SPECIAL REPORT: The Energy Crunch

Methane generators turn agricultural waste into energy

When the energy crisis struck in 1973, a number of entrepreneurs scrambled to devise systems to convert manure from swine, dairy and poultry operations into money. Nearly three decades and another energy crunch later, there are just 31 commercially successful methane generators operating in the United States (five in California). Despite the idea's promise, some of the older systems were poorly designed "white elephants" that many farmers shunned.

With California's 2001 energy crunch, interest is again high in methane generators; these systems use bacteria to break down or "digest" manure into a "biogas," which is then captured to produce energy. New technology developed by Ruihong Zhang, a UC Davis biological and agricultural engineer, and colleagues promises a brighter outlook for converting animal and other agricultural wastes to energy. A pilot plant of the APS-Digester, short for anaerobic phased solids digester, is nearing completion at UC Davis.

"Anaerobic digestion is not new," Zhang says. "It is a natural process, one that has been around about as long as life has existed on earth. What is new is the two-phase, closed-loop system, which encourages the best environmental conditions for the bacteria involved in the process."

In this process, organic materials are broken down by a mix of bacteria in an oxygen-deprived environment, converting complex carbon-containing molecules into a medium-Btu gas that is about 60% methane. This biogas is suitable for producing either heat or electricity — or both. Zhang has successfully tested her APS-Digester on rice straw, paper sludge and a variety of food processing wastes; several vegetable processors are investigating the financial feasibility of adopting the technology. However, the first wide-scale application of the APS-Digester will be at horseracing tracks around the country.

While UC applies for a patent on the system, the technology has been licensed exclusively to Onsite Power Systems of Fresno. Dave Konwinski, co-owner of Onsite, is coordinating the construction of the small-scale pilot plant at UC Davis. In addition, he is preparing to break ground in October on an APS-Digester system containing ten 350,000 gallon system tanks at the Palm Beach Thoroughbred Training Facility in Florida, to handle stable waste and wash-down water from 1,900 horses. The "feedstock" from the horse stables is about 20% manure and 80% straw, combined with the wash-down water. The manure-to-energy plant will generate about 2 megawatts of power — enough to meet the racetrack's needs and to sell surplus energy to local utilities.

The APS-Digester operates at 135°F, resulting in much more rapid digestion than would occur at ambient temperatures, such as in landfills. From an engineering standpoint, its two-phase nature is what distinguishes the APS-Digester from other methane generators. Solids to be digested are handled as a batch process, while the

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At UC Davis, a pilot plant is under construction of the APS-Digester, which converts animal manure and plant waste into biogas under anaerobic conditions. The first commercial application will be at a Florida racetrack, but it has broad applications for dairy, swine, poultry and other animal operations.

biogas generation is performed as a continuous process. This allows the solids to be loaded and unloaded without disrupting the anaerobic environment for the bacteria. The system is also fully automated and will be monitored remotely by UC Davis engineers via a Web site.

The racetrack systems cost about $20 million each, but Konwinski expects cost savings to come quickly, in as little as 5 years. A generator proposed for the L.A. Turf Club racetrack, for example, would yield estimated annual savings on electricity and hot water (calculated at 11 cents per kilowatt-hour) of $2.1 million. On-site power will also eliminate lost revenue and equipment damage from power-grid outages and poor power quality, estimated at $1.1 million annually. Another $720,000 savings is projected by eliminating the $25 per ton cost of hauling stable waste to the landfill.

"Environmental laws have become one of the driving forces behind this," Konwinski says, citing recent California regulations pertaining to groundwater and odor containment, as well as landfill reductions. The APS-Digester will also generate a soil amendment, which is being analyzed by UC Cooperative Extension horticulturist Richard Evans.

Zhang's "green power" system could also be tapped for fueling internal combustion engines, gas turbines or fuel cells for electricity production at mills, processing plants and refrigeration facilities with a consistent demand for power. The power produced from the APS-Digester is eligible for a 1.5 cents per kilowatt-hour green supplementary payment from a renewable energy program run by the California Energy Commission (CEC). California policymakers have also made methane generators more attractive to dairy farmers this year by passing Senate Bill 5X, which allocated $10 million to the CEC for a dairy power production program.

In the future, high-solid digestion systems could be in place to treat green solid wastes that are currently being disposed of in landfills, Zhang says. "Anaerobic digestion systems that are high-rate, simple to operate and easy to manage, and have reliable performance, are needed to make anaerobic digestion of organic waste a mainstream waste-to-bioenergy conversion technology."

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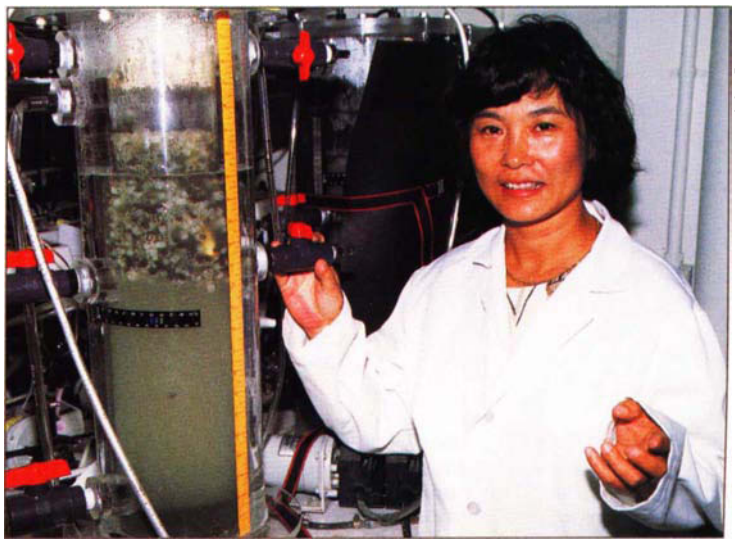

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Ruihong Zhang, a UC Davis biological and agricultural engineer (in her laboratory), says the new methane generator allows wastes to be loaded and unloaded without disturbing the anaerobic environment needed by digestive bacteria.

UC scientists "cracking the nut"

In June, more than 100 scientists from around the nation converged at UC Davis to explore innovative ways to "crack the nut," or convert sugars from California's 30 million tons of lignocellulosic, plant-derived crop residues into useful energy.

"Cellulose, nature's most abundant structural component, is the primary agricultural residue in California," explains Sharon Shoemaker, executive director of California Institute of Food and Agricultural Research (CIFAR), which convened the meeting. Other sources of sugars are food, agricultural and municipal wastes.

Scientists seek to understand the biological processes for both synthesis and breakdown of these natural polymers, Shoemaker says. "Once sugars are derived from cellulose or starch, they can be used to produce a variety of chemicals, materials and energy."

The conference emphasized the development of enzyme systems and their use in the production of ethanol, a oxygenate gasoline additive. Several research projects are currently underway in California to generate ethanol from rice straw, forest thinnings and food wastes.

Shoemaker reported that in California residues are readily available for conversion to ethanol, including forest (34%), crops (12%), animal waste (20%), municipal solid waste (22%) and urban wood waste (10%). The conference was cosponsored by the U.S. Department of Energy and the U.S. Department of Agriculture's Western Regional Research Center.

For more information, go to www.cifar.ucdavis.edu.