USE OF ANAEROBIC DIGESTION ON DOMESTIC SCALE

Study proves anaerobic digestion can mitigate climate change

Climate change is a significant environmental issue that the world is currently facing due to unsustainable energy consumption and global warming. The use of household digesters could help to address this problem by reducing deforestation, greenhouse gas emissions, soil erosion and the loss of cultivable land. Greenhouse gases emitted from burning fossil fuels are major contributors to global warming, and biogas production can partially reduce this problem. The utilisation of biogas in households offers various environmental, economic and social benefits, *writes Ishani Banerjee, BEng. Sustainable Energy and Environmental Engineering.*

Countries such as India and China make extensive use of biogas on domestic, agricultural and industrial levels. Ireland has set ambitious targets for the reduction of greenhouse gas emissions and the development of renewable energy sources, and anaerobic digestion can become a key technology for achieving these goals.

One of the major biogas plants in Ireland is Green Generation in County Kildare. The grid injection point for the plant is at Cush, and is the first of its kind in Ireland. The Irish government has introduced a range of supports and incentives to encourage the development of anaerobic digestion in the country. These include the Renewable Electricity Support Scheme (RESS), which is a provider of financial support for the development of renewable electricity projects, and the Support Scheme for Renewable Heat (SSRH), which supports the installation of renewable heat technologies such as anaerobic digestion.

The use of renewable energy technologies – even in households – to offset some of the electricity demand in a sustainable manner has been on the rise. A good example is photovoltaic cells. Is it possible biogas could also be one of those renewable technologies that would allow us to generate some of our daily energy demand?

I recently undertook a research project in TU Dublin to demonstrate the feasibility of anaerobic digestion on a domestic scale. This project was conducted under the supervision of Dr Gerard Ryder with the support of Hugh McGuinne, both of the Department of Mechanical Engineering.

What is anaerobic digestion?

Anaerobic digestion is a series of biological processes that use a diverse population of bacteria to break down organic materials into biogas, primarily methane, and a combination of solid and liquid effluents, the digestate. Organic materials comprise organic compounds resulting from the remains or decomposition of previously-living organisms (biomass) such as plants and animals and their waste products. Sources of organic material for anaerobic digestion include dairy manure, food processing waste, plant residues, municipal wastewater, food waste, fats, oils and grease.

Biomass is made of materials that come from living organisms and is therefore organic. Biomass materials that are used for the purpose of energy production are called biomass feedstock. In an anaerobic environment biomass decays and so produces methane, which is a valuable energy source. The energy from biomass can be transformed into energy through direct and indirect means. Biomass can be combusted to generate heat (direct), converted into electricity (direct), or processed into biofuel (indirect).

Anaerobic digestion can be divided into four steps, while different bacterial/archaea communities work in a syntropic relationship with each other to form methane. See Figure 1.

Research project overview

The research project was done in two steps. A digester was designed and set up in the lab to measure the amount of biogas generated from kitchen waste. A sizing calculation for the digester was also done as a method to gain an insight on the size of the digester and its impact on the amount of biogas that can be generated.

Two types of wastes were used – kitchen and cardboard. Through experimental analysis and associated calculations, it was found that cardboard waste, when turned into a slurry with some animal waste, can easily be broken down by methanogenic bacteria to produce biogas. This is an important result as cardboard waste can now be identified as a material that can also be "recycled" using the anaerobic digestion process to produce energy.

For methanogenic bacteria to be able to efficiently break down kitchen waste, it is important to add a base to the slurry to reduce its pH. In this experiment, 1g of NaOH was added to 149g of kitchen waste when preparing the slurry.

It was also concluded that an anerobic digester would not produce a sufficient amount of biogas in a small household. This is because the average food waste per person, per day, is not large enough to produce a significant amount of biogas. For example, if we assume that a person produces 0.2Kg of waste on a single day in a four-person household, the total amount of biogas generated from that household would be approximately 44.8 litres per day.

On the other hand, anaerobic digestion is a much more feasible option on a community level. For example, let's assume that a community comprises 3,115 people, with each person generating approximately 1Kg of waste. The amount of biogas produced in this scenario was calculated to be 174,440 litres per day. This is a significant amount of biogas in comparison to the previous example of a small household.

Benefits

Biogas production through anaerobic digestion plays an important role in the circular and bio economy because of the opportunity to produce renewable fuel from organic waste. This also provides a sustainable method for

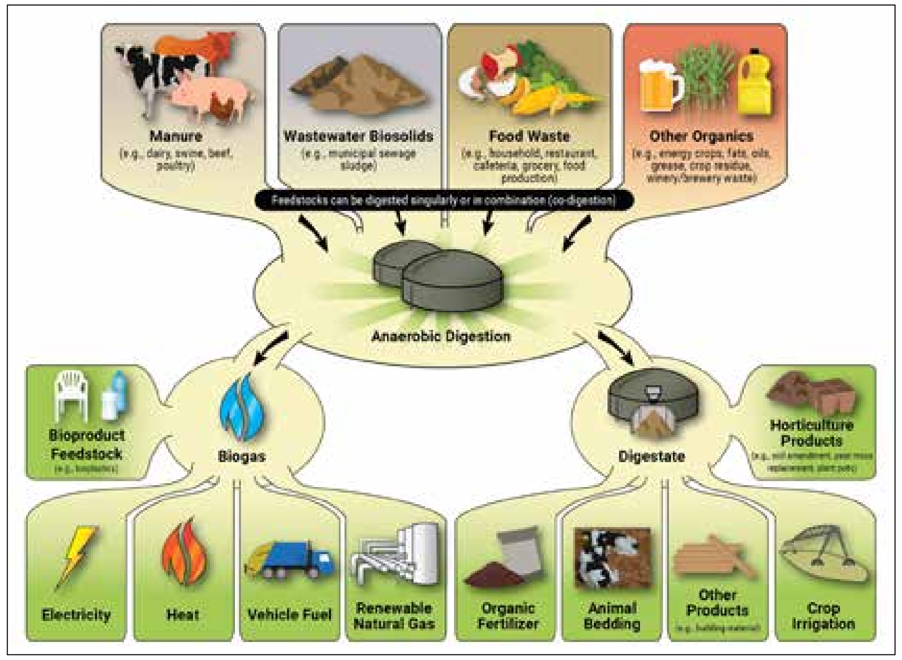


Figure 1. Different bacterial/archaea communities work in a syntropic relationship with each other to form methane. [Image Source: epa.gov]

waste management. Focusing on a residential level, some of the benefits of making use of anaerobic digestion are:

Food waste – Food waste in landfills generates methane, a potent greenhouse gas. Diverting food waste from landfills to biogas plants or anaerobic digestion facilities allows for the capture of the methane which can be used as an energy source. In residential areas, anaerobic digestion can be used as a means to utilise kitchen waste to generate energy. This can then be used by the residents for electricity and/or cooking and also helps to reduce the significant environmental impact of residential buildings.

Composting – The digestate can be used as a fertilizer to grow plants and improve landscaping around residential buildings. This is especially beneficial for buildings that have community gardens or green spaces.

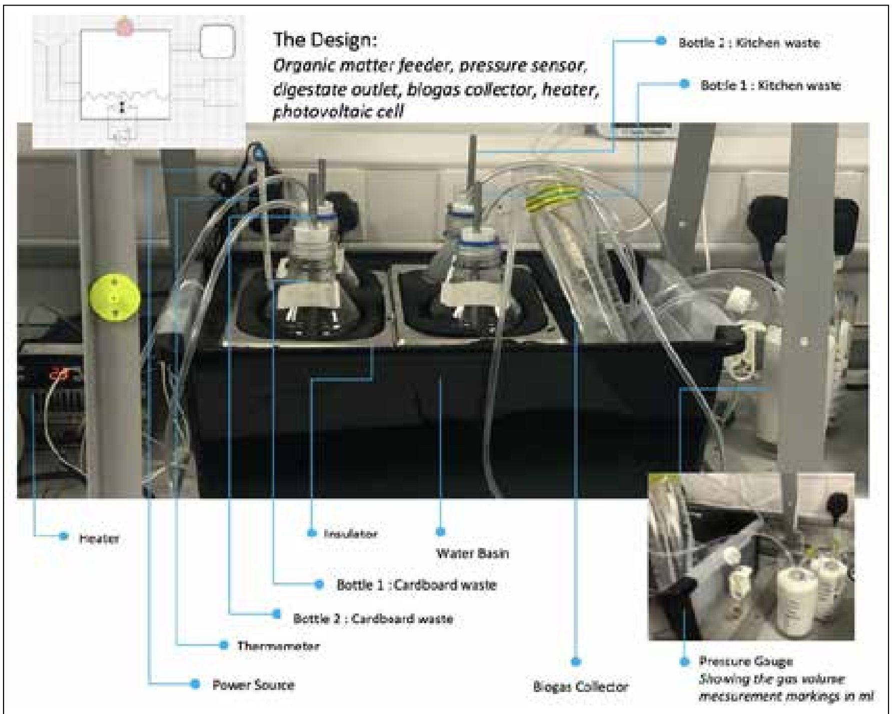
Cost reduction in building management – By reducing the amount of waste generated by the building, the cost of waste management and its subsequent disposal can be reduced. Additionally, the digestate produced through anaerobic digestion can be used for landscaping in residential areas instead of purchasing expensive and what can sometimes be harmful commercial fertilizers.

There are also several societal benefits associated with investing in anaerobic digestion technologies, such as:

Empowering communities – Anaerobic digestion allows the use of local resources and therefore supports the sustainable economic development of communities. Biogas can be sold or used to offset energy costs, and digestate can be sold or used to improve soil quality which can create new revenue streams.

Job creation – Several employment opportunities can be created for the construction and installation of digesters such as plumbing, electrical work, operation and maintenance mechanics, etc.

Research and development – The bio-energy systems industry is constantly evolving, and there is a need for research and development to improve the technology and find new uses for the byproducts. This creates educational and employment opportunities for scientists and engineers.



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Conclusion

Anaerobic digesters can now be incorporated in buildings as part of a sustainable design for managing organic waste, to reduce greenhouse emissions and to promote a circular economy.

However, the technology requires significant investment (depending on the design), safety measures and proper maintenance.

Anaerobic digestion systems require space for the necessary equipment, as well as infrastructure for storing the biogas and digestate that is produced. This is, of course, unless the process of distributing the biogas to residents in the building is automated and done as and when the biogas is produced.

In larger buildings, such as universities or hospitals for example, there may be enough space to install a small-scale anaerobic digestion system on site. In smaller buildings, such as offices, it may be more feasible to collect the organic waste and transport it to a centralised anaerobic digestion facility.

Nonetheless, anaerobic digestion is very much a key component of the circular economy as it allows for the recovery of energy and nutrients from waste streams, while reducing greenhouse gas emissions and minimising waste. It is very much a technology that must now be utilised as a sustainable solution to mitigate climate change. ■

• *Ishani Banerjee, who is currently pursuing a degree in Energy and Environmental Engineering at TU Dublin, Tallaght, has served as Chairperson on the committee of TU Dublin Eng Tech Society, was Intel Engineering Scholar 2021, and is a Power Systems Consultant (internship) at TNEI Ireland.*