NUI Galway
OÉ Gaillimh

IETSBIO³ Policy Brief series: No. 8
27.07.2022

Further reading:

Kakoulaki et al., 2021. Green hydrogen in Europe - A regional assessment: substituting existing production with electrolysis powered by renewables.

For enquires contact:

Prof. Piet Lens
Established Professor
NUI Galway
piet.lens@nuigalway.ie

Dr. Arul Manikandan Natarajan
Postdoctoral researcher
NUI Galway
arulmanikandan.n@nuigalway.ie

Acknowledgments: *This policy brief was prepared through a SFI Research Professorship Scheme Innovative Energy Technologies for Biofuels, Bioenergy and a Sustainable Irish Bioeconomy (IETSBIO3; grant number 15/RP/2763)*

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Decarbonising Irish wastewater treatment plants and converting them into green infrastructures for fuel generation

Background

Around the world, there is a significant surge in reducing carbon emissions and striving towards an ambitious target of attaining net-zero emissions by 2050. This "Race to zero-emission" by the United Nations and "Zero air, water and soil pollution" by the European Commission are essential to detain the global temperature rising beyond 1.5°C. National and international plans to become carbon-neutral by 2050 require renewable energy sources. One example is water electrolysis technology, in which water is split into hydrogen and oxygen using renewable electricity sources like wind and solar energy. The hydrogen produced is expected to decarbonise the transportation, industrial, and agricultural sectors by providing carbon-free fuel options and chemicals for fertiliser production such as ammonia.

On March 2022, under the "REPowerEU" plan, the European Comission announced its target to produce 10 million tonnes and import an additional 10 million tonnes of green hydrogen by 2030 [1]. Next to green hydrogen, biogas production produced by anaerobic digestion is a promising decarbonisation strategy. The process consists of breaking down and converting biomass into biogas in the absence of oxygen. In Ireland's 2021-2023 climate action plan, Ireland proposed building over 125 anaerobic digesters with 60 mega-watt capacity [2]. These two technologies are expected to play a key role in making Ireland more sustainable.

Decarbonisation of wastewater treatment plants has been overlooked, despite accounting for 1% of the total energy consumption in developed countries [3, 4]. Integrating water electrolysers powered by renewable energy and anaerobic digesters with the widespread Irish wastewater treatment plants, as shown in Fig. 1, provides abundant opportunities to convert treatment plants from energy spending to energy producing.

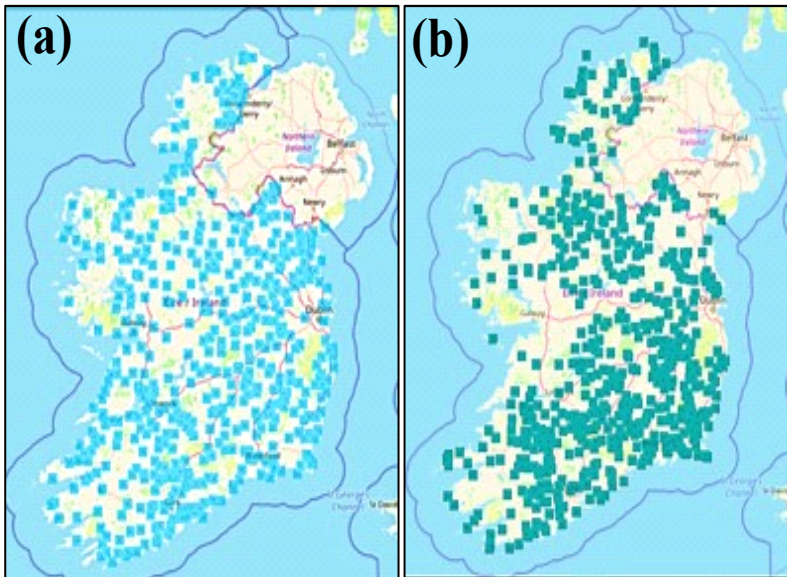

Fig. 1: Map showing the widespread nature of Irish wastewater treatment plants with a treatment capacity of (a) greater than 500 people and (b) less than 500 [5].

Integrating water electrolysis and anaerobic digestion to Irish public wastewater treatment plants

Fig. 2 illustrates incorporating water electrolysis, anaerobic digestion, and renewable energy with wastewater treatement plants. The activated sludge process in the conventional wastewater treatment plant alone uses 80% of the plant's operational energy due to pumping air through a compressor [3]. A simple calculation regarding the compressor portrays that the current Irish population of 5 million spends 1,425 mega-watt-hour per year on air pumping and compression. This energy expenditure was calculated based on the assumed per capita water usage of 250 liter per person per day and wastewater generation with a biological oxygen demand load of 300 miligram per liter [4]. The high energy expenditure for aeration can be overcome by implementing water electrolysers in wastewater treatment plants, as electrolysis of 1 kilogram (kg) of water will result in 0.11 kg of hydrogen and 0.89 kg of oxygen. Ideally, the oxygen by-product would be pumped by renewable energy sources through the compressor and into the aeration basin. The hydrogen can then be stored and used as fuel alternative to fossil fuels. The sludge produced in the wastewater treatment process can then go to anaerobic digestion, which produces biogas, an additional green fuel source.

Thus, it is advantageous to maximize the sustainability of the wastewater treatment process. Continued analysis of the electrolysis efficiency in the presence of minerals and carbon sources in the treatment plant effluent is essential. Replacing freshwater with treated wastewater for electrolysis demonstrates a zero waste discharge approach. Utilizing anaerobic digestion can reduce sludge disposal quantities while simultaneously producing biogas for direct grid injection. A holistic development of integrating these various technologies will make the Irish wastewater treatment plants a green industry, which can increase job opportunities and generate revenue for the nation.

Fig. 2. Proposed waste treatment scheme to convert Irish wastewater treatment plant to green infrastructure. In this new scheme, wastewater plants will replace conventional methods of pumping air through a compressor with pumping oxygen from water electrolysis and using renewable energy. Regular landfilling of treatement plant sludge is replaced by using sludge as feedstock for anaerobic digestion.

The data reference links can be found below:

[1] European Commission (2022). *Commision launches consultations on the regulatory framework for renewable hydrogen*. (https://ec.europa.eu)

[2] Department of Public Expenditure and Reform (2021). *National Development Plan 2021-2030* (https://www.gov.ie/en/publication/774e2-national-development-plan-2021-2030/)

[3] Herrmann-Heber, R., Reinecke, S. F., & Hampel, U. (2020). *Dynamic aeration for improved oxygen mass transfer in the wastewater treatment process*. Chemical Engineering Journal, 386, 122068.

[4] Mohammadpour, H., Cord-Ruwisch, R., Pivrikas, A., & Ho, G. (2021). *Utilisation of oxygen from water electrolysis–Assessment for wastewater treatment and aquaculture.* Chemical Engineering Science, 246, 117008.

[5] Environment Protection Agency. Sewage Treatment, Layer Used: Sewage Treatment >500 pe and Sewage Treatment < 500 pe (https://gis.epa.ie/EPAMaps/) (accessed 2021).