The POWER Toolbox:

Aid for Assessing Anaerobic Digestion of Organics

by Melanie Sattler, Opeyemi Adelegan, Ardeshir Anjomani, Mehrdad Arabi, Arpita Bhatt, Mithila Chakraborty, Victoria Chen, Kate Hyun, Bahareh Nasirian, Doreen Ntiamoah-Asare, and Nicholas Raven

Drs. Sattler, Bhatt, and **Hyun** are faculty members in Civil Engineering at the University of Texas at Arlington (UTA). **Drs. Anjomani** and **Chen** are faculty members at UTA in Public Affairs & Planning and Industrial, Manufacturing, and Systems Engineering, respectively. **Opeyemi Adelegan, Mehrdad Arabi, Mithila Chakraborty,** and **Doreen Ntiamoah-Asare** are graduate students in Civil Engineering. **Bahareh Nasirian** and **Nicholas Raven** are graduate students in Industrial, Manufacturing, and Systems Engineering; and Public Affairs & Planning, at UTA, respectively. E-mail: **sattler@uta.edu.**

A primer on the newly developed Prioritizing Organic Waste to Energy–Renewable (POWER) Toolbox, created at the University of Texas at Arlington, which can help cities and municipalities assess the feasibility of co-digesting organic wastes at existing or new wastewater recovery digesters, on-farm digesters, or stand-alone industrial digesters.

As a part of a sustainable future, many U.S. cities and municipalities are considering renewable fuels. Biogas is a promising alternative fuel that is primarily composed of methane. Biogas can be cleaned for use in natural gas vehicles, upgraded to pipeline-quality natural gas, burned to generate electricity for electric vehicles or other purposes, or used for direct heating. Use of biogas reduces emissions compared to non-renewable fossil fuel combustion.[1]

Organic waste generation and diversion is another challenge many cities and regions are facing due to urbanization. If wastes are diverted to make biogas, urban waste volume is reduced, freeing up landfill space. Nationwide, 22% of the waste that goes to landfills is food waste, and 7.8% is yard (flora) waste.[2] According to the U.S. Environmental Protection Agency's (EPA) Food Recovery Hierarchy, if food waste cannot be reduced or used to feed hungry people or animals, the next priority is using it to generate energy, rather than composting or sending it to the landfill.[3]

Many U.S. cities already have anaerobic digesters (AD) that convert sewage sludge at wastewater treatment plants, or water resource recovery facilities (WRRFs), to methane-rich biogas (see Figure 1). Taking advantage of this existing infrastructure, organic wastes like food, yard, and fats/oils/grease (FOG) can be co-digested with sludge to increase biogas production. Digesting the food waste generated by the average American in one year—around 248 pounds—could provide enough energy for an electric vehicle (EV) to travel about 41 miles or a compressed natural gas (CNG) vehicle to travel around 22 miles.[4-7] Of the 1,286 WRRFs with digesters in the United States, only 63 plants were co-digesting food waste in 2019; thus, substantial potential exists for expanding co-digestion of organic wastes.[8,9]

Additionally, food, yard, and FOG wastes can be co-digested at existing on-farm digesters, which are already processing manure and crop residues. As of 2019, 248 on-farm digesters were operating in the United States, with 10 co-digesting food waste. Finally, food, yard, and FOG wastes can be co-digested at stand-alone digesters; 45 were co-digesting food waste in 2019.[9]

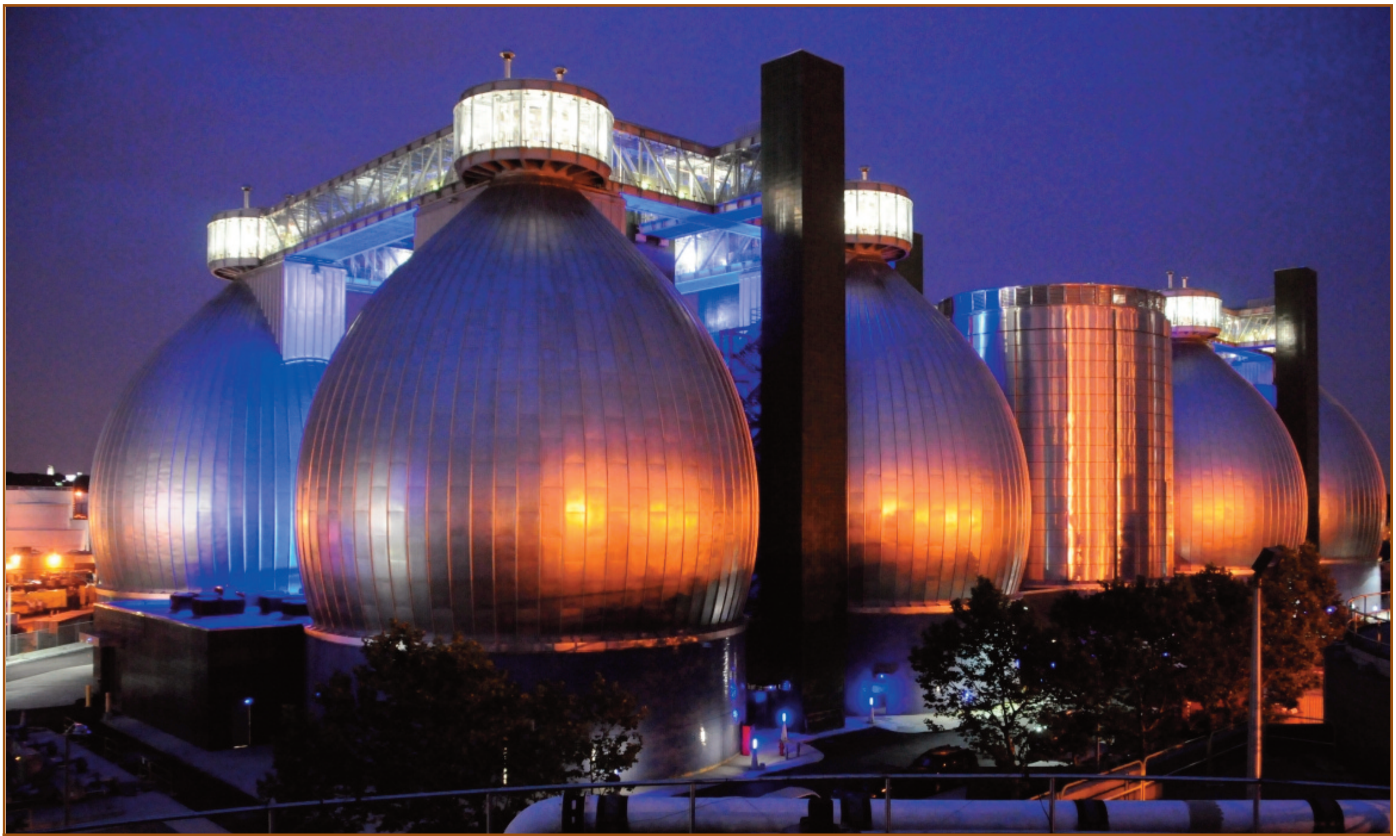

Figure 1. WRRF Digester and Biogas Facility in New York City.
Source: New York City Department of Environmental Protection and U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE).

The POWER Toolbox

The newly developed Prioritizing Organic Waste to Energy – Renewable (POWER) Toolbox, which is available for free at https://seerlab.uta.edu/, can help cities assess the feasibility of co-digesting organic wastes at existing or new WRRF digesters, on-farm digesters, or stand-alone industrial digesters. The POWER Toolbox, shown in Figure 2, was developed at the University of Texas at Arlington, with funding from the University's Center for Transportation, Equity, Decisions and Dollars (CTEDD), funded by the U.S. Department of Transportation Research and Innovative Technology Administration (OST-R Grant Number: 69A3551747134).

The POWER Toolbox consists of four components: (1) geographic information system (GIS) toolbox; (2) POWER tool; (3) optimization tool; and (4) city guidebook.

GIS Toolbox

The automated GIS toolbox allows users to estimate quantities of organic wastes potentially collected for digestion. For seven food-waste generator categories (e.g., K-12 educational institutions, food banks, food manufacturers/processors, restaurants and food services), EPA's Excess Food Opportunities map is used to provide institution-specific food-waste generation values in tons/year.[10] For other food waste-generator categories, as well as yard-waste and farm-waste generator categories, waste production per block group is estimated by multiplying a waste generation rate (from literature) by an activity level per block group, obtained from various GIS information sources, including the U.S. Census Bureau and Open Street Map (OSM). Figure 3 shows an example food waste map constructed for the City of Dallas by block group. In addition, the GIS shortest path algorithm is used to route waste to anaerobic digestion facilities for any region in the United States.

POWER Tool

The POWER tool, a user-friendly Microsoft Excel spreadsheet, estimates the following for the anaerobic digestion process, as shown in Figure 4: costs/benefits; pollutant emissions; electricity, CNG, or pipeline natural gas production; and net energy balance. To gather data for the POWER tool, interviews were conducted with personnel from WRRF, fleet services, and solid waste collection services from several cities; relevant literature was reviewed (>150 articles); and meetings were held with a multi-disciplinary advisory group. Information sources are referenced in the POWER tool itself.

Since the POWER tool is a screening tool, inputs are limited. Required inputs include distance of waste transport, as well as volume of waste being treated and excess capacity in existing digesters. The user can choose the categories of organic waste to evaluate, type of digester (e.g., WRRF, farm, or industrial), end use of biogas (e.g., electricity, CNG, or pipeline natural gas), type of vehicle if the end use is vehicle fuel, and baseline for comparison (e.g., landfilling or composting). Since the purpose of POWER Toolbox is screening, detailed impacts on digester performance and efficiency are not considered.

Optimization Tool

Using existing digester infrastructure to accommodate organic waste involves determining which digesters are the best candidates for co-digestion. The best candidates would provide the most biogas for the least cost. Determining this is not straightforward, however, because of the large number of potential digesters, waste collection routes, and variables that impact the cost. The 16-county region served by the North Central Texas Council of Governments, for example, has 9 existing anaerobic digesters at WRRF. Trade-offs must be balanced between organic waste transportation costs; capital costs for expanding anaerobic digesters, cleaning gas/generating electricity, and installing refueling stations; and on-going operation costs.

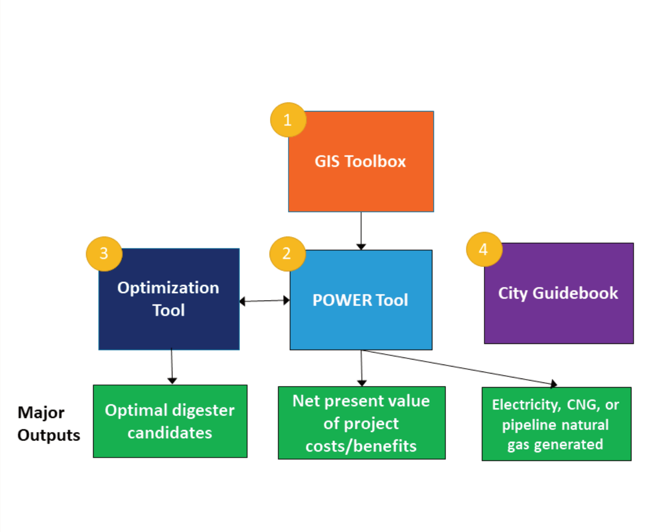

Figure 2. POWER Toolbox.
Source: Engineering Department at the University of Texas at Arlington; **https://seerlab.uta.edu/**.

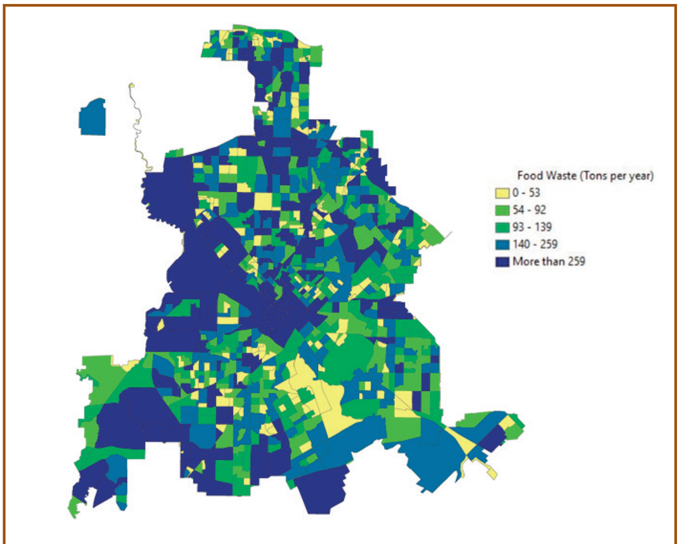

Figure 3. Waste Aggregated by Block Group, City of Dallas.
Source: Engineering Department at the University of Texas at Arlington; **https://seerlab.uta.edu/.**

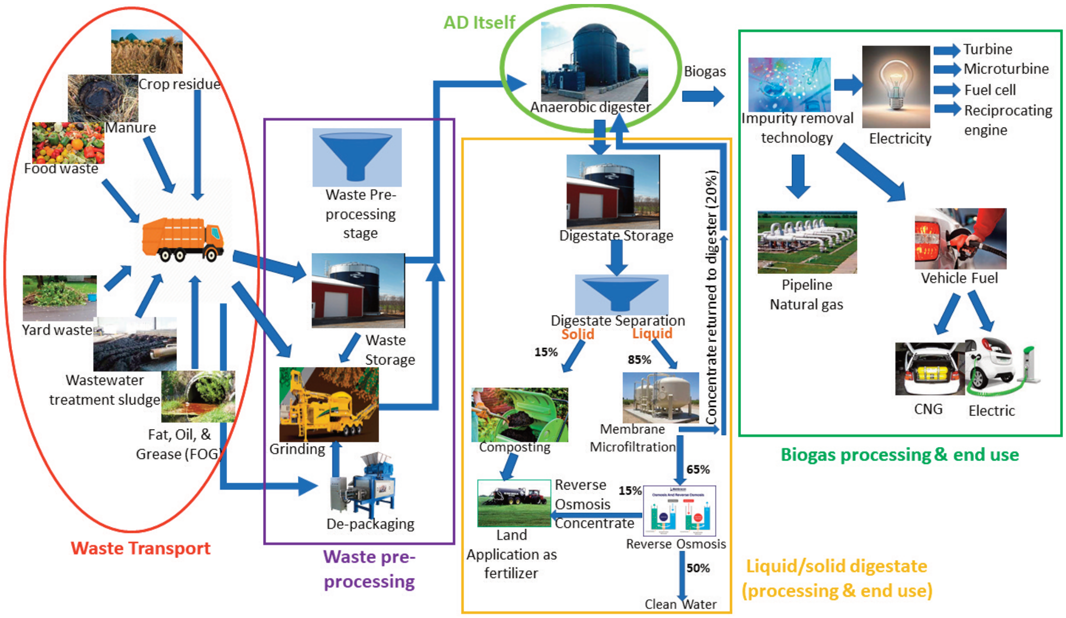

Figure 4. Anaerobic Digestion Process included in the POWER Tool.
Source: Engineering Department at the University of Texas at Arlington; **https://seerlab.uta.edu/**.

The Optimization tool (developed using Python) allows the user to determine the overall least-cost system of digesters for converting waste to energy. When more than one existing digester is available, the tool determines the optimum region(s) of waste to send to each. A scenario evaluated for the City of Dallas found that adding digesters to accommodate food and yard waste at a second WWRF was cheaper over the long term (50 years) than sending all food and yard waste to the one existing WWRF with digesters, due to reduced transportation costs.

City Guidebook

The POWER Toolbox city guidebook, entitled *Anaerobic Digestion of City Food and Yard Waste: Answers to 10 Critical Questions*, addresses common questions that cities and municipalities may face when considering diversion of food and yard waste from landfills. It is based on information from interviews with officials from seven U.S. cities/states with successful food/yard waste collection programs—San Francisco, CA; Connecticut; Massachusetts; Southern Nevada; Austin, Texas; Vermont; and Washington State—as well as information from relevant literature. For example, two important questions cities commonly face are: What obstacles have cities encountered in separate collection of food and yard waste, and how have these obstacles been overcome? What incentives/penalties could my city use to encourage public participation in a separate collection of food and yard waste?

Conclusion

The POWER Toolbox can help cities and municipalities assess the feasibility of co-digesting organic waste in existing or new WRRF, farm, and industrial/stand-alone digesters, in order to produce biogas for electricity production, CNG, or pipeline quality natural gas. The Toolbox can help select the optimal digesters and also provides information about costs/benefits, pollutants emissions, and energy production. The Toolbox is currently being used to conduct case studies for the state of Vermont, Las Vegas, and the Dallas/Fort Worth Metroplex. Hopefully, other regions will take advantage of the Toolbox to do their own assessments of potential benefits of digestion of organic waste.

The POWER Toolbox tools, user guide and video tutorials are available on the project website (https://seerlab.uta.edu/). **em**

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