organic matter present in residues has already been used for biogas production and energy generation in Ireland. Nonetheless, a more attractive strategy is to separate the anaerobic digestion process into two-phases (Fig.1A). In the first biodigestor, the organic matter is hydrolysed, and the smaller molecules formed will be converted in organic acids and alcohols through the dark fermentation process, generating a gaseous mixture of bioH_2 and CO_2. H_2 is an energy carrier with an energy density 2.75-fold higher than fossil fuels, such as gasoline and diesel. Its combustion generates only water and can be converted to electricity in fuel cells. H_2 can replace the energy from natural gas in industry and in road transport and decarbonize the demand for energy and heating in the built environment. The content of the first reactor, i.e. organic matter partially digested, feeds the second reactor, which produces biogas (CH_4 and CO_2). The microorganisms involved in the second-phase reactions, called methanogenesis, are more sensitive to operational conditions, pH, flow rate, and changes in residue composition, than the microbial community from the first reactor. Therefore, the phase separation allows to optimise each phase, enhancing the global energy production.

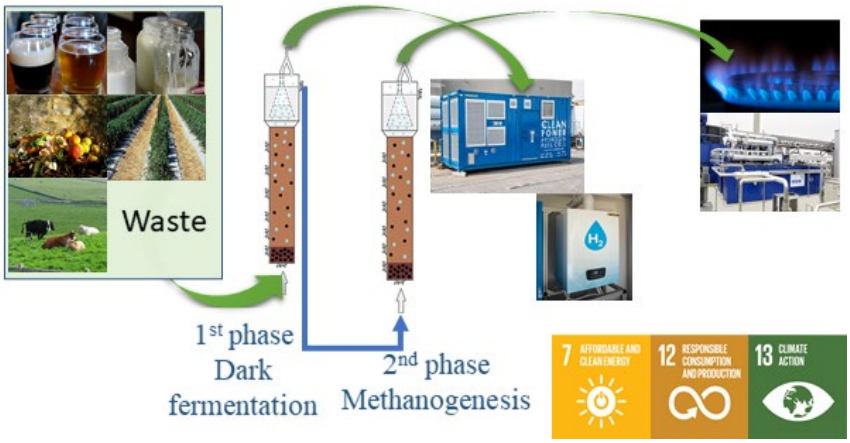

Figure 1: Schematic representation of energy generation from biodegradable municipal waste (BMW), agri-food, and beverage using two-phase anaerobic digestion.

The two-phase system with bioH_2 and biogas recovery, and utilization represents the next step towards a sustainable future. However, it requires the collaboration and action among government, agri-food and beverage industry sector, community, and academia:

Government

- Provide infrastructure for collecting MSW and implement two-phase anaerobic system and energy generation from MSW
- Stimulate private sector and farmers investment on H_2 and biogas production and energy generation
- Investment on research and development to overcome challenges

Academia

- Overcome challenges and optimize dark fermentation process
- Provide technical support for implementing the two-phase anaerobic system and energy generation
- Support decision makers through environment and economical assessments

Industry and farmers

- Collect diffuse waste (manure) and industrial process waste and wastewater streams
- Investment on implementation of two-phase anaerobic system and energy generation

Community

- Correct separation and disposal of MSW for using to H_2 and biogas production and energy generation
- Investment in appliances adequate for energy source in use

The data reference links can be found below:
IEA World Energy Balances 2020. https://www.iea.org/subscribe-to-data-services/world-energy-balances-and-statistics
SEAI Energy in Ireland 2020 Report. https://www.seai.ie/data-and-insights/seai-statistics/key-publications/energy-in-ireland/
CSO Statistics 2021 Livestock Slaughterings. https://www.cso.ie/en/releasesandpublications/er/ls/livestockslaughteringsdecember2020/
CSO Statistics 2021 Milk. https://www.cso.ie/en/releasesandpublications/er/ms/milkstatisticsdecember2020/
CSO Statistics 2021 Production of Crops. https://www.cso.ie/en/releasesandpublications/er/aypc/areayieldandproductionofcrops2020/
EPA Waste Data Release, October 2020. https://www.epa.ie/nationalwastestatistics/household/
IA, R., 2021. Agriculture Residue: A Potential Source for Biogas Production. Ann. Agric. Crop Sci. 6.
Ryan, M.P., Walsh, G., 2016. Research Report 173 - The Characterisation of Dairy Waste and the Potential of Whey for Industrial Fermentation.