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Significance of Renewable Energy Micro Grid Development for Remote Locations with Reference to Microbial Fuel Cell Micro Grid

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Abstract-Renewable energy is the prominent solution for environmental carbon foot printing control. Conventional energy generation plants are causing the reduction in fossil fuels and such precious fuels need to be controlled. Apart from this, fossil fuels are responsible for the increase in carbon foot printing. This paper discusses the various microbial fuel cell substrate performances which can be included in the formation of the renewable energy micro grid. The intention of such micro grid is to provide the facility of electricity for remote areas where transmission line setup is merely possible. Paper also discusses the applicability of renewable energy resources depending on the availability of natural resource at particular geographical region.
Keywords: renewable energy, PV, microbial fuel cell, wind energy, micro grid, substrate

1. Introduction

Mitigating environment transformation without sentencing the undesirable global impact to never ending poverty is the leading concern of energy policy in the present day. Our civilization depends intensively on fossil energy, with about 80% of major energy approaching from fossil fuels. Their burning is adding to a quick boost in the average temperature of the globe. Persisted large-scale production of fossil fuels makes serious risks for human civilization, however preserving and increasing an affluent civilization needs a particular level of energy supply. The standard claim is that renewable energy has turn into an essential notion within the areas of energy policy as well as climate change mitigation, and has a key role in driving the logics within these areas [1].

Renewable energy solutions are deemed clean energy solutions and are severely essential because of their environmental-friendly characteristics. Because of the rise in consciousness of a clean ecosystem, it is assumed that common reliance on fossil fuels has targeted to carbon dioxide (CO2) exhausts, greenhouse gas (GHG) challenges and geographical pollution. RES can encapsulate residential energy expectations with the potential to present energy solutions with almost zero release of air pollutants as well as , GHGs. Crucial responsibilities just like ecological development of remote areas in the desert and hill zones in addition to setup of the requirements to accomplish international agreements associated with environmental security are anticipated to be fixed with the development of RE [2]. RESs as well as ESSs are the key systems for smart grid uses and offer great possibilities to de-carbonize metropolitan aspects, control consistency, voltage deviations, as well as respond to critical time in the event that the load exceeds the generation [3]. ASEAN nation has also founded particular renewable energy objectives. In 2014, 9% of ASEAN's electricity usage is via renewable energy that involves significant hydropower. Nations can profit from the recent motivation in establishing a regional adjoining grid, ASEAN Power Grid [4].

Presently, the 100% RE strategy is getting momentum amongst a range of stakeholders. Illustrations can be found in Sweden where the goal is to attain zero net emissions of greenhouse gases through 2045 and in Denmark where the goal is to accomplish zero net exhausts by 2050 at the latest. Further, various parts of the world target at 100% renewable electricity through 2045 or 2050 incorporating Bangladesh, Barbados, Cambodia, Colombia, Ethiopia, Ghana, Mongolia, Vietnam, Hawaii and California [5].

2. Literature Review

Changing renewable including solar photovoltaic as well as wind power are important systems for obtaining the de-carbonization of the electricity sector. Nevertheless, they vary considerably from standard power generation resources. As the share of changing renewable raises, these kind of variations result in various difficulties in power systems. Inability to cope with these kinds of difficulties may endanger power system credibility or the accomplishment of de-carbonization goals. Different solution systems are obtainable to minimize these kinds of issues [6]. Author details the evaluation of the Stirling engine efficiency by evaluating biomass as well as , solar energy as alternative renewable energy resources. A program-code was formulated in the MatLab® to resolve the thermal model of an alpha-Stirling engine, accounting for the constraints in the heat transfer procedures in the regenerator and the deficits because of pumping results. The solar energy resource was patterned as a concentric solar dish collector, taking into consideration a receiver based at the key position and built to absorb the maximum possible of the solar radiation [7].

Author examined the role of different knowledge sourcing strategies for innovation in two technology fields, namely solar and wind power. The link between external knowledge sourcing and innovation performance is found to depend on sourcing strategies and technology fields. Results contributed to the evaluation of strategy design by showing that solar power innovation benefits from a broad search strategy drawing on a large number of external knowledge sources, while wind power innovation tends to thrive through intensive use of a more limited number of external sources. Author derived implications for innovation and energy policy [8]. The major worldwide challenge for these countries is to provide cost-effective and reliable energy services to these rural areas. Electricity has been found as a key source for human sustainable development. Installation and supply of grid electricity are financially impracticable or practically not feasible for such specific sparsely populated remote areas. Although, people of these rural areas have several electricity interruptions, and most of them still have no access to electricity [9].

Hybrid micro grid (HMG) is a small-scale power system consisting of distribution generations (DGs) and loads operating as one controllable unit with regards to grid. It gives advantages such as reliable power supply, lesser carbon emission, environmental friendly, etc. Author proposed a fractional order proportional-integral derivative (FOPID) controller to enhance the power quality of a HMG including wind turbine, aqua electrolyzer, fuel cell, load and BESS. Due to the computational simplicity of genetic algorithm (GA), it is employed to tune the gains of the FOPID [10]. Author focused on coastal region electrification using microbial fuel cell. Author found that development of single chamber microbial fuel cells (MFC) can convert Sargassum species and utilized for electricity generation. Author also included and analyzed the impact of organic catalyst materials on electricity generation using Sargassum [11].

Author presented dynamic modeling of various components of a small isolated system. The dynamic modeling of this nonlinear 45 Vdc energy system is done with Simulink. The simulation findings are analyzed, as well as the constraints of a fuel cell energy system.

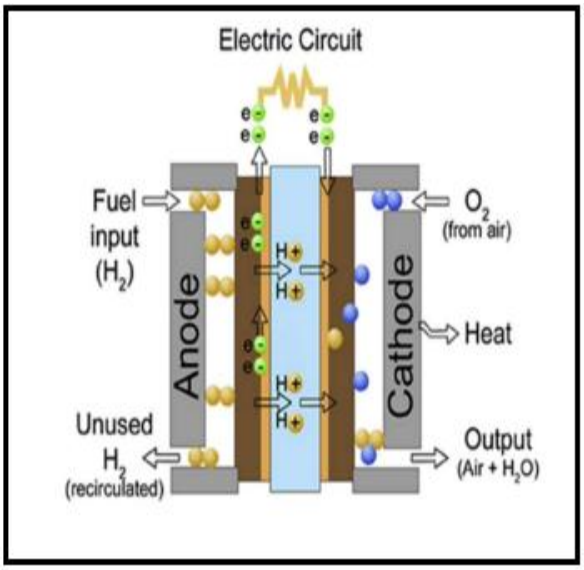

Fig. 1: Working of Fuel Cell (Chaouki et al, 2022)

Fuel cells transform the chemical energy of hydrocarbon fuels into direct current electrical energy, Because of its high-power density, high efficiency, and environmental friendliness, the Polymer Electrolyte Membrane Fuel Cell (PEMFC) is a promising alternative power generator [12].

3. Performance of MFC

As microbial fuel cell can be an efficient component of renewable energy micro grid, proposed study presents the different substrate usability for development of hybrid-substrate to boost overall efficiency. In existing research, author used single-chamber microbial fuel cells with zinc and copper as electrodes and pineapple waste as fuel (substrate). Current and voltage peaks of 4.95667 ± 0.54775 mA and 0.99 ± 0.03 V were generated on days 16 and 20, respectively, with the substrate operating at an acid pH of 5.21 ± 0.18 and an electrical conductivity of 145.16 ± 9.86 mS/cm at two degrees Brix.

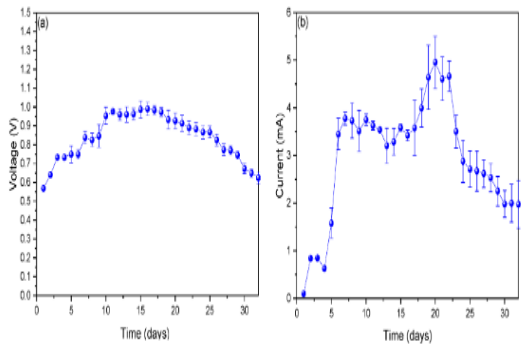

Fig.2: MFC voltage and current for substrate as a pineapple waste (Rojas-Flores et al, 2022)

Thus, it was also found that the internal resistance of the cells was 865.845 ± 4.726 Ω, and a maximum power density of 513.99 ± 6.54 mW/m^2 was generated at a current density of 6.123 A/m^2, and the final FTIR spectrum showed a clear decrease in the initial transmittance peaks [13].

Author constructed an air-cathode single-chamber mediator-less MFC and used acetate as a feed for assessment of the MFC efficiency for electricity generation and wastewater treatment. A study based on the utilization of wastewater as a substrate pointed out that the use of acetate in pretreatment of wastewater through the process of anaerobic acid genesis increases the efficiency of the MFC. Also, dairy wastewater consists of different carbohydrates, proteins, and fats and can be easily biodegraded and used as a substrate in MFCs. Dairy-based wastewater sources have been used as a substrate for a single-chamber MFC with optimization of the configurations to enhance output [14]. According to the author, the potential application of double-chamber microbial fuel cell (DC-MFC) for chemical oxygen demand (COD) removal and generated power from wastewater in the different conditions is investigated. DC-MFC is operated with anaerobic sludge as an active biocatalyst in an anode section, an aerobic cathode section and a Nafion117 membrane as a separator. The performance of the bioreactor is determined with different concentrations of chemical oxygen demand (COD) loadings in the MFC process [15]. Refer Fig. 3 below.

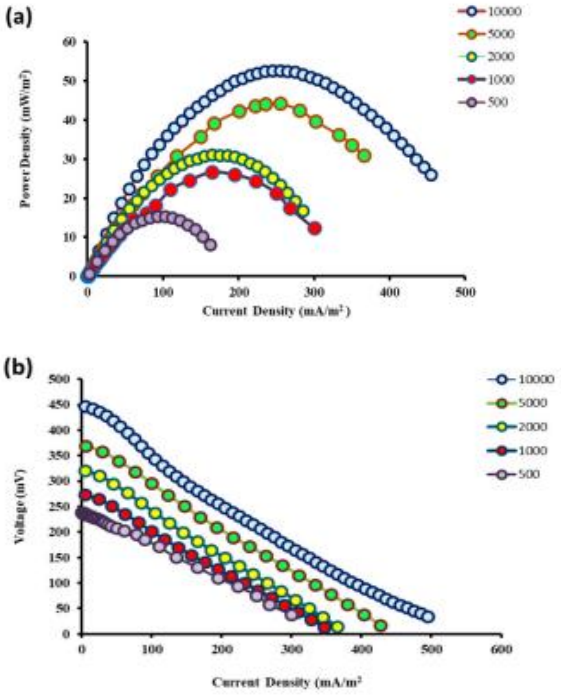

Fig. 3: Power density and voltage as a function of current density (a), (b) in batch DC-MFC with different initial COD concentrations (Rahmani et al,2022)

Author presented several organic waste substrates that can be employed as fuels in MFCs for bio-energy generation and the effect of their usage on power density, COD (chemical oxygen demand) removal, and Coulombic efficiency enhancement. Moreover, a demonstration and comparison of the different types of mixed waste regarding their efficiency for energy generation via MFCs are presented. Future perspectives for manufacturing and cost analysis plans can support scale-up processes fulfilling waste-treatment efficiency and energy-output densities [16].

4. Conclusion

As discussed in this paper, the various substrate materials like dairy waste, fruit waste, industrial

waste water and coastal region waste materials can produce efficient power density by varying the concentration level. Also, such microbial fuel cells can be set up as a micro-grid component at remote/rural areas for small electricity needs. The existing research also discussed to identify the better substrate option for single chamber microbial fuel cell with air cathode membrane. The future study can be tested for series and parallel connections of microbial fuel cell grid for household electrification.

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