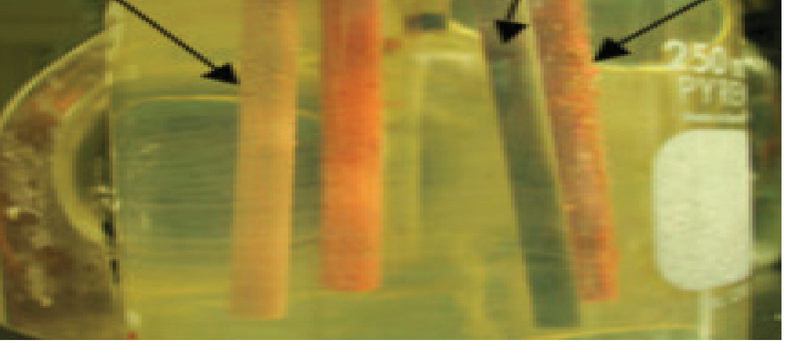

Swette Center

for Environmental Biotechnology

Biodesign Institute and Julie Ann Wrigley Global
Institute of Sustainability at Arizona State University

The Swette Center for Environmental Biotechnology focuses on “managing microbial communities to provide services to society.”

To manage microbial communities well, Center researchers conduct fundamental research to understand what microorganisms are present, what reactions they are capable of carrying out, what reactions they are carrying out, and how they interact with each and their environment. This research brings to bear state-of-the-art research tools involving genomics, proteomics, chemistry, and mathematical modeling.

Armed with understanding, Center researchers design and evaluate systems that create conditions allowing the right microorganisms to flourish and perform the needed services. Managing the microbial communities means creating the ideal “win-win” situation: The microorganisms thrive while providing the services. This more applied research often is carried out in the field in partnership with leading practitioners. The idea is to move Center technologies to practical application with a firm foundation.

The Center has two large research themes: sustainable energy and water. For each theme, Center researchers follow a two-step strategy. The first step is to “think like the microorganisms.” This means understanding how the different microorganisms work, what they need to do their jobs, and how they work together as a community. The second step, based on the understanding from the first step, can be described as “work for the microorganisms so that they work for us.”

Within the energy realm, the Center has a portfolio of options that are complementary to each other.

On one end of the spectrum, we work on ways to improve the well-established biotechnology of improving the performance of anaerobic processes that generate methane gas.

On the other end of the spectrum, we carry out leading-edge research on the fundamentals of microbial electrochemical cells (MXCs) that can produce hydrogen gas or electricity from organic wastes.

A major source of biomass for methanogenesis or MXCs is from animal wastes. Other sources include crop residues, microalgae, food-processing waste, and human waste.

The Center is developing and evaluating several novel photobioreactors to grow the photosynthetic bacteria and harvest the products.

The Center is directed by Regents’ Professor Bruce Rittmann, who is a member of the National Academy of Engineering, a Distinguished Member of the American Society of Civil Engineering, a Fellow of the American association for the Advancement of Sciences, a recipient of the Simon Freese Environmental Engineering Prize from the American Society of Civil Engineers, and one of the world’s most highly cited researchers.

ASU LightWorks™

ARIZONA STATE UNIVERSITY

Light-Inspired Solutions

Bioenergy from Biomass

Capturing all Energy and Nutrients from Microalgae and Organic Waste Streams

The Current Dilemma of Organic Wastes in Agriculture

- Today, less than 3% of the energy in livestock wastes is captured as CH_4. The low price of natural gas has halted or delayed capital investments in AD, and regulatory risks associated with handling animal wastes have further slowed investment.
- Animal wastes contain valuable nutrients (N & P), but much of the N & P is lost as water or air pollution, even though long-term trajectories indicate threats to our nation's P supply.
- Resource-rich animal wastes, particularly at large confined animal operations, are too dilute and heavy to economically be transported to meet the fertilizer needs of row crops in other regions. The lack of cost-effective logistics has forced row-crop farmers to rely on fertilizers based on imported phosphate rock and ammonium produced through use of fossil fuel.

Current animal-waste management is an economic and environmental liability, not a source of economic return. That value proposition needs to change.
PARENS will change it!

Profitable Agriculture through Recovered Energy, Nutrients, and Solids (PARENS).

PARENS will create smart, connected systems that synergistically produce renewable and high-value energy, fertilizers, and soil amendment from organic wastes. PARENS technologies will transform today's economic and environmental liabilities into profitable and sustainable resources.

PARENS will organize itself in four technical objectives:
(1) Maximizing Energy Capture,
(2) Increasing the Value of the Energy Output,
(3) Producing Mobile Nutrients, and
(4) Creating a High-Value Soil Amendment.

The technologies in Objectives (1) and (2) provide feedstock for the technologies in Objectives (3) and (4).

Objectives (5) and (6) are TechnoEconomic Analysis (TEA) and Extension/Outreach (E/O), which will translate the benefits of the synergistic technologies to partners and customers. The two-year project will involve coordinated technology advancement, technology integration, TEA, E/O engagement with stakeholders, and field-testing with dairy-cow waste. The ultimate results will be a set of integrated technologies, financial metrics useful for attracting investors and partners, and active involvement by livestock producers, fertilizer vendors, and farmers.

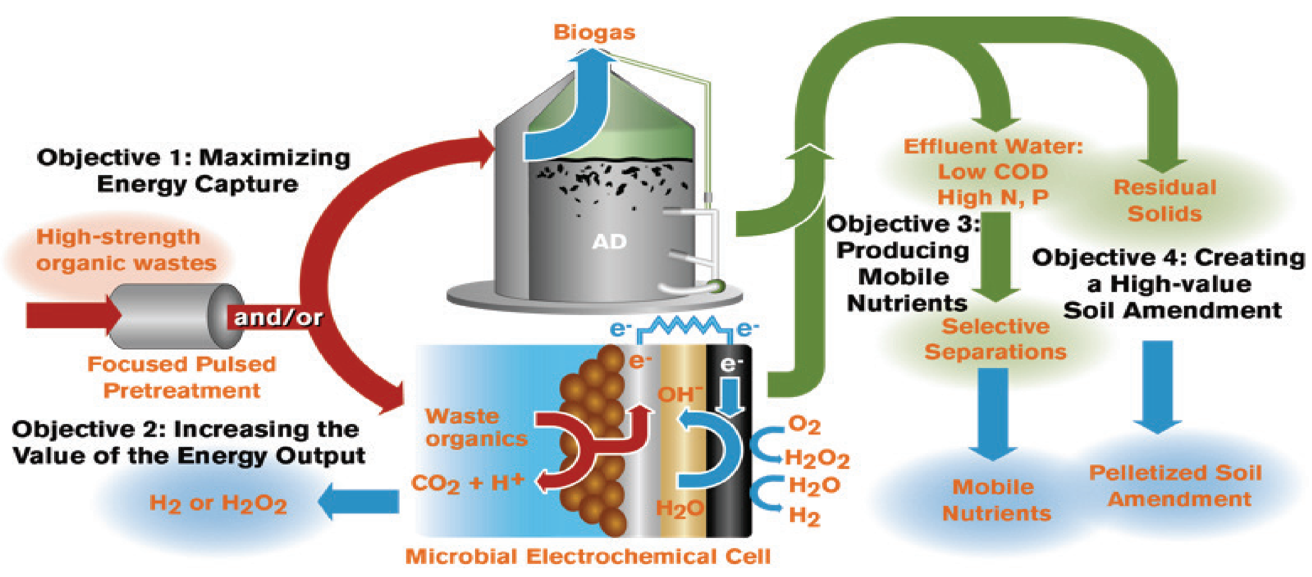

Figure 1: The four PARENS technical objectives work synergistically to produce multiple valuable outputs. Objectives (1) and (2) maximize the value of the energy output and deliver well-tailored inputs to Objectives (3) and (4).

Objective 1

Maximizing Energy Capture, will expand the ability of anaerobic digestion (AD) to generate methane gas (CH4) by employing effective pre-treatment to convert 50% to 200% more or the organics into this readily usable gas, thus greatly improving the economic return on capital investment.

Objective 2

Microbial Electrochemical Cells (MxCs) represent a truly novel platform within the realm of biotechnologies used in waste treatment. Anode-respiring bacteria (ARB) generate electrical current after oxidizing organic compounds. The electrical current produced by ARB can be used to produce a range of high-value chemicals, such as H2 gas and H2O2, at the cathode of the MxC. Increasing the Value of the Energy Output, will demonstrate the feasibility of microbial electrochemical cells to generate energy outputs that have 5-10-fold greater economic value than methane: hydrogen gas (H2) and hydrogen peroxide (H2O2). PARENS will partner with the ASU-spin-out company Arbsource to advance the microbial electrochemical cells for pilot testing.

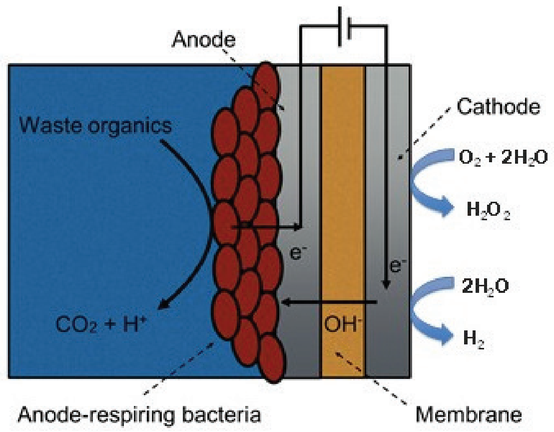

Figure 2: Schematic of an MxC to produce H2 or H2O2 from organics in dairy wastewater.

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Objective 3

Producing Mobile Nutrients, will realize the vision of readily transportable fertilizer feedstock. PARENS will develop a set of novel sorbents that capture high-value N & P from the effluents of Objectives (1) and (2) technologies and generate "mobile nutrients." This feedstock can be further modified into modern, specialty fertilizers that are ready-to-use in conjunction with practices that increase the sustainability of agriculture at large scales.

Objective 4

Creating a High-Value Soil Amendment, will integrate technology developed by partner Midwestern BioAg for pelletizing the solid residual from the Objectives (1) and (2) technologies into a high-value, easily transported soil amendment that can be used regionally to boost soil health and productivity. This creates another income stream and avoids the costs of residuals disposal.

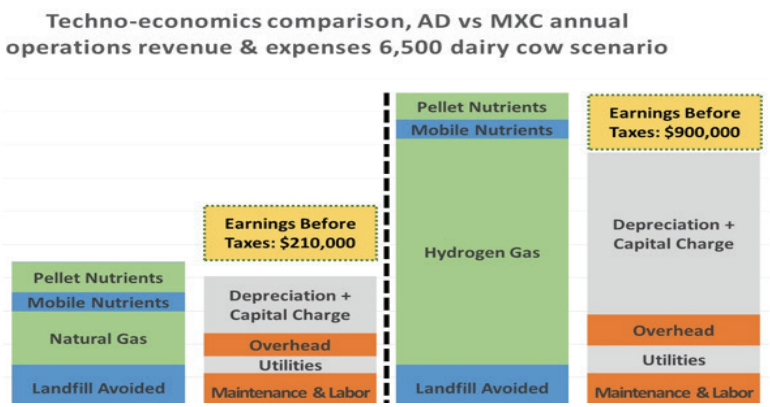

Figure 3. Results of our preliminary TEA showing that PARENS technologies lead to a net positive income stream whether the energy output is CH_4 (left bars) or H_2 (right bars).

Objective 5

Techno-Economic Analysis (TEA) will be applied across the technical objectives to guide R&D and to present PARENS's compelling case to technology partners, investors, early adopters, and long-term customers. The net positive income streams are the result of the diversity of multiple outputs (both scenarios), the increase in CH4 or H2 production from pre-treatment (both scenarios), and the higher economic value of H2 over CH4 (the MxC scenario). The addition of pelletized soil amendments and mobile nutrients has the dual benefit of increasing the earnings before taxes per ton manure processed and decreasing risk from volatile natural gas prices.

Objective 6

Extension/Outreach (E/O), will engage the agricultural community in the process of finding early adopters, collaborate with grass root producer associations (e.g., Dairy Producers of New Mexico, Western States Dairy Producers Trade Association, and United Arizona Dairymen) to determine how best to deploy PARENS technologies. E/O will be led by the Dairy Extension Program of New Mexico State University (NMSU).