EC MICROBIOLOGY
Editorial

Energy Production by Microbial Fuel Cells

Kelsey Guy and Mahnaz Mazaheri Assadi*

Engineering for Professionals, Johns Hopkins University, Whiting School of Engineering, Baltimore, MD, USA

***Corresponding Author**: Mahnaz Mazaheri Assadi, Engineering for Professionals, Johns Hopkins University, Whiting School of Engineering, Baltimore, MD, USA.

Received: September 21, 2021; **Published:** October 30, 2021

Microbial fuel cells (MFCs) can run off several different sources. Microorganisms feed on the source - specifically a substrate converting the chemical energy into electricity; this is specifically based on the microorganism's ability to oxidize the substrate and then transfer created electrons to the anode of the MFC [1]. Most common substrates include acetate, glucose, lignocellulosic biomass, synthetic wastewater, brewery wastewater, starch processing wastewater, dye wastewater, landfill leachates, cellulose and chitin, sunlight, and inorganic and other substrates [1]. In attempts to find specific data on energy and electricity production in the United States specific to MFCs, data seemed to be lacking. The best information obtained was from the Environmental Protection Agency (EPA). According to the EPA [2], the Combined Heat and Power (CHP) Partnership promotes voluntary use of greener energies such as fuel cells, among other renewable energies. The EPA [3] supports that using MFCs, specifically in municipal wastewater plants that annually consume nearly 3% of all electrical power, can make these treatment plants into electrical energy producers instead of consumers.

Comparing energy sources in Massachusetts (MA), over 90% of energy used comes from fossil fuel energy sources (coal, natural gas, and petroleum). Comparing the same energy source consumptions in MA to the United States (US) as a whole, MA uses less natural gas, biomass, geothermal, and solar energies, and more petroleum energy. Reasons for these variances between more and less energy source uses could be due to resource availability, state regulations, or even the data itself - the table of data provided by the Energy Information Administration [4] - Table C5. Residential Sector Energy Consumption Estimates, 2018 - did not include residential wind energy consumption for the US which could alter the energy source consumption rates greatly for MA alone. Both diagrams seen here were created from table C5 [4].

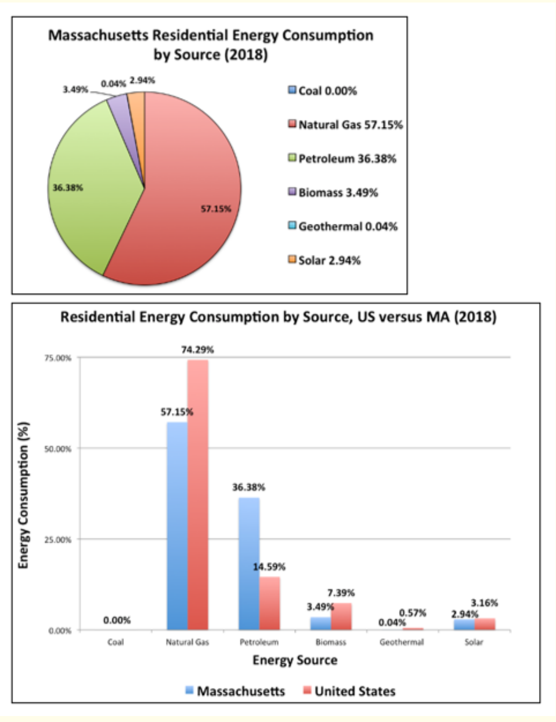

Figure 1

Mediator MFCs allow for non-electrochemically active microbes to be used, but they are expensive and are toxic. In a search for a more sustainable energy source, mediator based MFCs are unlikely going to be successful based on their negative impacts alone. Focus for energy production should be on mediator free MFCs. As MFCs do not yet provide largely significant amounts of energy, serving a dual purpose enhances their usefulness - MFCs that use waste to create energy, while at the same time cleaning the waste, are currently the most likely to be beneficial to work towards goals of sustainability, by allowing cleaning of wastes, energy production, and not creating negative impacts. For example, look at how urine has been used in England as a fuel for MFCs.

Ieropoulos., *et al*. [5] studied the use of urine as a fuel for microbial fuel cells (MFCs). About 6.4 trillion litres of urine are annually produced around the world by humans and a nearly 2 - 3 fold additional urine output is produced by farm animals [5], creating an abundance of potential fuel source for MFCs. Ieropoulos., *et al*. [5] studied this by creating several MFCs which had activated sludge microflora in them that fresh (less than a week old) and neat/raw urine was added to every 8 weeks for a year long period to start; they found that long term the MFCs responded consistently with electricity production to urine additions based on composition and volume of the urine and also that urine has excess nitrogen, phosphorous and potassium present, but that adding acetate - extra carbon energy - offsets this surplus, removing it from the effluent. This is a huge accomplishment for this process in regards to nutrient pollution. A single MFC from their study can create 25 PJ of energy annually [5], though this is insufficient compared to biofuels (2.48 EJ), there is still potential for MFCs using urine, especially as advancements occur [5]; examples include stacking the MFCs, miniaturization of the MFCs, or even large scale treatment systems for more energy output [5].

After further development in Bristol, this method - using sewage wastes flushed through MFCs for energy production - was trialed and found successful for production of enough energy for lighting and for mobile phone charging, after which it then was introduced into schools in Africa with minimal electricity [6]. This is hugely important for real world study of the method and obtaining investors to achieve further advancements, for commercialization purposes, and for use/adaptation of the method throughout the world.

This system could work very well in poorer areas of the US, assuming there are no associate risks. It is an easily and largely renewable resource and beneficial to the environment. This system could improve sanitation and safety for humans, not only in the US, but throughout the world [6]. On top of that, the MFCs using the urine as fuel can provide power to run lights or charge cell phones, all while producing the natural byproduct of fertilizer for plants [6]. At an industrial level, wastewaters would no longer need intensive treatments and many costs could be saved [5], as well as lessening potential environmental impacts these wastewater treatments can cause.

The following MFC companies would get researched and asked about the following questions while considering investing in them. All companies would be asked: How much energy are they expected to produce? How much are they currently producing? How much energy is required for the process? What are the current/intended/possible future applications? Who has access to the energy produced? What are the costs to produce the MFC? What are the expected impacts from the MFCs? Have any unexpected impacts occurred?

1. Microbial electrolysis: What strains of bacteria are used for consuming the plant wastes? Any GMOs? If yes to GMOs, how are risk assessments conducted? What problems are faced? What are the plans to control, minimize, or remove these problems? How is the external power source provided energy?

2. Algae farms using wastewater: What photosynthetic microorganisms are used? GMOs? What are the biofilm lifecycle stages and durations? What are the light sources for the exposure? How are they powered?

3. Remote power sources: What is the remote MFC made of? How much can it process and how often? Where would they be placed to work? How are they maintained?

4. Sludge production panels: What wastes/sewage would be used for the MFC? How efficient is it? How much energy is required for aeration? How do the modules get scaled to accommodate different plants?

Investments would be focused on most sustainable options - the mission of the companies and their impacts and goals for the environment and people; energy required to run and maintain the MFC versus energy output by the MFC, additional impacts - both good and bad - by the MFC, how much profit the company makes from the technology and how that profit is used, along with others. Algae farms seem very promising and remote power sources create great opportunities for those in need of energy sources. Likely most investments would be allocated between those two companies, but again it all depends on the research done and answers found/provided [7,8].

Bibliography

1. Pant D., *et al.* "A review of the substrates used in microbial fuel cells (MFCs) for sustainable energy production*". Bioresource Technology* 101.6 (2010): 1533-1543.
2. EPA. Sustainable Water Infrastructure [Website]. U.S. Environmental Protection Agency (2020, July 7).
3. EPA. Electricity generation from anaerobic wastewater treatment in microbial fuel cells (MFCs) - Phase I [Website]. U.S. Environmental Protection Agency (2020, July 25).
4. EIA. State energy consumption estimates 1960 through 2018 (2020).
5. Ieropoulous I., *et al.* "Urine utilization by microbial fuel cells; energy fuel for the future". *Physical Chemistry Chemical Physics* 14I.1 (2012): 94-98.
6. UWE Bristol. Technology that turns urine into electricity commercialized through spin out company (2018).
7. EIA. (n.d.). State energy production estimates 1960 through 2018 [Website]. U.S. Energy Information Administration (2018).
8. UWE Bristol. Could 'wee-power' be the future of electricity generation (2011).

Volume 17 Issue 11 November 2021