The analysis of electrolyte water by using electrolysis cell and Galvani cell as electrical power storage

E Kurniawan*, B S Aprillia and I M W Hasan
School of Electrical Engineering, Telkom University, Bandung, Indonesia

*ekkikurniawan@telkomuniversity.ac.id

Abstract. Any power generated by renewable electricity sources must be used immediately or it will be wasted. In this research, battery cell test will be carried out using the Galvani cell theory and electrolysis cell approach. Salt (NaCl) is an ingredient that can easily found. Salt itself is an ionic compound consisting of positive ions and negative ions to form neutral compounds, formed from the acidic reactions obtained from sodium and bases that are obtained from chlorine. Salt water is an element that is easy to electrolyze even though it uses a small current input. Salt water can also collect electricity in certain periods. This study discusses the use of salt or NaCl (Sodium Chloride) which will be combined with copper electrodes (Cu), carbon (C) and also aluminium (Al) as a storage of power generated from renewable energy sources. Based on the experimental analysis, combination of electrode that is the most linear in producing voltage and current are C and Zn.

1. Introduction
These days technological advancement grows at a rapid pace. A side effect from the rapid pace is the increasing usage of electrical energy that is also just as high. According to the data from Ministry of Energy and Mineral Resources, electrical consumption in 2017 Indonesia reached 1.012 Kilowatt per hour (KWH)/capita, a 5.9 percentile increase from the previous year [1]. The increase in the need for electrical energy is contrary to the amount of fuel resources that can be utilized for power plants. Indonesia itself is predicted to be threatened by an energy crisis by the year 2020. Our non-renewable energy resources which are the backbone for our electricity is already thinning. Consequently, renewable energies are increasingly popular such as solar power plants, wind, and etc [2-5]. Renewable energies or alternative energies are energies that can be renewed and cannot be used up.

Indonesia is an archipelago state that consists of the second longest coastline in the world. data from the Geospatial Information Agency (GIS) recorded the total amount of coastline for Indonesia is 99,093 km and consists of 13,466 islands [6]. From this information, we can safely say that there is potential to use the oceanic resources of Indonesia from Sabang to Merauke. To this day, the utilization of ocean water in Indonesia is only limited to salt, salted fish, and generator coolers located around beaches [6]. Even though when we see the exterior of the oceanic waters of Indonesia there are more that we can utilize from the sea itself. In a world that consists of 97.5% salt water and 2.5% of fresh water. There are 1.365,000,000 km³ salt water in the world, meaning salt water is easier to obtain than freshwater.

One of the challenges in renewable energy is storage. Solar panel farms or wind farms are one of the many renewable energies that can be used. Although if the sun is set or when the winds aren’t strong enough to rotate the propellers then these generators can’t be used [7,8]. This happens because the design
for alternative energies aren’t accompanied by power storage. Even if there are batteries the cost of batteries to store the capacity needed for individual houses are very high [2].

The high capacity of available sea water can be utilized to overcome the problem of energy storage. Sea water / salt water / NaCl solution can be used in Galvani cell reactions. Galvani cells or also called voltaic cells are electrochemical cells that can produce electrical energy from a spontaneous redox reaction. Galvani cell series in general consists of several parts, namely salt bridges, anodes, and cathodes. In this study, the anode used was copper (Cu) and the cathode used was carbon (C) and Aluminium (Al).

2. System design

2.1. Use of carbon as an inert electrode

Carbon is a unique element that can bond with other elements to create several new compounds. The biggest group of carbon bonds are with hydrogen atoms which creates compounds called hydrocarbon bonds. At least around 1 million organic components consists of hydrocarbons. Carbon can also bond with other compounds that are considered inorganic, even though the quantities are far lower than bonds with organic compounds. Carbon elements can be seen in two shapes that are allotropic crystal which are diamond and graphite. Other forms with a small amount of crystallinity are carbon plant and soot. Physical and chemical properties of carbon is dependent on its’ crystal structure. The density of carbon can also vary from 2.25 g/cm³ for graphite and 3.51 g/cm³ for diamond. The melting point for graphite is 3500 °C with a 4830 °C boiling point.

Carbon element is an inert material, cannot dissolve in water, dilutes acid, dilutes bases, and is an organic solvent. The choice of graphite as an electrode is done by taking into account the properties of this material in an electrolysis system, conductivity, stability(inert) and obtainability. In this research Analysis of Carbon Phase through heating coconut shells it can be said that the graphite cells consist of many constituent elements inside.

2.2. Electrochemical cells

Electrochemistry is a part of chemistry that studies the relationship of chemical reaction with electrical current [9]. Electrochemical cells can be classified into a few different types, which consists of:

2.2.1. Galvanic cells / volta cells. Galvanic Cells consists of two electrode and electrolyte. This electrode is then connected by a conductor that can transport electron from and into the cell [10].

![Figure 1. Galvanic cell.](image)

2.2.2. Electrolysis cell. Electrolysis Cell is a cell that utilize electrical currents to create a wanted redox reaction and is used widely by the public.
System design

3.1. Hardware design
In this research we designed a primary battery cell using graphite electrodes, zinc and aluminium. Then perform discharging/galvanic cells, charging/electrolysis cell, TDS and conductivities. Output from this final project includes the usefulness from the NaCl electrolysis solution as electrical power storage media.

In the charge cycle, we use a buck converter to change power from ac to dc. In the discharge cycle we use a load of 5-Watt lightbulb as shown in figure 3.

Software design
Design of software is used to integrate all the system and hardware.
4. Results of tests

4.1. Galvanic cell tests

After the finding the data for voltage and current, the electrode combination with the highest voltage and current value is chosen. The combination of electrode that is chosen is graphite and zinc diluted in NaCl solution with a salinity of 10% and is arranged series for 12 cells.

![Flowchart of charging system](image)

**Figure 4.** Flowchart of charging system.

![Graphic of galvanic cells voltage testing](image)

**Figure 5.** Graphic of galvanic cells voltage testing.
4.2. Electrolysis cells test
Testing of electrolysis cell is done by integrating the two electrode poles chosen with a voltage source.

5. Conclusion
Salinity content from water and the types of electrode can have a huge impact on the amount of voltage that can be produced by Galvanic Cells. Combination of electrode that is the most linear in producing voltage are C and Zn. Combination of electrode that is the most linear in producing current are C and Zn. From the combination of electrode C and Zn we can find the linear equation as follows: Linear equation of voltage produced is \( V = 0.0222A + 0.08927 \), with \( V \): voltage(V) and \( A \): water salinity and Linear equation of current produced is \( I = 0.0054B + 1.5393 \), with \( I \): current(mA) and \( B \): water salinity. Based on the linear equations of voltage and current, we can find that the level of water salinity influences the value of voltage that are produced.

References
[1] Direktorat Jendral Ketenagalistrikan 2017 Statistik Ketenagalistrikan (Jakarta: Kementerian Energi dan Sumber Daya Mineral)
[2] Aprillia B S, Silalahi D K and Rigoursyah M A F 2019 Desain Sistem On-Grid Energi Terbarukan
Skala Rumah Tangga Menggunakan Perangkat Lunak HOMER *JTIM: Jurnal Teknologi Informasi dan Multimedia* 1 3 pp 174-180

[3] Nurfaidah Y, Wibawa I P D, Aprilia B N D, Ekaputri C and Reza M 2019 Analysis of smart house power savings with on-grid photovoltaic power system *Journal of Physics: Conference Series* **1367** 1 p 012047

[4] Afif A R, Priharti W and Aprillia B S 2019 Desain dan Implementasi Battery Management System Panel Surya Portabel Dengan Metode Coulomb Counting *eProceedings of Engineering* 6 2

[5] Boyle G 2004 *Renewable energy. Renewable Energy, by Edited by Godfrey Boyle* (Oxford University Press) p 456

[6] Astor Y, Sulasdi W N, Hendriatiningsih S and Wisayantono D 2017 *The Evaluation of Marine Cadastre Definitions Among Australia, Canada and United States of America Based on Indonesia’s Perspective as an Archipelagic State* (In Cadastre: Geo-Information Innovations in Land Administration Springer, Cham.) pp 275-308

[7] Aprillia B S, Zulfahmi M R and Rizal A 2019 Investigasi Efek Partial Shading Terhadap Daya Keluaran Sel Surya *Jurnal Elektro dan Mesin Terapan* **5** 2 pp 9-17

[8] Jain P 2011 *Wind energy engineering* (New York: McGraw-Hill)

[9] Widjajanti Enardi 2005 *Elektrokimia* (Yogyakarta: FMIPA UNY)

[10] Wirosobo H D and Rochim S 2014 SAW-GEN Sebagai Sumber Energi Listrik Ramah Lingkungan dan Murah *Prosiding SNST ke-5* 1 1