Technology Brief

Scaling of Microbial Power to Gas (P2G) Conversion for Long Term Operation

Description: **To test and identify limitations and successes in the long-term operation of microbial electromethanogenesis with intermittent electricity supply cycles.**

Status: **Intermittency testing has concluded successfully - a next phase of work to advance the electrochemistry of the microbial P2G system is being examined.**

BENEFITS

As the natural gas industry is beginning to shift towards decarbonization and investigating the potential of emerging fuels, NYSEARCH is taking the opportunity to investigate an innovative energy storage solution and an unconventional method to create a renewable resource through microbial electromethanogenesis. There is a need and a business opportunity for long-term storage of electrical energy, especially as renewably produced energy becomes more abundant. This innovative microbial power-to-gas platform provides the potential to produce methane that can be upgraded as renewable natural gas (RNG) and injected into existing infrastructure.
Moreover, conversion of power to natural gas from CO_2 is an emerging platform for producing carbon-neutral methane, which also provides an important business opportunity for Local Distribution Companies (LDC's).

BACKGROUND

This research addresses the molecular, cellular and metabolic processes associated with a long-term operation of an electromethanogenic system; converting electrical energy plus CO_2 + H_2 into methane at high rates.–Electricity produced from renewables is becoming a more abundant and common resource. However, currently electricity produced from renewables fluctuates and is inevitably lost when not used following production. One desirable and promising path to store intermittent, renewable electrical energy is Power-to-Gas technology, where electricity is converted into methane or hydrogen, which is immediately compatible with today's energy infrastructure. Conventional power-to-gas technologies produce hydrogen or methane from electrochemical processes with technical limitations. Further, hydrogen is not an ideal chemical storage compound with its low energy density.

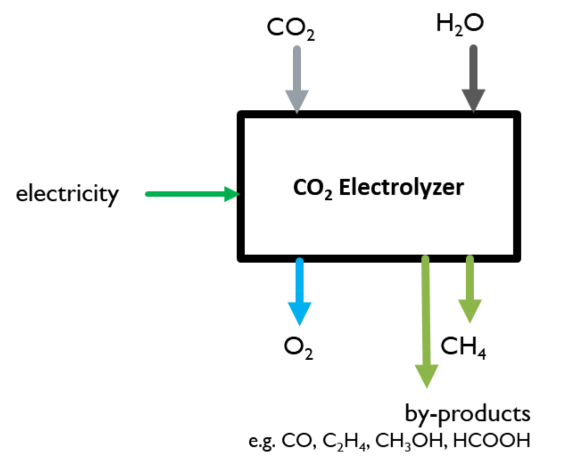

Figure 1. Traditional Power to Gas (P2G) process

Microbial electromethanogenesis is emerging as a viable technology platform for converting electrical energy into natural gas by reduction reactions at high selectivity and efficiency at the cathode.
The current state-of-the-art in microbial Power-to-Gas technology includes a traditional water electrolyzer that generates hydrogen which is then pumped into an anaerobic digestor to upgrade methane into biogas (see Figure 2). The cost and complexity of these electrolyzers represent severe technical and cost limitations.

The basis of this project explores Stanford University's innovation where microbes directly consume CO_2 and hydrogen, which is

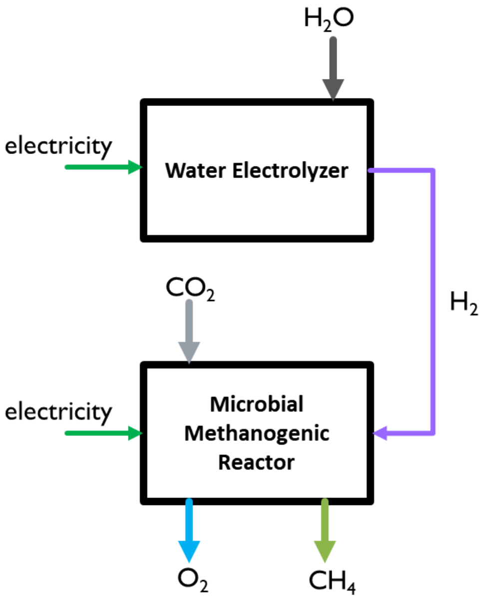

Figure 2. Current State-of-the-Art microbial P2G process

generated at the cathode (created from low-cost sustainable metals) and is immediately consumed, providing a viable alternative beyond batteries for long-term and seasonal energy storage. The innovation of an integrated microbial power-to-gas conversion is that it is a carbon neutral process (uses atmospheric CO_2 as a substrate) and one where hydrogen gas does not need to be transferred as seen in the current state-of-the-art technology. This phenomenon significantly reduces capital and operating costs.

TECHNICAL APPROACH

Figure 3 depicts the electromethanogenesis process being evaluated in this project. Stanford University's recent work on microbial electro-methanogenesis provides the first molecular understanding of how microbes take up electrons from the cathode. They have demonstrated how a microbial electrosynthesis platform can be integrated with advanced catalysts to efficiently funnel electrons and enhance the conversion rate from power to gas [current to methane]. NYSEARCH and Stanford are working to better understand the long-term effects that the microbes experience as living agents of electrochemical reactors.

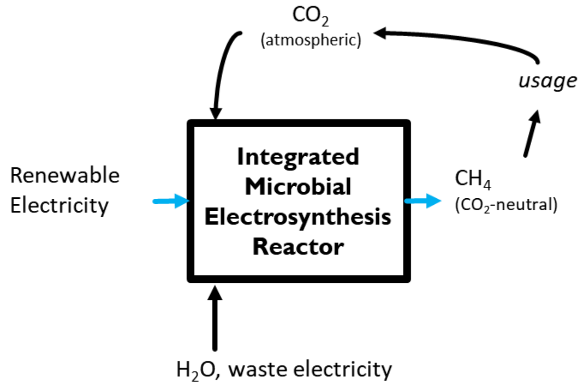

Figure 3. Integrated electromethanogenesis process

Specifically, this research is improving the microbial capacities associated with long-term operation of an electric power-to-gas operation. Stanford is investigating factors impacting long term performance such as microbial viability, performance of the microbes with intermittent supplies of renewable electricity, and microbial compatibility with different electrode materials.

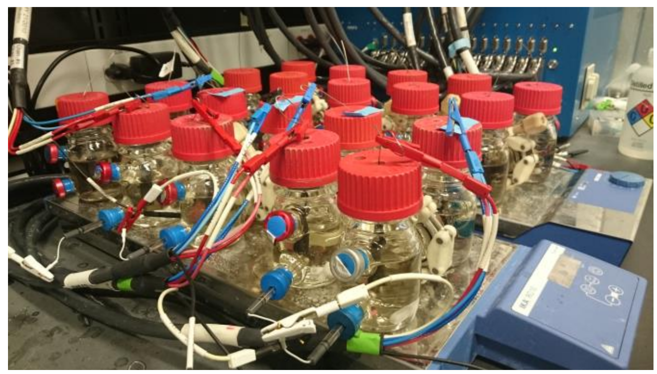

Figure 4. Laboratory set-up of electrochemical reactors prepared for long-term operation

PROGRAM STATUS

Tasks that included biomolecular and chemical monitoring and reporting of the electrochemical reactor performance with intermittent electricity supply are completed. The Stanford and NYSEARCH teams are examining how to fully develop and test a scaled up electrochemical system that will maintain the performance of the microbes as seen during laboratory experimentation.

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