A proposed working model of Microbial Fuel Cell and it's online data analysis

A PROJECT REPORT

Submitted by group 174

Thaithe Kalathil Haryshwa Nair *(20BCE10394)*

Abhinay Prakash Reddy Gujjala *(20BCE10928)*

Ishika Agarwal *(20BCE10953)*

Ishita Singh *(20BCE10971)*

Priya Singh *(20BCE11068)*

in partial fulfillment for the award of the degree

of

VIT BHOPAL

www.vitbhopal.ac.in

BACHELOR OF TECHNOLOGY

in

COMPUTER SCIENCE AND ENGINEERING

SCHOOL OF COMPUTING SCIENCE AND ENGINEERING

VIT BHOPAL UNIVERSITY

KOTHRIKALAN, SEHORE

MADHYA PRADESH - 466114

Dec 2021

(A typical specimen of Bonafide Certificate)

VIT BHOPAL UNIVERSITY, KOTHRIKALAN, SEHORE

MADHYA PRADESH – 466114

BONAFIDE CERTIFICATE

Certified that this project report titled **"GREEN TECH"** is the bonafide work of **"Thaithe Kalathil Haryshwa Nair (20BCE10394), Abhinay Prakash Reddy Gujjala (20BCE10928), Ishika Agarwal (20BCE10953) , Ishita Singh (20BCE10971),Priya Singh (20BCE11068)"** who carried out the project work under my supervision. Certified further that to the best of my knowledge the work reported at this time does not form part of any other project/research work based on which a degree or award was conferred on an earlier occasion on this or any other candidate.

PROGRAM CHAIR	**PROJECT GUIDE**
Sandeep Mal	Dr. Vignesh U
School of Computer Science and Engineering	School of Computer Science and Engineering
VIT BHOPAL UNIVERSITY	VIT BHOPAL UNIVERSITY

The Project Exhibition I Examination is held on 21.12.21

ACKNOWLEDGEMENT

First and foremost we would like to thank the Lord Almighty for His presence and immense blessings throughout the project work.

I wish to express my heartfelt gratitude to Dr Sandip Mal , Head of the Department, School of Computer Science for much of his valuable support and encouragement in carrying out this work.

I would like to thank my internal guide Mr. Vignesh U ,for continually guiding and actively participating in my project, giving valuable suggestions to complete the project work.

I would like to thank all the technical and teaching staff of the School of Computer Science, who extended directly or indirectly all support.

Last, but not least, I am deeply indebted to my parents who have been the greatest support while I worked day and night for the project to make it a success.

LIST OF ABBREVIATIONS

MFC = Microbial Fuel cell

LIST OF FIGURES AND GRAPHS

LIST OF TABLES

ABSTRACT

We are facing a global energy crisis. It is immediately needed to switch to cleaner, sustainable fuels and develop energy using that. Fuel cells produce electricity and

heat as long as fuel is supplied. In this project, We have introduced MFC Microbial Fuel Cells as an alternative. Apart from the model of MFC a website has been introduced to make it easier to use Microbial Fuel Cells and its maintenance.

[PURPOSE-METHODOLOGY-FINDINGS]

Cleaner greener option for fuel and energy

TABLE OF CONTENTS (SPECIMEN)

CHAPTER-1

PROJECT DESCRIPTION AND OUTLINE

1.1 Introduction -

An energy resource generates heat, power, moves objects and generates electricity. The energy-saving matter is known as fuel. Energy plays a vital role in our life. Due to excess demand of energy our sources are depleting, many of them are creating pollution in our environment. The energy crisis is the concern that the world's demands on the limited natural resources that are used to power industrial society are diminishing as the demand rises. These natural resources are in limited supply. While they do occur naturally, it can take hundreds of thousands of years to replenish the stores.

1.2 Motivation for the work -

Due to the energy crisis it is needed to take immediate action and find resources that are sustainable and do not harm the environment. Hence we came across a fuel cell. Fuel cells produce electricity and heat as long as fuel is supplied. In a Hydrogen fuel cell, a catalyst separates hydrogen molecules into protons and electrons. The protons migrate through the electrolyte to the cathode, where they unite with oxygen and the electrons to produce water and heat and there exists a Microbial fuel cell.

1.3 About Introduction to the project including techniques -

We introduced Microbial fuel cell. There are some limitations with fuel cells. Fuel Cell Hardware is an electrochemical device that converts chemical fuel, such as hydrogen, natural gas, methanol, etc. into energy and water. This item includes all the key components to make such reactions occur. It also performs compression of the membrane electrode assembly (MEA) while providing uniform gas distribution and uniform temperature to the cell. However there exist few cons in using fuel cell and they are as follows -

- Fuel cells are very costly because they are complex and require expensive materials such as platinum
- Hydrogen fuel cells do not work in every situation as of yet
- You must regulate the temperature of a hydrogen fuel cell to maximize its use
- There are still some risks to the environment to consider with hydrogen fuel cells
- The cost to store hydrogen is expensive enough that it is prohibitive for most people
- There are transportation losses to consider with hydrogen as well

1.5 Problem Statement

- Even though fuel cells are one of the most efficient fuels, it is not in wide use yet.
- Reasons behind this are discussed before as the limitations
- We need to focus on a technology that overcomes these limitations

1.6 Objective of the work

- Reduce the production cost of fuel cell systems to be used in transport applications while increasing their lifetime to levels competitive with conventional technologies.
- Increase the electrical efficiency and the durability of the different fuel cells used for power production, while reducing costs, to levels competitive with conventional technologies.
- The combined system of the hydrogen production and the conversion using the fuel cell system is competitive with the alternatives available in the marketplace;
- Reduce the use of the EU-defined "Critical raw materials", for instance via low or platinum-free resources and through recycling or reducing or avoiding the use of rare earth elements.

1.7 Organization of the project

We considered the energy crisis hence started finding alternatives for clean fuel. We came across fuel cells however there were some cons that have been mentioned above. Later we studied about hydrogen cells and how they work but there were drawbacks as well. We shifted our focus on microbial fuel cells and continued our research towards MFC. We came up with an idea that let us use MFC at home and a feasible option. It does not take much space and is cost effective as well. Along with that we prepared a website where we can calculate when mud needs to be changed using quality and quantity of mud along with a watt of bulb. Any user can go to a website and easily get it done. User interface of the website has been created user friendly so it is easy to use for everyone. On account of this, a better way to produce energy.

1.8 Summary

Our idea is to use plants for the working of Microbial fuel cells. This energy can be used to generate energy that is enough to light up a bulb and using website a reminder will be given when mud needs to be changed and how much power will be provided by the system. Therefore, using sustainable alternative we can create energy efficiently.

Chapter-2

RELATED WORK INVESTIGATION

2.1 Introduction

MFC has gained attention due to its capability to produce electricity from organic as well as inorganic compounds. In terms of setup, MFC has many properties in common with standard hydrogen fuel cells. Therefore, we have started our investigation towards Microbial fuel cells.

2.2 Core area of the project

Core area of the project is Microbial fuel cell. The plant based microbial fuel cell can be attached to a plug board which in turn can be used for various dynamic purposes like charging phones, lighting bulbs etc. When the energy isn't in use we can store it for future use. Along with that a website which can provide us a reminder when mud needs to be changed.

Benefits -

- A greener alternative to saving electricity
- Can be used as a decorative item considering the plant's aesthetics.
- Clean fuel
- Portable

2.3 Existing Approaches/Methods

- Instead of using typical Hydrogen fuel cells in cars or power banks we can switch to Microbial fuel cells. Microbial fuel cells work by allowing bacteria to do what they do best, oxidize and reduce organic molecules. A MFC consists of an anode and a cathode separated by a cation specific membrane. The trick of course is collecting the electrons released by bacteria as they respire. This leads to two types of MFCs: mediator and mediator less.

2.4 Issues/observations from investigation

Microbial Fuel Cell is a bio-electrochemical system that produces electric current by using bacteria. MFC is essentially a device that converts chemical energy into electrical energy by using bacteria or microorganisms.

- MFC has gained attention due to its capability to produce electricity from organic as well as inorganic compounds. In terms of setup, MFC has many properties in common with standard hydrogen fuel cell.
- MFC consists of an anode and cathode chamber and a proton exchange membrane between the two chambers.

2.5 Investigation

Wastewater	Influent COD (mg L^{-1})	Type of MFC	Working volume (mL)	COD removal (%)	Power output (mW m^{-2})	Refer
Food-processing wastewater	1900	Dual chambers	24	86	230	Mans et al.
Potato chips processing wastewater	8000	Dual chambers	1900	90	95.7	Radee Ismai (2019
Brewery wastewater	1501	Single chamber	100	20.7	669	Wen (2010
Brewery wastewater	627	Single chamber	100	40	264	Wen (2009
Dairy wastewater	8010	Dual chambers	200	94.4	34.82	Chou et al. (2021
Dairy wastewater	4000	Single chamber	200	95.3	62.27	Chou et al. (2021
Starch processing wastewater	4852	Single chamber	425	98	239.4	Lu et (2009
Olive mill wastewater	4300	Single chamber	28	65	124.6	Sciarr al. (20
Swine wastewater	3300	Dual chambers	800	83	13	Ma et (2016
Swine wastewater	8320	Single chambers	250	86	261	Min e (2005
Pharmaceutical wastewater	6590	Single chambers	430	85	205.6	Velviz Venka Moha (2012
Pharmaceutical wastewater	5460	Dual chambers	186	80.6	168	Rashi al. (20
Paper recycling wastewater	2452	Single chambers	300	76	501	Huan Logar (2008
Textile dye wastewater	45,600	Single chambers	125	98	123.2	Logro al. (20

2.6 Summary

Our world needs a cleaner alternative to fuels as soon as possible. Options like hydrogen fuel cells are available but they are not in wide use due to the cost and resources they require. An innovative alternative to this is MFC and taking it to a next level we replaced the microbes with green plants that release hydrogen during biological processes. Thus, taking a step towards a greener and cleaner world with greentech. We will continue our research for the next review and come up with more updates.

Chapter-3

Requirement Artifacts

3.1 Let’s look at the Requirement Artifacts of this project.

3.2 Requirements:

The microbial fuel cell is made up of many components that are split into two chambers. An anodic chamber and a cathodic chamber are the two types of chambers. The anode is kept in the anodic chamber, while the cathode is kept in the cathodic chamber.

3.2.1 Anodic Chamber

It's a biocompatible and conductive material that's chemically stable with the substrate. This chamber's microbes convert the substrate to H_2O (water), CO_2 (carbon dioxide), and energy. These bacteria are kept in an environment with very little oxygen. Stainless steel mesh with graphite rods or plates make up the structure.

3.2.2 Cathodic Chamber

Protons and electrons are recombined in this chamber. The amount of oxygen (O_2) in the atmosphere is decreased to water. Pt is used as a catalyst in this process.

3.2.3 Exchange Membrane

It can function as a cation exchange or proton exchange membrane. Ultrex or Nafion is used as the exchange membrane in MFC technology. This membrane allows protons to pass across it. The electrons and protons, on the other hand, are recombined.

3.2.4 Substrate

These are utilised by the bacterium cell to create energy. The kind of substrate utilised has an impact on the power density, Coulombic efficiency, performance, and economic feasibility of a microbial fuel cell. Protein, volatile acids, carbohydrates, wastewater, and cellulose are examples of organic substrates that can be employed in MFC. Acetate is the most widely used substrate.

3.2.5 Electric Circuit

The electrons leave the anode chamber and move through the electrical circuit to supply the power to load.

3.2.6 Microbes

The microorganisms or microbes used in the MFC technology are based on the culture of bacteria.

1). Axenic bacteria

- Metal that reduces bacteria
- Geobacter sulfurreducens
- Rhodoferax ferrireducens
- Clostridium beijerinckii
- Shewanella putrefaciens.

2). Mixed bacterial fuel

- Alcaligenes faecalis
- Pseudomonas aeruginosa
- Enterococcus faecium
- Proteobacteria

- Desulfuromonas
- Clostridium butricum
- Bacteroides
- Nitrogen-fixing bacteria like Azospirillum and Azoarcus
- Aeromonas species

3.2.7 Electrodes and Copper Wires for connecting

3.3 Specific project requirements

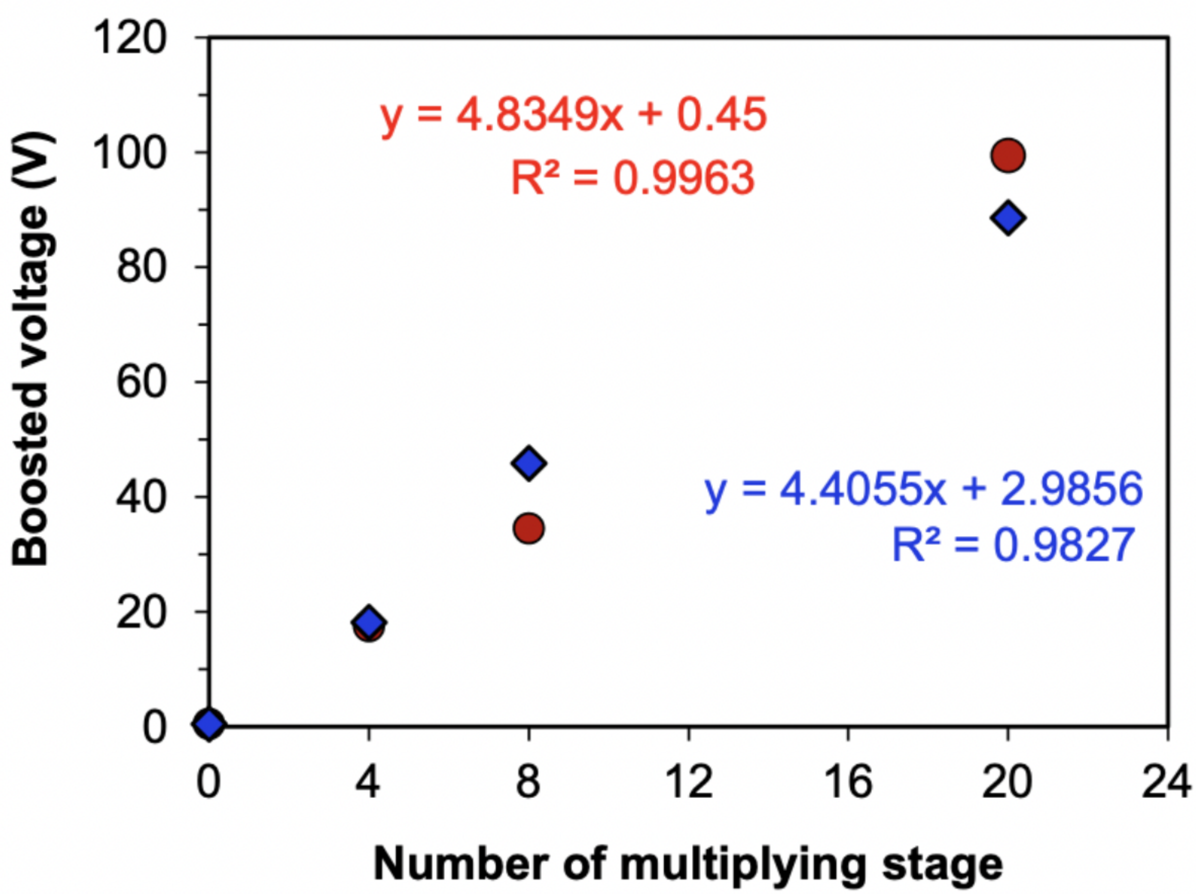
- 2x 1l plastic containers
- 15cm plastic pipe with cap
- 3g agar
- 11.8g salt, dissolved in 150ml of distilled water
- 2x pencil leads
- Coated copper
- Glue gun
- Aquarium air pump
- Voltmeter
- Sediment from the bottom of a lake

Chapter-4

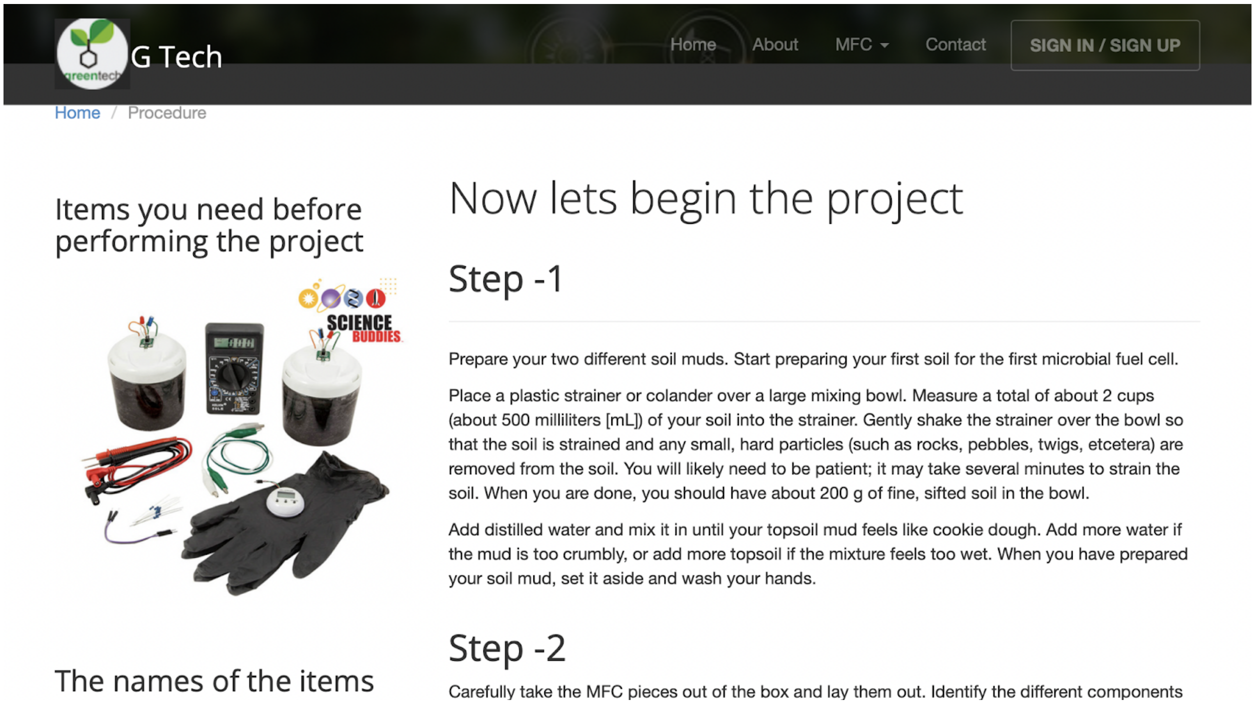
DESIGN METHODOLOGY AND ITS NOVELTY

Methodology

Fuel cells produce electricity and heat as long as fuel is supplied. In a hydrogen fuel cell, a catalyst separates hydrogen molecules into protons and electrons. The protons migrate through the electrolyte to the cathode, where they unite with oxygen and the electrons to produce water and heat.



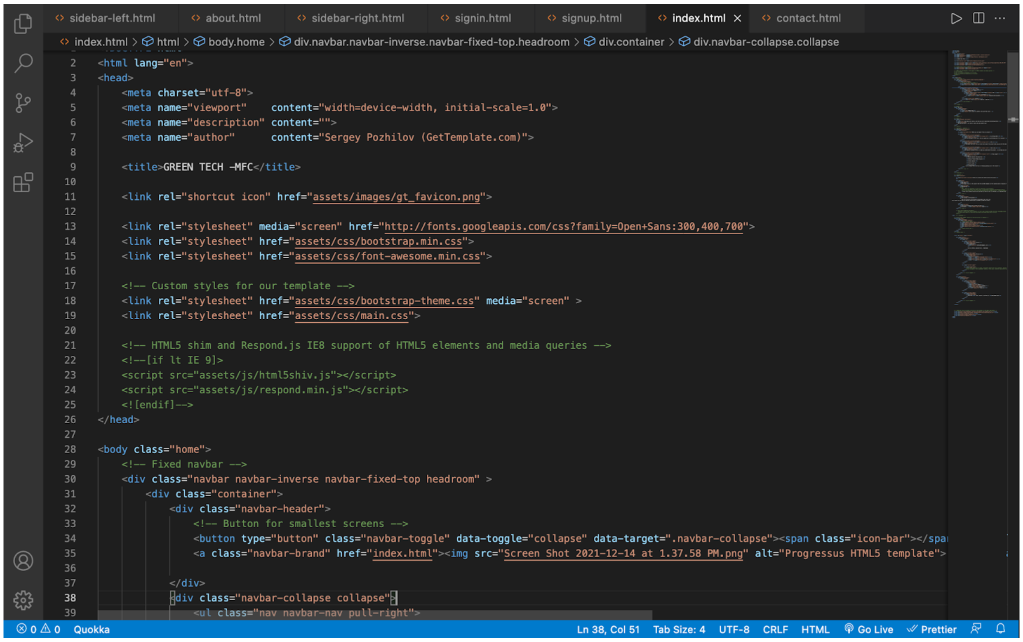
USER INTERFACE



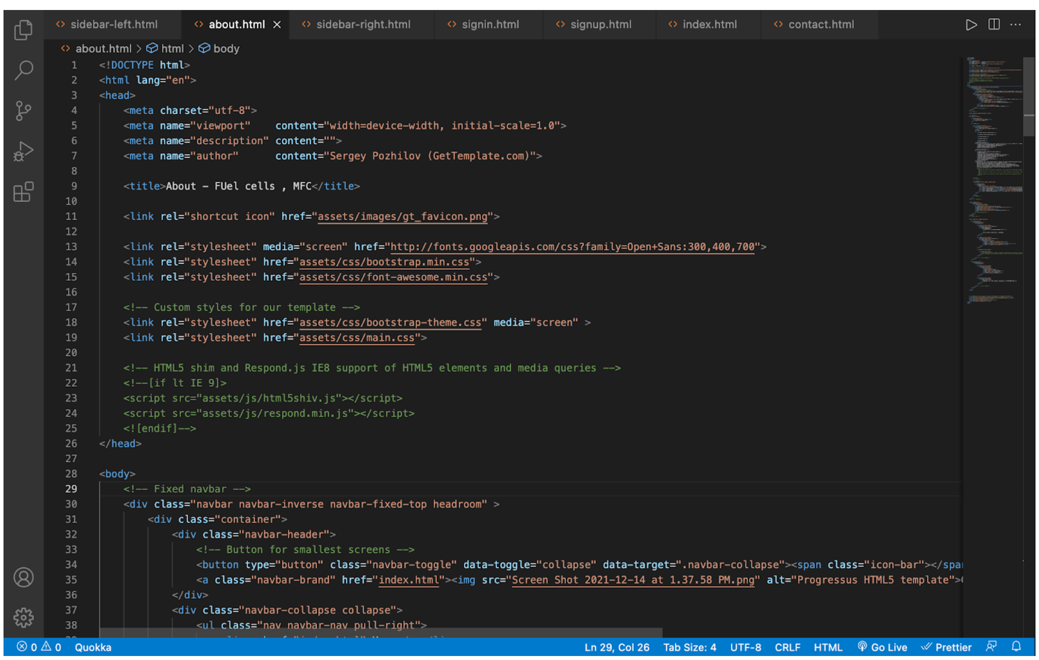
Chapter-5

Technical coding and code solutions

HTML CODE

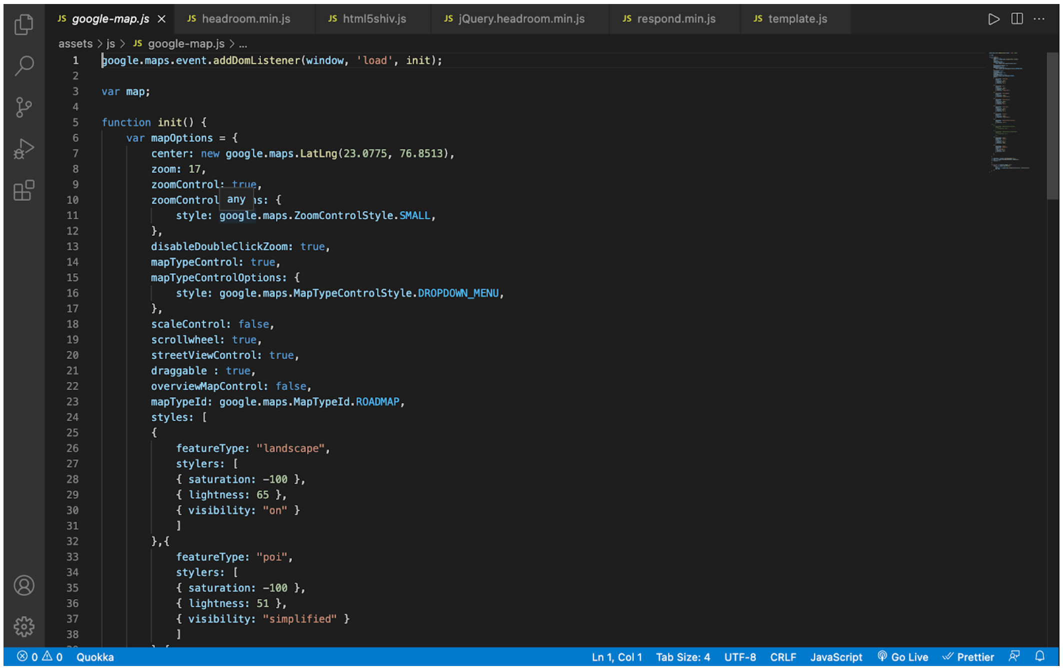


```html
<html lang="en">
<head>
    <meta charset="utf-8">
    <meta name="viewport"    content="width=device-width, initial-scale=1.0">
    <meta name="description" content="">
    <meta name="author"      content="Sergey Pozhilov (GetTemplate.com)">

    <title>GREEN TECH -MFC</title>

    <link rel="shortcut icon" href="assets/images/gt_favicon.png">

    <link rel="stylesheet" media="screen" href="http://fonts.googleapis.com/css?family=Open+Sans:300,400,700">
    <link rel="stylesheet" href="assets/css/bootstrap.min.css">
    <link rel="stylesheet" href="assets/css/font-awesome.min.css">

    <!-- Custom styles for our template -->
    <link rel="stylesheet" href="assets/css/bootstrap-theme.css" media="screen" >
    <link rel="stylesheet" href="assets/css/main.css">

    <!-- HTML5 shim and Respond.js IE8 support of HTML5 elements and media queries -->
    <!--[if lt IE 9]>
    <script src="assets/js/html5shiv.js"></script>
    <script src="assets/js/respond.min.js"></script>
    <![endif]-->
</head>

<body class="home">
    <!-- Fixed navbar -->
    <div class="navbar navbar-inverse navbar-fixed-top headroom" >
        <div class="container">
            <div class="navbar-header">
                <!-- Button for smallest screens -->
                <button type="button" class="navbar-toggle" data-toggle="collapse" data-target=".navbar-collapse"><span class="icon-bar"></spa
                <a class="navbar-brand" href="index.html"><img src="Screen Shot 2021-12-14 at 1.37.58 PM.png" alt="Progressus HTML5 template">

            </div>
            <div class="navbar-collapse collapse">
                <ul class="nav navbar-nav pull-right">
```



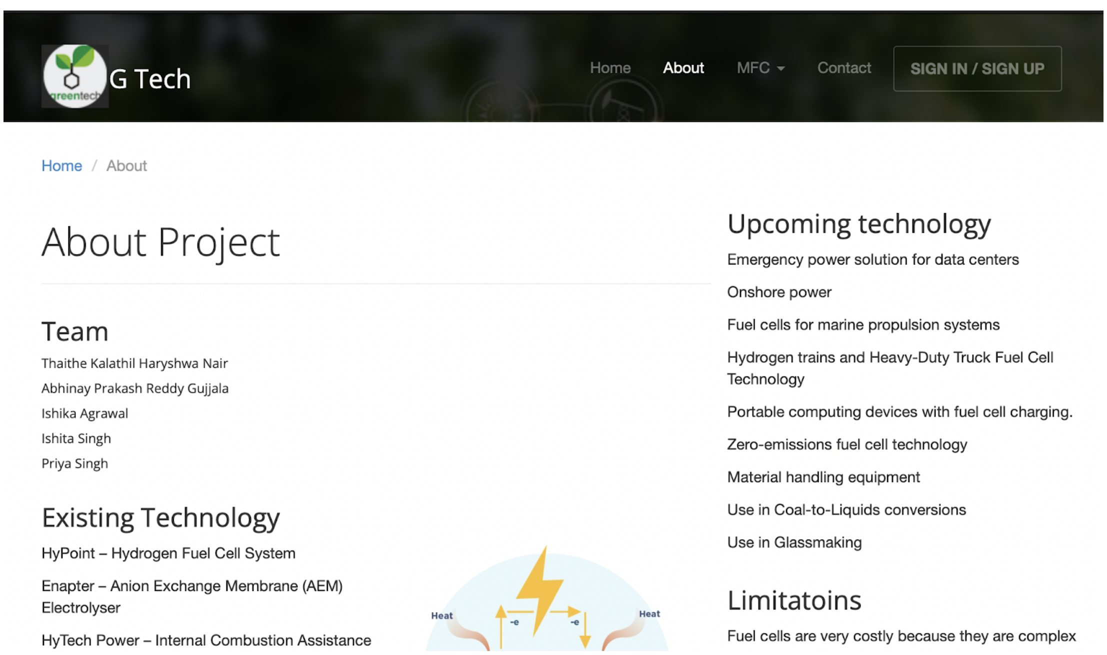
```html
<!DOCTYPE html>
<html lang="en">
<head>
    <meta charset="utf-8">
    <meta name="viewport"    content="width=device-width, initial-scale=1.0">
    <meta name="description" content="">
    <meta name="author"      content="Sergey Pozhilov (GetTemplate.com)">

    <title>About - FUel cells , MFC</title>

    <link rel="shortcut icon" href="assets/images/gt_favicon.png">

    <link rel="stylesheet" media="screen" href="http://fonts.googleapis.com/css?family=Open+Sans:300,400,700">
    <link rel="stylesheet" href="assets/css/bootstrap.min.css">
    <link rel="stylesheet" href="assets/css/font-awesome.min.css">

    <!-- Custom styles for our template -->
    <link rel="stylesheet" href="assets/css/bootstrap-theme.css" media="screen" >
    <link rel="stylesheet" href="assets/css/main.css">

    <!-- HTML5 shim and Respond.js IE8 support of HTML5 elements and media queries -->
    <!--[if lt IE 9]>
    <script src="assets/js/html5shiv.js"></script>
    <script src="assets/js/respond.min.js"></script>
    <![endif]-->
</head>

<body>
    <!-- Fixed navbar -->
    <div class="navbar navbar-inverse navbar-fixed-top headroom" >
        <div class="container">
            <div class="navbar-header">
                <!-- Button for smallest screens -->
                <button type="button" class="navbar-toggle" data-toggle="collapse" data-target=".navbar-collapse"><span class="icon-bar"></spa
                <a class="navbar-brand" href="index.html"><img src="Screen Shot 2021-12-14 at 1.37.58 PM.png" alt="Progressus HTML5 template">
            </div>
            <div class="navbar-collapse collapse">
                <ul class="nav navbar-nav pull-right">
```

JAVA SCRIPT



```
google.maps.event.addDomListener(window, 'load', init);

var map;

function init() {
    var mapOptions = {
        center: new google.maps.LatLng(23.0775, 76.8513),
        zoom: 17,
        zoomControl: true,
        zoomControl any s: {
            style: google.maps.ZoomControlStyle.SMALL,
        },
        disableDoubleClickZoom: true,
        mapTypeControl: true,
        mapTypeControlOptions: {
            style: google.maps.MapTypeControlStyle.DROPDOWN_MENU,
        },
        scaleControl: false,
        scrollwheel: true,
        streetViewControl: true,
        draggable : true,
        overviewMapControl: false,
        mapTypeId: google.maps.MapTypeId.ROADMAP,
        styles: [
        {
            featureType: "landscape",
            stylers: [
            { saturation: -100 },
            { lightness: 65 },
            { visibility: "on" }
            ]
        },{
            featureType: "poi",
            stylers: [
            { saturation: -100 },
            { lightness: 51 },
            { visibility: "simplified" }
            ]
```

THE OUTCOME



THE WEBSITE

THE PROTOTYPE

Calculation

(Estimated power output)

Enter the substrates Quantity (ml)

Quantity(ml)

Enter the substrates quality

(high contaminated - 10,medium contaminated-5, less contaminated - 3)

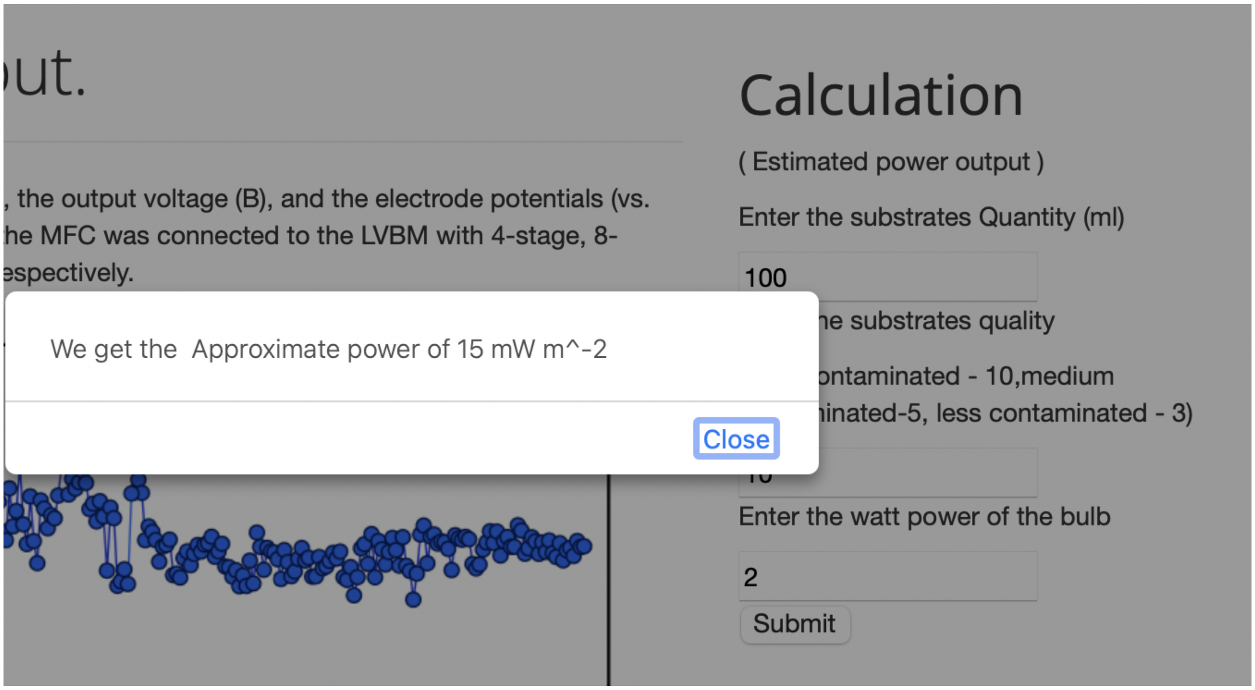
substrates quality

Enter the watt power of the bulb

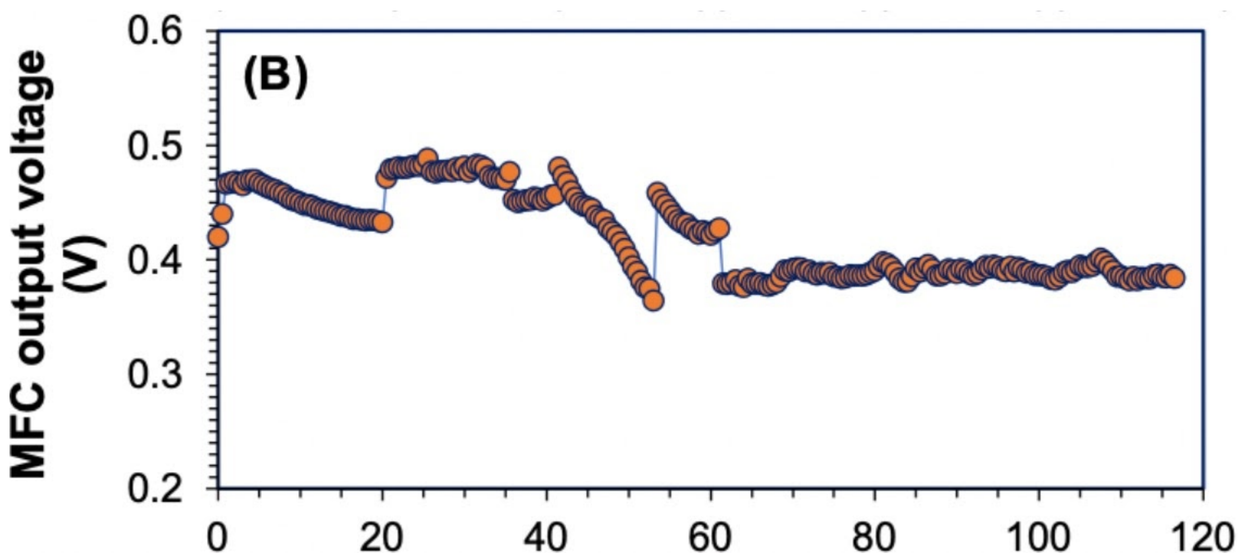
watt

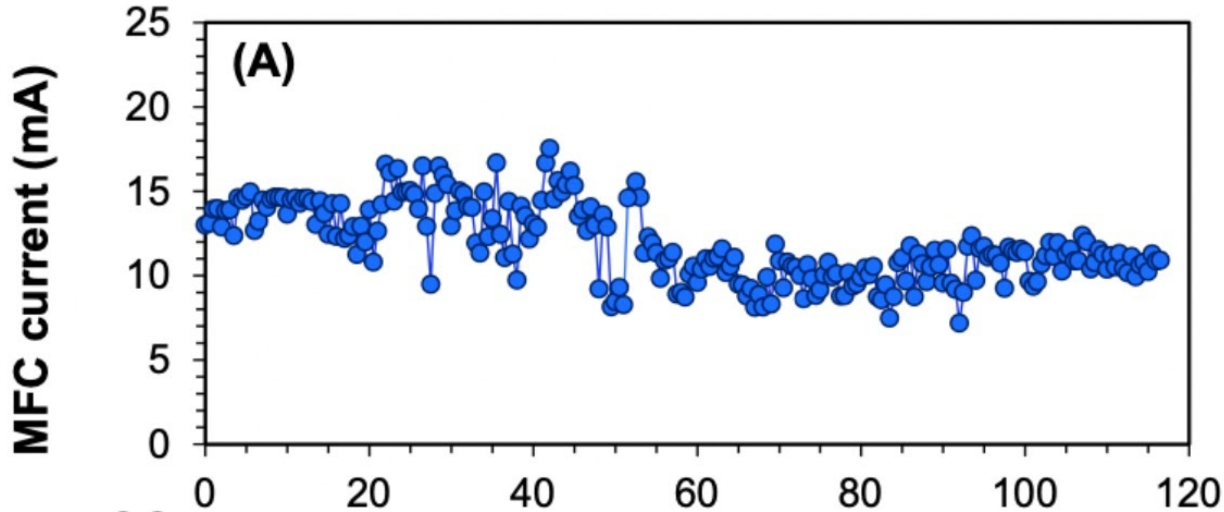
Submit

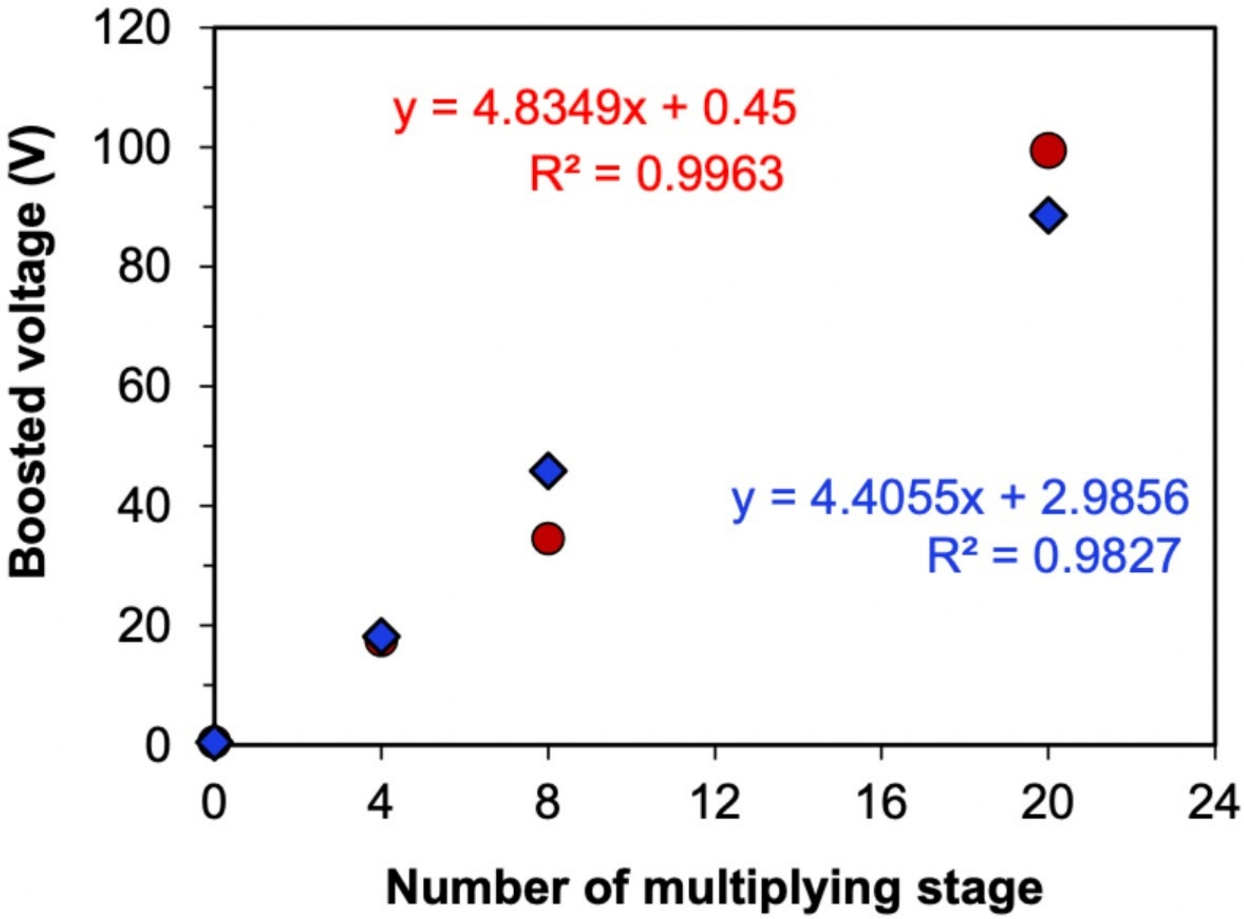
THE RESULT


ut.
, the output voltage (B), and the electrode potentials (vs.
he MFC was connected to the LVBM with 4-stage, 8-
espectively.
We get the Approximate power of 15 mW m^-2
Close
Calculation
(Estimated power output)
Enter the substrates Quantity (ml)
100
he substrates quality
ontaminated - 10,medium
inated-5, less contaminated - 3)
Enter the watt power of the bulb
2
Submit

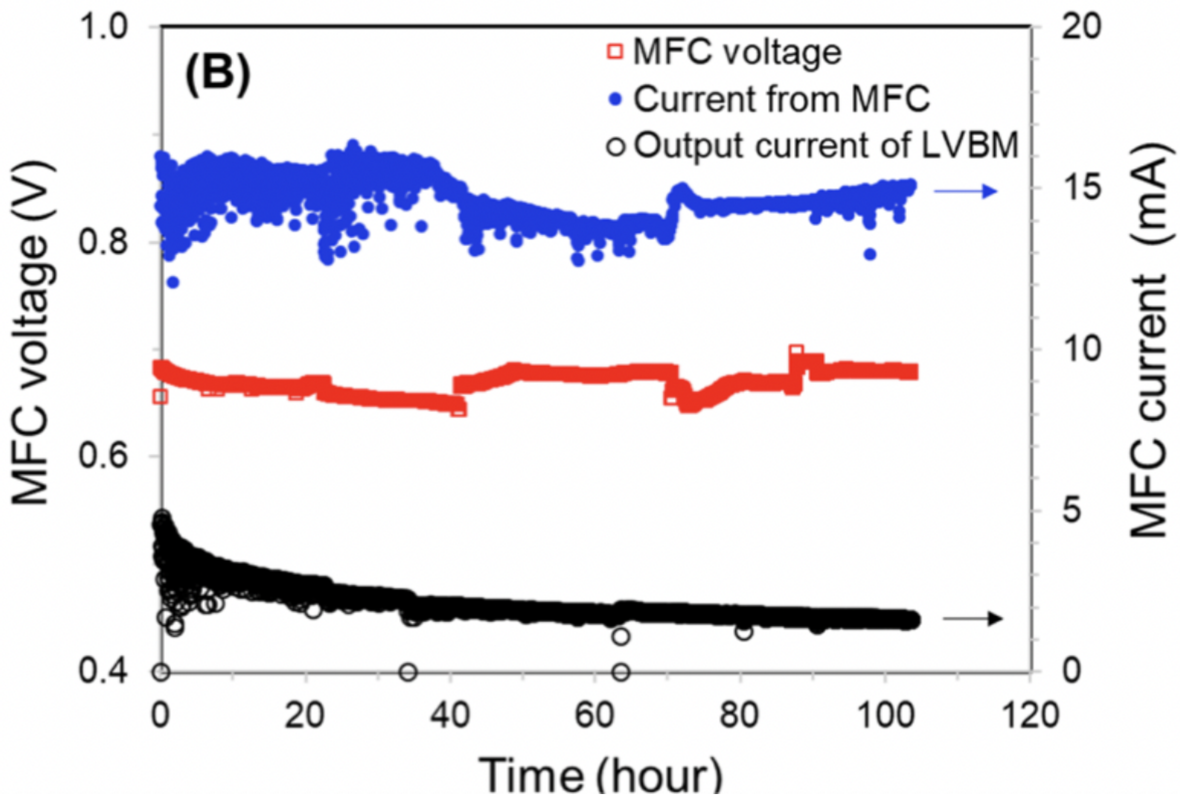
PERFORMANCE

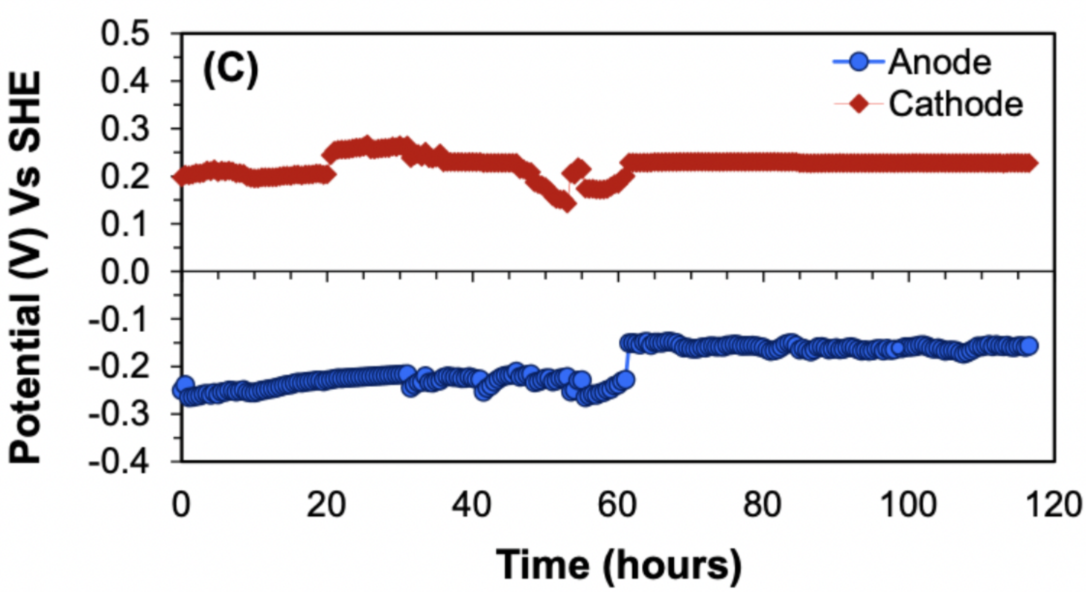





y = 4.8349x + 0.45
R² = 0.9963
y = 4.4055x + 2.9856
R² = 0.9827
Boosted voltage (V)
Number of multiplying stage
0
20
40
60
80
100
120
0
4
8
12
16
20
24

Voltage and Current vs Time(hrs)





The output of MFC is as shown above.

Chapter 6

PROJECT OUTCOME AND APPLICABILITY

6.1 Outline

Our project provides us with the following outcomes:

- Reduce the production cost of fuel cell systems
- Increase the electrical efficiency and the durability of the different fuel cells
- Reduce the use of the EU-defined "Critical raw materials"
- Analysis device data online through website

6.2 Key implementations outlines of the System

- The plant based microbial fuel cell can be attached to a plug board which in turn can be used for various dynamic purposes like charging phones, lighting bulbs etc.
- When the energy isn't in use we can store it for future use.
- Along with that a website which can provide us a reminder when mud needs to be changed.

6.3 Significant project outcomes

- Increasing their lifetime to levels competitive with conventional technologies thus reducing the production cost of fuel cell systems to be used in transport applications
- Reducing costs, to levels competitive with conventional technologies by increasing the electrical efficiency and the durability of the different fuel cell

- Use of low or platinum-free resources and through recycling or reducing or avoiding the use of rare earth elements thus reducing the use of the EU-defined "Critical raw materials"

6.4 Project applicability on Real-world application

- A greener portable alternative for charging devices.
- A cleaner alternative light bulb
- In various fuel cell based systems like electric cars and battery backups.
- The website can be used to similarly track various other devices' data.
- Can be used as a decorative item considering the plant's aesthetics.

6.5 Inference

The final outcome of this project includes a cleaner, greener option for fuel and energy; analysis of battery life of the device through a website which shares important information about the device as well.

Chapter-7

CONCLUSIONS AND RECOMMENDATION

7.1 Outline

Our world needs a cleaner alternative to fuels as soon as possible. Options like hydrogen fuel cells are available but they are not in wide use due to the cost and resources they require. An innovative alternative to this is MFC and taking it to a next level we replaced the microbes with green plants that release hydrogen during biological processes. Microbial fuel cells are a good renewable source of energy useful to meet some demands of energy in future. Though it has some limitations it will be improved for the coming Years by use MFCs along with other renewable sources like Solar , Tidal , Hydro etc.

7.2 Limitation/Constraints of the System

- There are health issues concerned with long term use of MFC.

REFERENCES

1. https://pubmed.ncbi.nlm.nih.gov/19895647/
2. https://en.wikipedia.org/wiki/Microbial_fuel_cell
3. https://www.mdpi.com/1422-0067/17/5/762/htm
4. https://www.researchgate.net/publication/269107704_Dual_gas_diffusion_cathode_design_for_microbial_fuel_cell_MFC_Optimizing_the_suitable_mode_of_operation_in_terms_of_bioelectrochemical_and_bioelectro-kinetic_evaluation
5. https://www.elprocus.com/microbial-fuel-cell/
6. https://youtu.be/bECIaInLmRw