It's electric: Cows show promise as powerplants

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A new study suggests that some of the microorganisms found in cow waste may provide a reliable source of electricity.

Results showed that the microbes in about a half a liter of rumen fluid – fermented, liquefied feed extracted from the rumen, the largest chamber of a cow's stomach – produced about 600 millivolts of electricity. That's about half the voltage needed to run one rechargeable AA-sized battery, said Ann Christy, a study co-author and an associate professor of food, agricultural and biological engineering at Ohio State University.

While rumen fluid itself won't be used as an energy source, some of the microorganisms found in the fluid are also found in cow dung, which may prove to be a good source for generating electricity. In fact, in a related experiment, the researchers used cow manure directly to create energy for a fuel cell.

Using cow dung as an energy source isn't a new idea – some farmers already use the methane released by livestock waste to power machinery and lights. But converting methane into electricity requires costly equipment – one California farmer reportedly spent $280,000 to convert his operation to a methane digester system.

“Methane still needs to undergo combustion, which creates issues with energy efficiency,” said Hamid Rismani-Yazdi, the study's lead author and a graduate student in food, agricultural and biological engineering at Ohio State.

The research showed how electricity can be created as the microorganisms in rumen fluid break down cellulose – a complex carbohydrate that is the primary component of the roughage that cows eat. That breakdown releases electrons.

This study represents the first time that scientists have used cellulose to help charge a fuel cell.

The researchers presented their findings on August 31 in Washington, D.C., at the national meeting of the American Chemical Society. Christy and Rismani-Yazdi conducted the work with Ohio State colleagues Olli Tuovinen, a professor of microbiology, and Burk Dehority, a professor of animal sciences.

The researchers extracted rumen fluid from a living cow. The rumen is essentially a fermentation vat crawling with microorganisms where much of the food that a cow eats is temporarily held and is continuously churned until it can be completely digested. This liquid mass is what scientists call rumen fluid.

The researchers collected the fluid through a cannula, a surgically implanted tube that leads directly from the cow's hide into its rumen. The cow used in the study ate a normal diet.

The researchers filled each of two sterilized glass chambers with strained rumen fluid to create the microbial fuel cell. Each chamber was about a foot high and about 6 inches in diameter.

The chambers were separated by a special material that allowed protons to move from the negative (anode) chamber into the positive (cathode) chamber. This movement of protons, along with the movement of electrons across the resistor and wire that connects the two electrodes, creates electrical current.

The anode chamber was filled with rumen fluid and cellulose, which served as a food source for the microorganisms. Cellulose is plentiful on most farms, as harvesting usually leaves behind plenty of it in the form of crop residue in the fields.

The other chamber, the cathode, was filled with potassium ferricyanide, a chemical that acts as an oxidizing agent to round out the electrical circuit.

Two small pieces of plain graphite served as the fuel cell's electrodes (an electrode draws and emits electrical charge.) A piece of graphite was placed in each chamber. The researchers used a meter to measure the output of the fuel cell.

That output reached a consistent maximum of 0.58 volts. After about four days, the voltage fell to around 0.2 volts, at which time the researchers added fresh cellulose to bring the voltage back up to a higher level.

“While that's a very small amount of voltage, the results show that it is possible to create electricity from cow waste,” Christy said.

“Putting a couple of these fuel cells together should generate enough power to run a rechargeable double-A battery,” Rismani-Yazdi said.

In related work done in Christy's lab, she and Rismani-Yazdi, along with a number of undergraduate students, used actual cow manure to power a microbial fuel cell. These individual cells produced between 300 and 400 millivolts.

“The students put a few of these cells together and were able to fuel their rechargeable batteries over and over again,” Christy said.

In that work, the researchers didn't need to use cellulose to feed microbes, as some plant material passes undigested through a cow.

“We've run some of these trials well over 30 days without a decrease in the voltage output,” Christy said. “Both studies suggest that cow waste is a promising fuel source. It's cheap and plentiful, and it may someday be a useful source of sustainable energy in developing parts of the world.”

While the source of energy for the fuel cell used in these studies is somewhat unique, microbial fuel cells aren't a new idea; other scientists have produced electricity from a handful of specific microbes and also from effluent from municipal wastewater.

“Although it's too early to tell if this kind of fuel cell can produce significantly more electricity, the fact that the rumen fluid worked in our study means that there are additional electricity-producing microbes that we have yet to identify,” Christy said.

“The hope is that one day livestock farmers could use their farm's livestock waste lagoon as a huge fuel cell and generate enough power for their operation,” Rismani-Yazdi said.

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Source: Ohio State University