European Commission

Science for Environment Policy

Processing London's local food waste in an anaerobic digester avoids 3.9 tonnes of GHG emissions

Analysis of the operation of a novel, micro-scale anaerobic digester has shown that this technology could provide a useful means of processing food waste in urban areas. The study found that the digester, located in London and fed mainly with local food waste, avoided 3.9 tonnes of greenhouse gas emissions, while providing biogas for cooking, heat and power. Anaerobic digestion on this scale could play a part in reducing the amount of food waste that goes to landfill[1] and contribute to the circular economy.

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Source: Walker, M., Theaker, H., Yaman, R., Poggio, D., Nimmo, W., Bywater, A., Blanch, G. & Pourkashanian, M. (2017). Assessment of micro-scale anaerobic digestion for management of urban organic waste: A case study in London, UK. *Waste Management*, 61: 258–268.

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Anaerobic digestion (AD) is a means of processing waste or crop biomass which produces digestate, a substance which can be used as fertiliser, and biogas, which can be used as fuel. Thanks to policy incentives[2], the technology has been widely adopted in Europe in the past 20 years, note the researchers behind this study. For example, in the UK, there are around 400 (non-sewage) AD plants, processing material such as dairy-farm waste and manure.

The researchers highlight that AD mostly operates at a large scale in the developed world, though it is a popular household-scale technology in India and China, where there are five million small-scale digesters. Urban, micro-scale digesters could offer many benefits in Europe, they suggest, by offering non-centralised processing of organic waste. This can reduce transport emissions, offer opportunities for community involvement, and contribute to the circular economy through the production of fertiliser, while also producing energy. In this study, a novel micro-scale system operating in London, UK, is described.

The digester studied was a two-cubic-metre (m^3) system, installed in a community wildlife park in 2013 in order to convert local organic waste into biogas for cooking, heating and electricity. The gas produced during the study period was used on a gas hob in the site's café; a generator to convert it to heat and power came later. The researchers monitored the system from January to November 2014, assessing various aspects of its operation. The main feedstocks processed during this period were commercial catering waste, oats, tea leaves, and soaked paper bin liners, as well as water, amounting to an average 14 kilograms (kg) per day. The system could have managed more than this weight, but potential performance at a higher capacity is not covered by the study.

In total, over the monitoring period, 4 574 kg of waste was processed, yielding an average of 3.15 m^3 of biogas per day, of which about 60% was methane (useful as fuel). The system covered some of its operational costs by generating revenue from waste disposal and energy production, but grant funding supported its installation. Savings could be made by increasing production volume, say the researchers, but the main objective of this installation was promotion of the technology, rather than financial return.

The system's relatively large pre-digester tank was found to be very useful, as it allowed feedstock to be stored until required by the main digester. Such large pre-digesters (compared to the size of the main system) are not generally possible with larger-scale systems, the researchers note. Operators commented that the tank needed to be properly sealed, however, to control unpleasant odours.

Continued on next page.

1. See: http://ec.europa.eu/environment/waste/compost/index.htm

2. Edwards J. *et al*. A review of policy drivers and barriers for the use of anaerobic digestion in Europe, the United States and Australia. *Renewable and Sustainable Energy Reviews*, 52 (2015): 815–828

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The volume of biogas produced varied over the period, in relation to the amount and composition of the feedstock. Methane content gradually reduced from 65% to about 57% over the period — a possible sign of problems occurring with the digestion process, according to the researchers, or possibly due to a change in feedstock composition, as fewer oats were added later on.

The digestate was analysed and found to be high in nitrogen and potassium, but towards the end of the period its composition (with rising levels of ammonia and volatile fatty acids) also indicated possible problems in the digestion process. Ammonia and deficiencies in certain elements can inhibit digestion, so the necessary trace elements were later added to the digester, resolving the issue.

The digester used approximately 1.68 kilowatt hours (kW h) per day in electricity (not including power used by the monitoring equipment) and 1.92 kWh per day in heat (hot water). Energy was also used to maintain it at a suitable temperature for functioning (33 °C), which was aided by its location in a greenhouse. Analysis of digester energy use compared to potential energy output (with biogas fuelling a combined heat and power (CHP) generator), indicated that the digester could produce a net power output of 151 watts of electricity and 362 watts of heat. The electricity would be about enough to power a fridge for four hours. Heat generation was particularly efficient, but this was partly attributed to the location of the system inside a greenhouse; efficiency would drop by about 50% if the digester was located outside.

According to the researchers' analysis, the digester could result in the net avoidance of about 3.9 tonnes of greenhouse gases (GHGs) per year, at the performance levels reported. This was mainly achieved through the avoidance of fossil fuel use on site thanks to the biogas produced. Reduced transport of waste and its diversion from landfill, and use of digestate instead of inorganic fertiliser also contributed. Specifically, 2.95 kg of GHGs could be saved per kilowatt hour of electricity produced, and 0.741 kg per kg of waste treated (as opposed to going to landfill).

The researchers compare some performance outputs with those reported for a large-scale (900 m^3), commercial digester[3]. The findings show broadly similar biogas yield, indicating a similar level of performance in both the large and micro-systems. However, green waste as well as food waste was used in the large-scale system, and energy-intensive pasteurisation was necessary, making it difficult to directly compare the two systems in other ways. The researchers note that life-cycle analysis of both small- and large-scale anaerobic digesters would be interesting.

Based on their findings, the researchers conclude that the micro-scale anaerobic digester is an example of a viable technology with the potential to help solve the problem of food waste processing in urban areas, while generating GHG emissions savings. Operational performance was similar to a large-scale plant, with a net positive energy output. Some issues were raised, however. One was that the noise of the system could be problematic in an urban area. Also, there was a lack of local demand for the digestate, partly due to lack of information on its use in horticulture.

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3. Banks, C.J., Chesshire, M., Heaven, S. and Arnold R. (2011). Anaerobic digestion of source-segregated domestic food waste: performance assessment by mass and energy balance. *Bioresource Technology*, 102: 612–620