Education & Training | Jan DeWaters & Stefan J Grimberg

Food Waste-to-Energy

A project-based school learning experience

One of the challenges facing the uptake in renewable energy and waste-reduction methods is sufficiently changing peoples' perceptions to ensure a cultural shift needed for momentum. A possible model for achieving this sits in the small village of Potsdam in the US state of New York. Professors Jan DeWaters and Stefan J Grimberg at Clarkson University have established an ongoing partnership programme with a nearby school that combines biogas production and waste reduction. The outcome is not only renewable energy and reduced waste, but also the seeds of a sustainable legacy in young minds.

Middle and high school learners collect and sort organic food waste.

Within the renewable energy spectrum, biogas production is probably the ugly cousin to shiny solar photovoltaic systems and majestic, slowly whirring wind turbines. But it has an ace up its sleeve: it does three things, not just one. Anaerobic digesters, which lie at the heart of biogas production, use microorganisms to break down organic material in the absence of oxygen to produce the biogas used for heating. The residue – or digestate – remains rich in nutrients, making it an excellent fertiliser. But the real gem is that feeding this whole process is organic waste. So, not only does the system produce gas and fertiliser, it also removes organic materials from the solid waste system. This is a significant drawcard because the scope of food waste in the US alone is staggering.

According to the US National Resources Defense Council, approximately 40% of all food produced in the US – over 90 million tonnes per year – ends up uneaten. This wastage occurs throughout the entire food supply chain, from production through delivery to consumption. Most of the country's food waste ends up in landfills. In fact, food waste is the single largest fraction of material in landfills. Not only does it diminish landfill capacity, but in its decomposition, it generates greenhouse gases. The issue is so dire that one of several states – New York – has mandated that as of 2022, any facility generating more than 1.8 tonnes of food waste a year will not be allowed to landfill its organic waste. Students in a small northern town close to the Canadian border are exploring one solution to the problem.

A YOUNG IDEA GROWS

Potsdam may be small as towns go, but it punches above its weight in tertiary education. It hosts two universities. One of those is Clarkson University, a private research university and the home of the Food-to-Energy programme headed by Professors Jan DeWaters and Stefan Grimberg.

The programme's genesis came from the high school environmental club at Canton Central School (CCS) in neighbouring Canton. The learners were interested in whether they could use food waste from their cafeteria in the anaerobic digester on a nearby farm. The farm is part of the Cornell Cooperative Extension at Saint Lawrence County (CCE), an educational outreach facility focused on food and agricultural systems.

Inspired by the learners, DeWaters and Grimberg developed the idea into a three-way partnership. It works like this: the school's middle and high school learners collect and sort organic food waste from their cafeterias. The university students collect the waste from the school and take it to the CCE farm. It is then fed into the anaerobic digester, producing biogas to heat a greenhouse on the farm, animal bedding from the recovered solids, and fertiliser. But there's so much more to the partnership than a steady stream of waste-to-fuel, and it's one where the learners are essential.

Education is central to the whole programme, and for a good reason. It is well-known that long-term behavioural change originates in early experience. It's easier to plant the seed of behavioural change in a young mind than it is to reform a habituated adult. Furthermore, young minds are fertile grounds for environmental issues – hyper-connected, social media-savvy youth are part of the popular groundswell to address climate change. It's no accident that the kernel for this project came from the school learners.

The Environmental Club and Green Team organise education and awareness projects.

The separation and collection of food waste is actually only one part of a much broader education programme involving classroom and extracurricular activities in resource recovery. DeWaters and Grimberg knew that if the programme was to succeed in changing the learners' long-term behaviour, it must do three things: make the learners aware of the problem, increase their understanding of the solution, and increase their participation in the solution. In essence, the school must become a living laboratory.

EDUCATION AT MULTIPLE LEVELS

Education throughout the programme happens at multiple levels. The Clarkson University students are engaged in a credit-bearing course. They help design project-based activities for the high school learners on food waste, anaerobic digesters, and biogas production. These are presented together with teachers. One of the most popular is a science class experiment where students build small anaerobic bioreactors using small-mouthed glass bottles and balloons. Microorganisms digest organic material in the bottles, producing gas that blows up the balloons.

At the same time, teachers incorporate other project components into lessons to meet class-specific learning objectives.

For example, environmental science classes estimate the biogas produced from a typical dairy farm and the resulting impact on electricity-related CO_2 emissions, and chemistry classes learn the stoichiometry and biogas potential for digesting various types of food waste. At the peer level, the high school Environmental Club and the middle school Green Team – an active group of 5th and 6th graders – drive education and awareness projects. The learners use posters and other forms of peer contact to encourage an awareness of food waste and its impacts. Educating other learners to sort their food waste at the cafeteria is essential for the project. The economic viability of biogas production relies on the provision of 'clean' organic waste. Therefore, the learners must ensure that what they send for recovery is free of plastic, metal, glass, and other non-biodegradable contaminants. Tellingly, the programme uncovered that the younger learners typically produced the cleanest food waste, compared to the older learners and cafeteria staff.

Approximately 40% of all food produced in the US – over 90 million tonnes per year – ends up uneaten.

The learners also visit the farm to see the end product of their food waste collection and separation: the anaerobic digester at work. They, therefore, get first-hand experience of the process of resource recovery within a closed system. This makes them more engaged

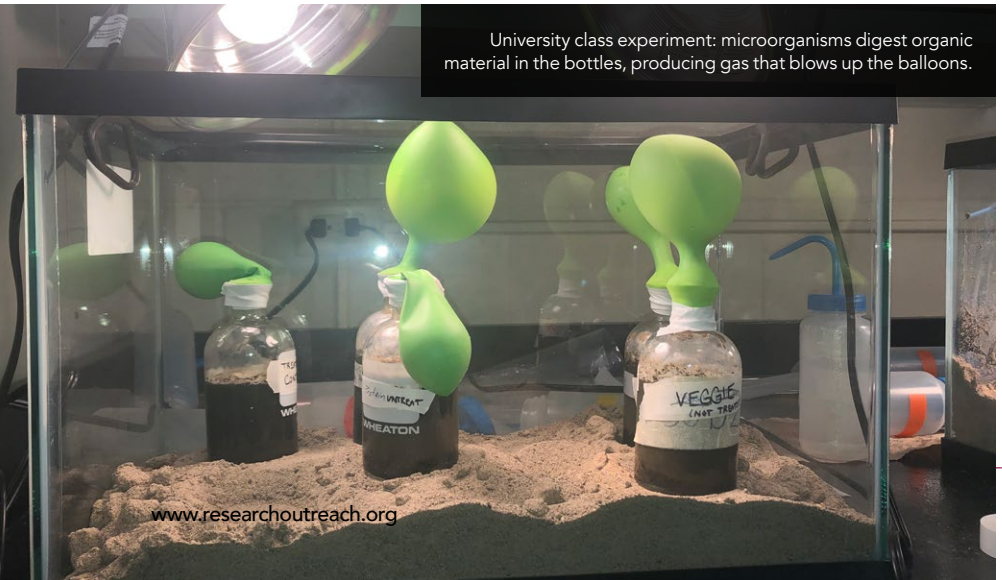
The learners see the anaerobic digester at work.

After the programme, all the learners showed a significant increase in their knowledge of food waste, biogas production, and resource recovery.

The younger learners exhibited more significant feelings of self-efficacy about their ability to contribute toward solving issues related to energy and the environment.

in the learning process because they see the relevance of what they learn to their lives outside of school.

Teachers also learn from the programme. The university hosts a full-day professional development workshop on the value of resource recovery from food waste; here, they share the insights learned from the project with other educators. The CCS teachers involved in the programme have found opportunities to present their findings to teachers at other schools, too. Additionally, DeWaters, Grimberg, and their team have disseminated details about the programme to other universities interested in outreach opportunities.



University class experiment: microorganisms digest organic material in the bottles, producing gas that blows up the balloons.

MORE THAN JUST GAS

For DeWaters and Grimberg, the programme has three measures of success: the extent to which they foster a successful food waste recovery programme in the school cafeterias, learner and teacher engagement in the programme's educational activities, and their impact on learner knowledge or behavioural outcomes.

Over the first three years of the programme, approximately 16 metric tonnes of food waste found its way from the school cafeterias into the farm's anaerobic digester, producing about 3,400 m^3 of biogas and saving the school district approximately $4,000 in waste hauling fees. Those figures would have been higher had the COVID-19 pandemic not shut the school down for a protracted period and sent much of the educational part of the programme online. The university estimates that an entire school year could produce 12 metric tonnes of food waste from the middle and high school cafeterias alone.

Learners complete two surveys – one before and one after the programme – to help determine the impact on their knowledge and behaviour. After the programme, all the learners showed a significant increase in their knowledge of food waste, biogas production, and resource recovery. There were also measurable improvements in their waste-related behaviours. One of the standout insights, though not surprising, was that middle school learners embraced separating their food waste more so than high school learners, although high school behaviours have improved steadily from year to year. The younger learners also exhibited more significant feelings of self-efficacy about their ability to contribute toward solving issues related to energy and the environment.

In terms of turning food waste into energy, because of COVID-19, the actual outcomes potential of the Food-to-Energy programme is still to be realised. What is already clear, though, is that it is a true example of an immersive, relevant, project-based learning experience. Importantly, it is one that can be replicated, and should be.

Behind the Research

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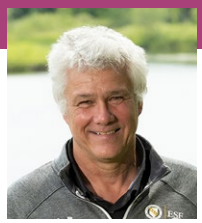

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Research Objectives

Professors Jan DeWaters and Stefan Grimberg at Clarkson University have partnered with a public school to develop a school-wide food waste recovery programme that includes classroom and extracurricular education.

Detail

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Bio
Dr Jan DeWaters is an Associate Professor in the Institute for STEM Education at Clarkson University in Potsdam, New York. She teaches courses that introduce students to engineering, energy, and energy systems. Her research interests include the implementation and evaluation of evidence-based learning practices in STEM education, environmental education, and energy education.

Dr Stefan J Grimberg is Professor of Civil and Environmental Engineering at Clarkson University, Potsdam, New York. His research focuses on delineating the role of microorganisms on contaminant transport in atmospheric and aqueous systems. Most recently, he and his students have been investigating the most efficient process to convert farm waste into biogas using anaerobic digestion.

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Collaborators
James Burdick, Megan Smith, and Tom Van de Water (all from Canton Central School)

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Personal Response

You're now over three years into the programme. What has been the most surprising outcome for you, and why?

"There have been many unexpected outcomes from this project but probably the most surprising, to us, was the way our Clarkson students have embraced the mission of educating students/peers about food waste and resource recovery. On their own initiative, and above and beyond our expectations, they created educational materials – brochures, flyers, refrigerator magnets – to engage Clarkson and the broader community. They also started an Instagram account for the project, which currently has about 130 followers. They create regular posts with information, quizzes, and polls about food waste and resource recovery, which typically gain 10-20 'likes' per post."