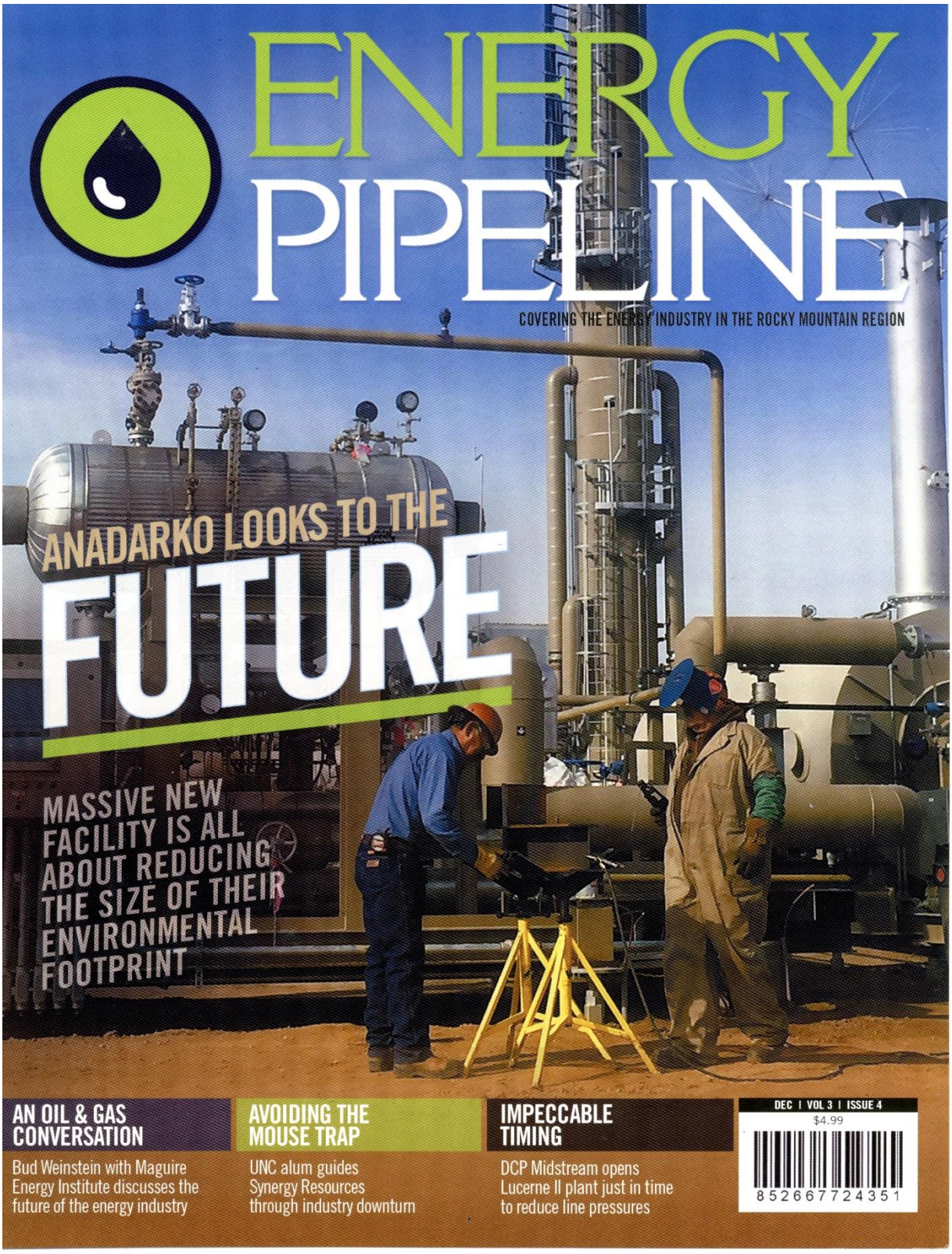
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TECH TALK

CAN ENERGY IN PRODUCED WATER BE USED TO DESALINATE PRODUCED WATER?

BY GARY BEERS • FOR ENERGY PIPELINE

For over 50 years, **GARY BEERS**, has worked in numerous fields of environmental science as a consultant, regulator and educator. This career included senior management position with major consulting, nonprofit and public organizations. He has founded several successful firms to capture emerging resource management markets. One of his latest ventures, EnviroScienceINFO, provides content for public media.

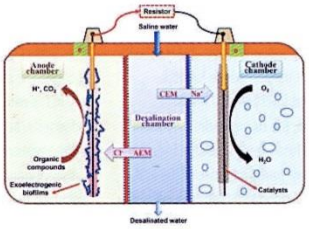
IN MANY RURAL arid areas, the generation of produced water in oilfields would be a welcome new source of water - but the elevated salt content of produced water hinders agricultural and domestic uses. Petroleum-related organic chemicals can be economically removed but, currently, expensive additional treatment (i.e., reverse osmosis) is needed to remove the salts (desalination). The latter process is complex and requires access to large amounts of electricity from the grid. Consequently, salt-laden produced waters (a potential water resource) are wasted through disposal in injection wells.

WHAT IF WASTEWATER CAN PROVIDE ITS OWN ENERGY FOR TREATMENT?

Scientists estimate wastewater contains about 10 times more energy than is required for treatment and that this locked-up energy is present in three forms: organic matter (19 percent), thermal heat (74 percent), and nutrients (7 percent) (Source: Beneficial Bioelectrochemical Systems for Energy, Water, and Biomass Production, J. Microbial & Biochemical Technology, 2013). Technological breakthroughs in applications of microbial fuel technology by scientist and engineers at universities in the United States and China have engineered bioprocesses that generate energy from organic matter in wastewater for use in self-treatment.

Leading-edge research on using locked-up energy to self-treat produced water is going on in Colorado.

Dr. Z. J. Ren and co-researchers (University of Colorado's Center for Sustainable Infrastructure Systems) have developed microbial desalination



cells (MDC) to fill the need for self-driven, energy-efficient, modular, and mobile water-treatment systems for produced waters in oilfields. This unique, stand-alone process generates, rather than consumes, energy while removing hydrocarbons, salts, and metals from produced waters.

HOW DOES A MICROBIAL DESALINATION CELL (MDC) WORK ?

A typical MDC consists of three chambers (see graphic, source: Development of Bioelectrochemical Systems to Promote Sustainable Agriculture, Agriculture, 2015) that contains the following chemical processes (source: Microbial Desalination Fuel Cells: Assessment of Technology Status and Potential Benefit for Reclamation, Bureau of Reclamation, Denver, 2014).

In the anode chamber, naturally occurring bacteria survive and grow on the anode as a result of their decomposing organic matter present in the produced water. Through a bio-electrochemical reaction, the bacteria release protons into the water. The protons cannot move out of the chamber because they cannot diffuse through the anion exchange membrane (AEM).

In the cathode chamber, a catalyst serves to remove protons from the fresh water supply, as oxygen is reduced on the cathode.

The desalination chamber holds the produced water. To maintain the change balance in the anode chamber, anions (i.e., chloride) move out through the AEM to the anode chamber. Concurrently, to maintain balance in the cathode chamber, cations (i.e., sodium) move out through the cation exchange membrane (CEM) to the cathode chamber. Produced water leaving the desalination chamber has reduced levels of salts.

The net result is the production of electricity as electrons flow between the two electrodes.

The researchers at the University of Colorado conducted experiments on treatability of produced water from oil wells in western Colorado. The chemical profile of the produced water was as follows: total dissolved solids (15,870 mg/l), chemical oxygen demand (800 to 1,100 mg/l), and pH (7.4 to 7.8). After the treatment cycle, which lasted four hours, the treated produced water leaving the MDC contained 5,270 mg/l of total dissolved solids (i.e, 65 percent removal). Some of the electricity generated by the MDC can be harvested for other uses. The details of this project are available in a recent paper (Microbial Capacitive Desalination for Integrated Organic Matter and Salt Removal and Energy Production from Unconventional Natural Gas Produced Water. Environmental Science Water Research & Technology, 2015)

HOW SOON WILL MDC-BASED TREATMENT UNITS BE COMMERCIALLY AVAILABLE ?

While basic technology for MDC-based treatment units is proven at the laboratory scale, the commercial development is low on the technical readiness scale - perhaps where solar power development was in the 1990s. In 2013, a start-up company (BioElectric, Inc.) was founded to turn the MDC technology into a commercial reality for treating produced water.

Certainly, the scale-up of MDC technology to commercialization requires a high capital investment.

The key technical barriers to commercialization of this innovative technology include needed production of large-scale cathodes with a cost of less than $90 per square yard, improvement in adsorptive materials, more efficient module configurations, understanding bacterial population dynamics, pH control and electrode stability.

In the coming years, the first commercial application of MDC-based treatment units may be realized as a pretreatment step for conventional desalination (i.e., reverse osmosis) to render produced water suitable for agricultural or domestic uses. This pretreatment step would reduce the salt content and provide energy for the downstream desalination process. Thus, the expensive cost of convention desalination would be significantly decreased and produced water would become feasible as a new water resource.