# PROPOSED WATER MONITORING SYSTEM FOR SUSTAINABLE ELECTRICITY GENERATION IN WATER BATTERY SYSTEM

Solomon Esomu[1], Oluchukwu Nathan[2]

[1]Department of Computer Engineering, Ballsbridge University, Dominican Republic

[2]Department of Computer Science, National Open University of Nigeria (NOUN), Abuja, Nigeria

**Email**: esomu1@gmail.com; upgradednath@gmail.com

## Abstract

There is a growing demand for the development of sustainable electrical energy. However, irrespective of the source of alternative energy embarked upon there is also a need to have rechargeable energy storage systems or units that can store energy from the sun or wind when they are available. Such Rechargeable Energy storage devices are critically important if we desire to move fully into renewable sources of power and usher in sustainable electrical energy. One widely used source of energy storage is the battery. Battery storage, or battery energy storage systems (BESS). However, the use of water batteries requires ensuring that the water level and quality are in the required amount. The paper reviews the use of the internet of things and how it can be applied for use in a water battery system that generates electricity. When applied the Water batteries can feed into an existing electric grid and help in ensuring constant electricity by redistributing electricity when demand is high. This study proposes the use of IoT systems in that regard to ensure automatic water monitoring of water-based devices.

**Keywords:** IoT, Water Battery, Water Monitoring, Storage Devices

## 1. Introduction

Demand for the creation of sustainable electrical energy is rising ( Karmakar, Pramanik, Kumbhakar, Sarkar,& Kumbhakar, 2021). Although the use of electricity produced by the sun and the wind is growing in popularity worldwide, these renewable energy sources only offer sporadic power. When accessible, the sporadic energy from the sun or wind needs to be stored so that it can be used later. As a result, a system or device for rechargeable energy storage that can store the energy is required.

A hydropower plant can produce electricity by utilizing a dam to store river water in a tank in addition to using the sun and wind as energy sources. Water released from the reservoir travels through a turbine and turns it, thus stimulating a generator to create power. An extended system like storage hydropower can employ a dam to keep water in a reservoir. Storage hydropower offers a base load and the flexibility to be quickly shut down and restarted in response to patterns caused (peak load).

High-capacity wind or solar energy produced when the sun is shining and the wind is blowing might be inexpensively stored using a water-based battery system consisting of zinc and manganese oxide. A water battery or pumped storage power plant is a type of hydroelectric energy storage, according to Rebecca Hughes (2019). Two sizable pools of water situated at various heights form the battery. By pumping water from the lower pool to the higher pool, it can store extra electricity by "charging" the battery. A tiny hydropower plant can produce up to 100 kW. A house, farm, ranch, or hamlet may be able to run on the electricity produced by a small or micro-hydroelectric power system (Gerrard, 2015). A water-activated battery is a disposable reserve battery that does not contain an electrolyte and hence produces no voltage until it is soaked in water for several minutes.

The hydroelectric system generates electricity by releasing water from a reservoir through a turbine, which then powers a generator. For several weeks or even months, the storage power can provide enough reserve capacity to function without the hydrological inflow. Peak-load supply is provided by pumped storage hydropower, which uses pumps that cycle water between a lower and higher reservoir when there is a high demand for electricity. Water is returned through turbines to the sedimentation tank when there is a significant demand for electricity. This pumped storage power plant, also known as a system water battery, is a type of energy storage.

To prevent short-circuiting of the grid, water batteries are utilized. Water batteries, also known as pumped storage hydropower, are made up of two pools of water that work together like an hourglass to generate electricity. Although the idea may seem novel, Switzerland has been using it for generations. While China recently chose to build 270 GW more storage capacity by 2025, the U.S. has also used use that technology for a century. With a 20 million kWh storage capacity or approximately 400,000 hybrid cars, the water battery that lately began operating in Switzerland is intended to assist in stabilizing the energy grid in Geneva and other interconnected grids in Europe. Six turbines in the plant have a 900 MW capacity. Additionally, scientists from the U.S. Department of Energy's (DOE) Brookhaven National Laboratories and Stony Brook University (SBU) have pinpointed the main reaction mechanism that takes place in a rechargeable, solvent battery consisting of zinc and manganese oxide.

The system can use IoT to handle or control changes that can have an impact on the batteries (Priyadharsnee & Rathi, 2017). IoT systems will be able to detect, monitor, control, and take action, among other tasks. It will contain interfaces that enable connections with other devices so that it may communicate the required data. In general, the data collected by sensors will be processed, and the outcomes will be transferred to various actuators. The observed data and response actions must then be transmitted here between devices (Ferrández-Pastor, Garca-Chamizo, Nieto-Hidalgo, Mora-Pascual, Mora-Martnez, 2016).
The popularity of water batteries is low and effort to put them into mainstream electricity generation is needed.

The paper reviews water battery systems and proposes how water monitoring can be applied in water batteries for sustainable electricity.

**2. Water Battery System**

A battery is an electronic device that may be loaded with a current flow and emptied as needed. It is made up of one or maybe more rechargeable batteries. The majority of the time, batteries are constructed from a number of electrochemical cells that are coupled to various inputs and outputs. (Pan, Li, Shang, Feng, Tao, Ye, Yang, Li, Liao,2019). The cathode and anode of a battery are the positive and negative terminals, respectively when the battery is producing power (Pauling, 1988). The source of the electrons that will move from the terminal labelled "negative" to the terminal labelled "positive" is an external electric circuit. When a battery is connected to an external electric load, a redox reaction converts high-energy reactants to lower-energy products, and the free-energy difference is delivered to the external circuit as electrical energy.

Because lithium is scarce and distributed unevenly, there is a significant incentive to create new battery chargers that use different charge carriers. Due to their relatively high energy density, quick charge transfer kinetics in the solution, and low price, potassium-ion batteries (PIBs) are the best solution by far. The development of PIBs is currently hampered by a number of issues, including low reversible capacity, subpar rate performance, and poor long cycle life (Min, Xiao, Fang, Wang, Zhao, Liu, Abdelkader., Kumar, & Huang, 2021).

Batteries that enable backup for wind and solar power often have limited energy storage capacity due to their high energy density. They have previously been based on the chemistry of lead-acid (Pb-acid). In addition, depending on the depth of drain, Pb-acid batteries have a reputation for lasting up to ten years (if you discharge them regularly, they last longer; irregular discharges shorten their life). However, they use sulfuric acid, which is extremely corrosive, as the electrolyte and only delivers meagre energy content (Fowler, 2016). These problems emphasize how urgently the lead-acid battery needs to be replaced. The disadvantages of other battery chemistries, however, are their high cost and health concerns.

Water batteries often referred to as pumped storage hydropower, are comprised of two sizable water pools, one perched high above the other and acting as an energy-producing hourglass. They are among the largest batteries on the planet (Energy Efficiency & Renewable Energy, 2022). Solar cells in a water battery have light rays or photons that a semiconductor can absorb. The atoms in the battery are converted into electricity by these photons. Typically, the fluid contains a variety of compounds, such as lithium perchlorate and dimethyl sulfoxide. Compared to other electrolyte mixtures, water offers an environmentally favourable solution and functions as a solvent for lithium iodide. To function, this kind of battery needs electrolytes or water. The required amount of water depends on the size of something like the battery plates. In addition to this, you would also have to check the lead acid battery to determine how much water it can store.  A water battery or pumped storage power plant is a type of hydroelectric energy storage.

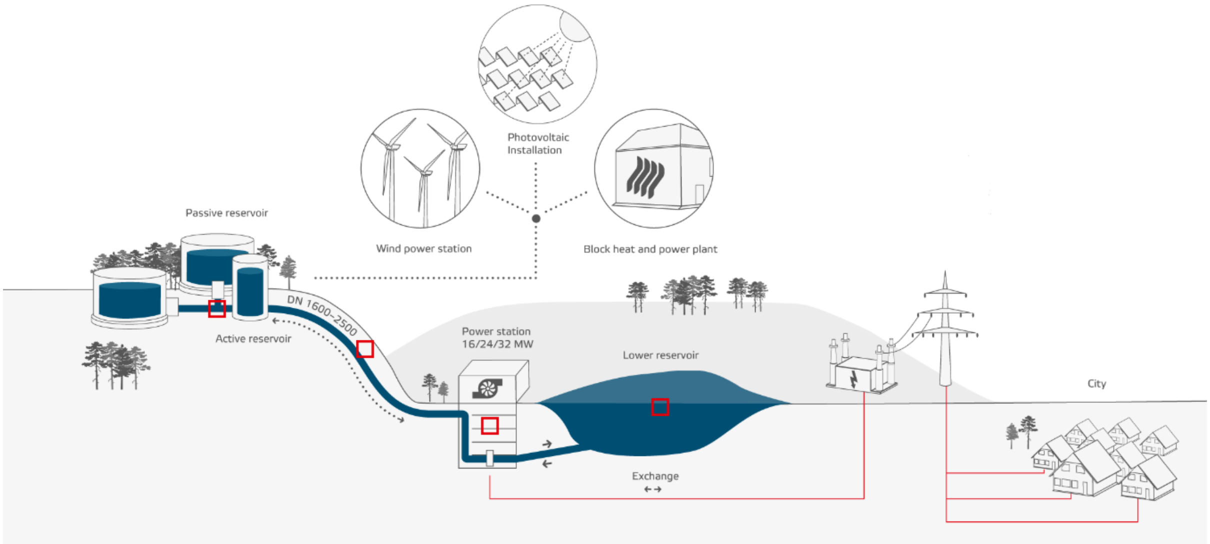


**Figure 1 Component of the Water Battery System (Source: Max Bogi, 2022)**

An electric current can be created by the transfer of current and employed to perform tasks. To prevent short-circuiting of the grid, water batteries are utilized. Water batteries, also known as pumped storage hydropower, are made up of two pools of water that work together like an hourglass to generate electricity. Two sizable water pools spaced at various elevations make up a water battery. Water is moved from the bottom pool to the pond at a higher height using excessive power when power generation is high, which is equivalent to charging a traditional battery (Sean, 2020).

### Advantages and Benefits of using a Water Battery System

Utilizing water batteries have a number of benefits. These advantages include assisting with grid overload, storage, renewable energy capacity, and maintenance of steady power at affordable prices. Water batteries' ability to reduce grid overload is one of their best qualities. The water battery includes a top pool that charges up and keeps things from getting out of hand during a heat wave. Clean Energy is facilitated by water batteries. They are incredibly dependable and act as a store for energy spikes. After a blackout, water batteries can jumpstart the grid. Water batteries can assist in resetting the grid during power outages. They enable the restoration of electricity to households and businesses. Whether there is a wildfire, heatwave, or ice storm, the electric grid requires water batteries. It does not take long for an entire system to boot and fill the lacuna suffered when a grid goes down.

Water batteries can handle Natural Disasters. The batteries offer irrigation and flood control benefits, and they can easily absorb extra water and keep the home powered. Moreover, the system can help put out wildfires and ensure that the grid does not experience serious harm. A great thing about water batteries is that they do not require any new construction when scale in gup is needed. Thus, it saves tons of money and other resources.

### 2.2 IoT

IoT systems are objects placed in a specific setting and designed to carry out a variety of tasks, including detection, surveillance, control, and action. To communicate the required information, the electronics must have interfaces that enable connection with other devices. In general, the data collected by sensors will be processed, and the outcomes will be used to control various actuators (Ferrández-Pastor, Garca-Chamizo, Nieto-Hidalgo, Mora-Pascual, Mora-Martnez, 2016). An online network of physical things is referred to as the "Internet of Things" (IoT) (Gillis, 2021). The term "Internet of Things" refers to a general idea of network devices' capacity to detect and gather data from their environment, then transmit that data through the Internet so that it can be processed and used for a variety of fascinating reasons (Priyadharsnee & Rathi, 2017).

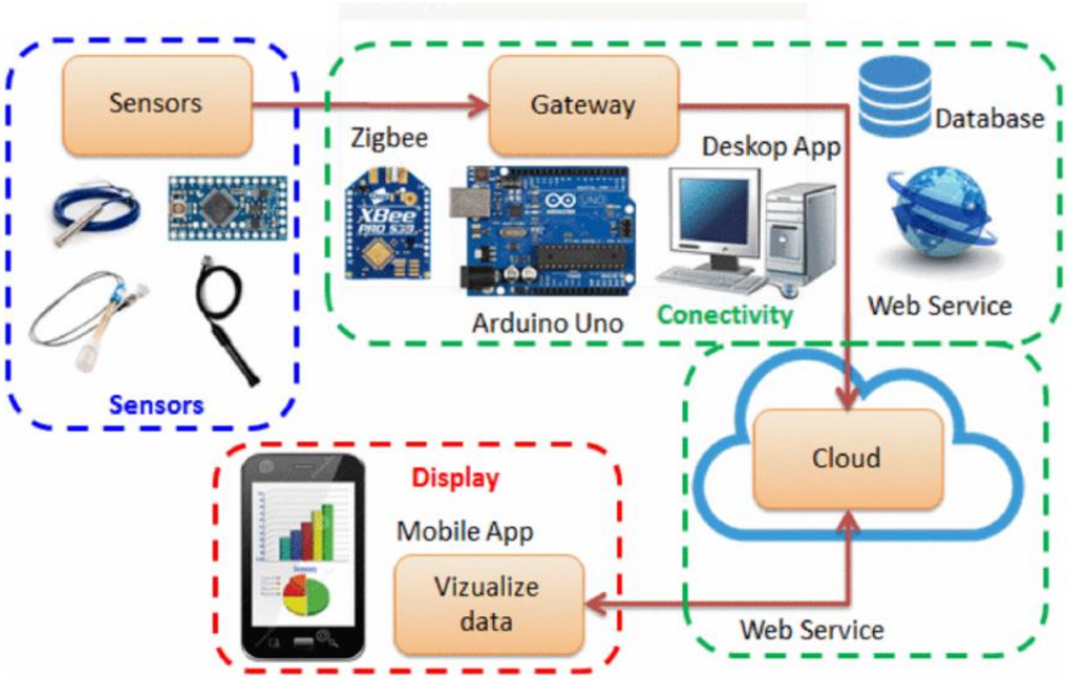


**Figure 2. Flow in IoT System (Source: Encinas, Ruiz, Cortez & Espinoza, 2017)**

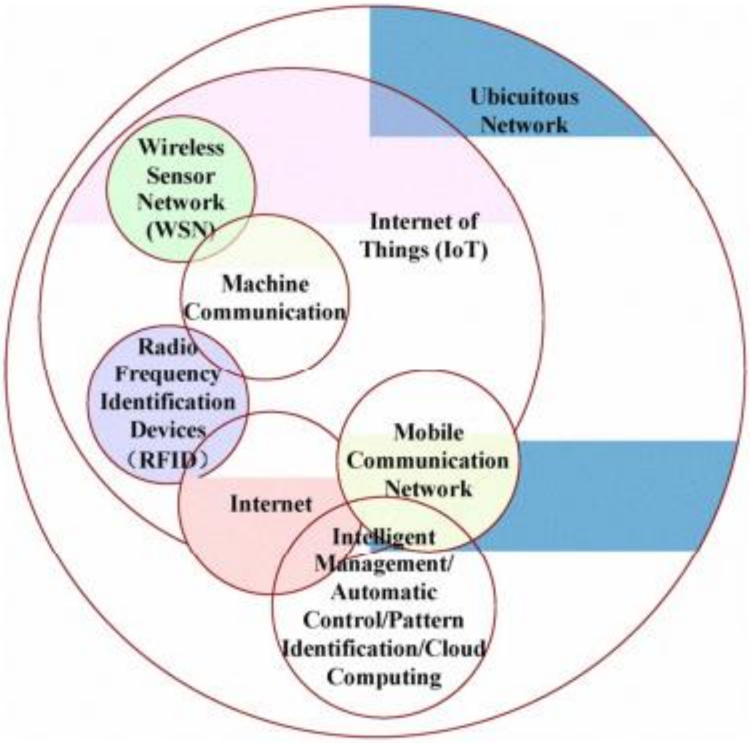


**Figure 3  Relationship between IoT and Water Battery Water monitoring (**

### 3. Water Monitoring System

By ensuring that the water battery system has a sufficient volume of water, the battery water monitoring prototype system significantly improves water quality. Due to the system's continuous operation, there is no need for a battery watering schedule, which results in less time wasted. A flickering red LED indicates the need for water, while a blinking green LED indicates a healthy electrolyte balance. The red and green signaling system makes sure the operator doesn't make mistakes. The technique does away with water, and Smart Blinky's "smart sensing" technology does away with batteries drying up as a result of erroneous signals.

The light that aquatic plants need to grow submerged is partially obstructed by turbidity. Because suspended particles at the surface make it easier for heat from sunlight to be absorbed, it can also cause surface water temperatures to rise above average. The entire system is created in Embedded-C, and the Arduino IDE simulates the written code. The water quality monitoring system uses sensors to gather information on the pH, turbidity, water level, temperature, and humidity of the surrounding atmosphere.

The Agile model of technology and software development was used to implement the system. Wireless Sensor Network (WSN) theory and the adoption model might serve as the study's theoretical foundations. It's incredibly easy to utilize and comprehend the Agile technique. This architecture makes it simple to design projects and achieve quick procedures.

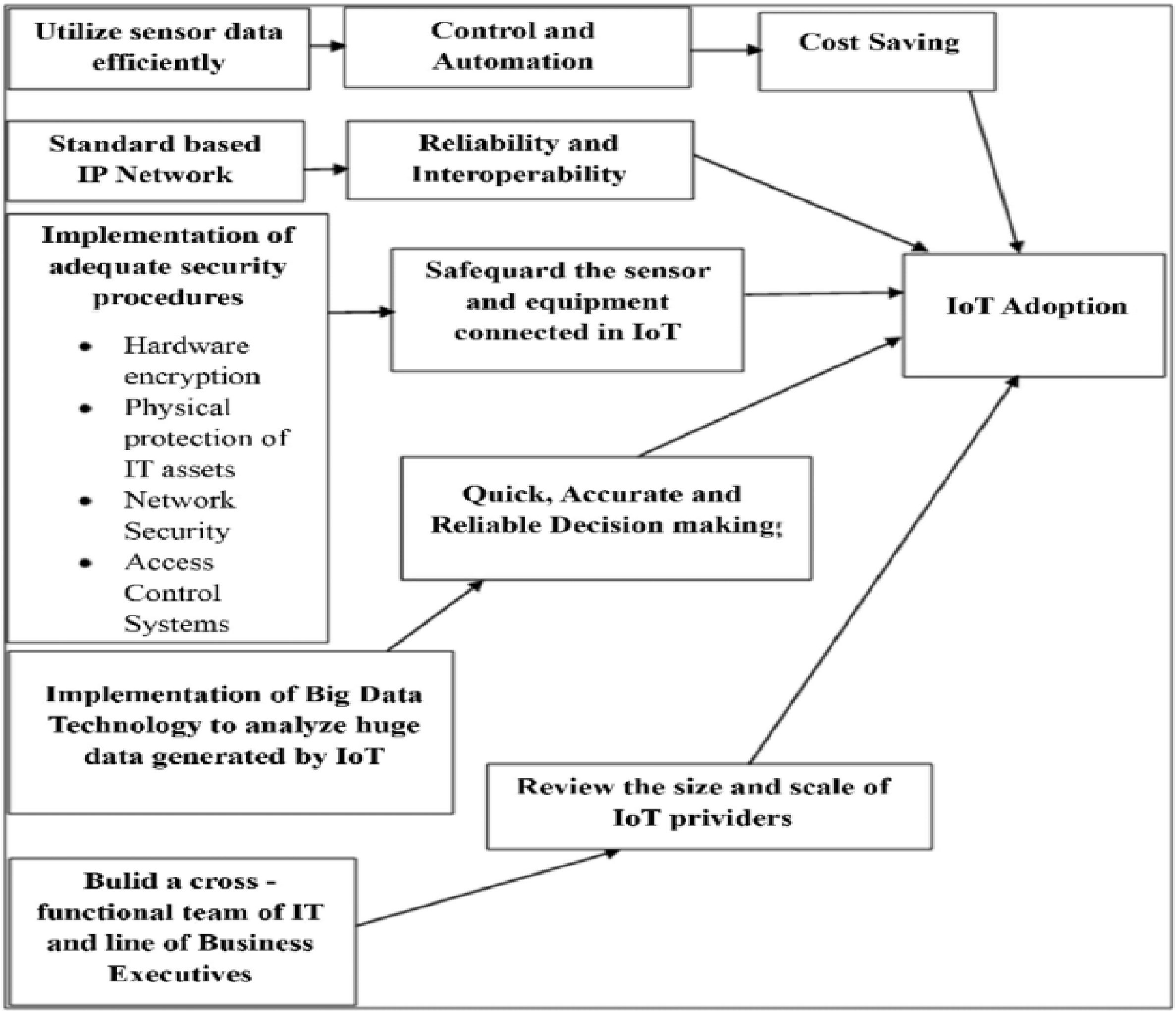


**Figure 4 Modified Technology Adoption Model for the IoT-based Battery Water System (Source: Tripathi, S. & Vishwakarma, L. (2019).**

In order to monitor the system and any physical or environmental variables, a Wireless Sensor Network (WSN) is a wireless network without any underlying infrastructure that is deployed in a large number of wireless sensors on an as-needed basis (Agrawal, 2011). A WSN system's base station connects to the Internet to share data. Two different kinds of sensors exist. A passive sensor may produce an output signal without the requirement for a power source like a battery, whereas an active sensor needs external power. Thermistors, strain gauges, infrared sensors, and Hall effect sensors are examples of active sensors. Mice, photodiodes, and thermocouples are a few examples of passive sensors. A significant number of people could be affected if wireless campaign sensor networks fill the space between the real world and the Internet (Megerian, et al 2020). Conversely, chaos theory (GT) is a mathematical approach that explains the phenomenon of competition and cooperation between wise, intelligent decision-makers. The approach has proven very valuable when designing wireless sensor systems (WSNs) (Hai, wan-Liang, Ngai-Ming & Sheng, 2012). Game theory (GT) is viewed as an appealing and acceptable foundation for achieving the design aim in order to create a workable and feasible WSN due to the functional nature of the network. Game theory is gaining popularity as a method to address numerous issues in WSNs (Wang, & Li, 2016).

Real-time water flow and preservation are managed using an IoT-based groundwater battery surveillance system. This system comprises of a few sensors that gauge various aspects of water quality, including temperature, conductivity, dissolved oxygen, pH, and turbidity. The microcontroller processes the sensor-measured values before transmitting them over the Zigbee protocol to the raspberry pi, which serves as the core controller. The ground-level storage stations' ability to store water will be monitored by the water level sensors. Figure 5 is a system schematic diagram demonstrating the connections between the various aspects.

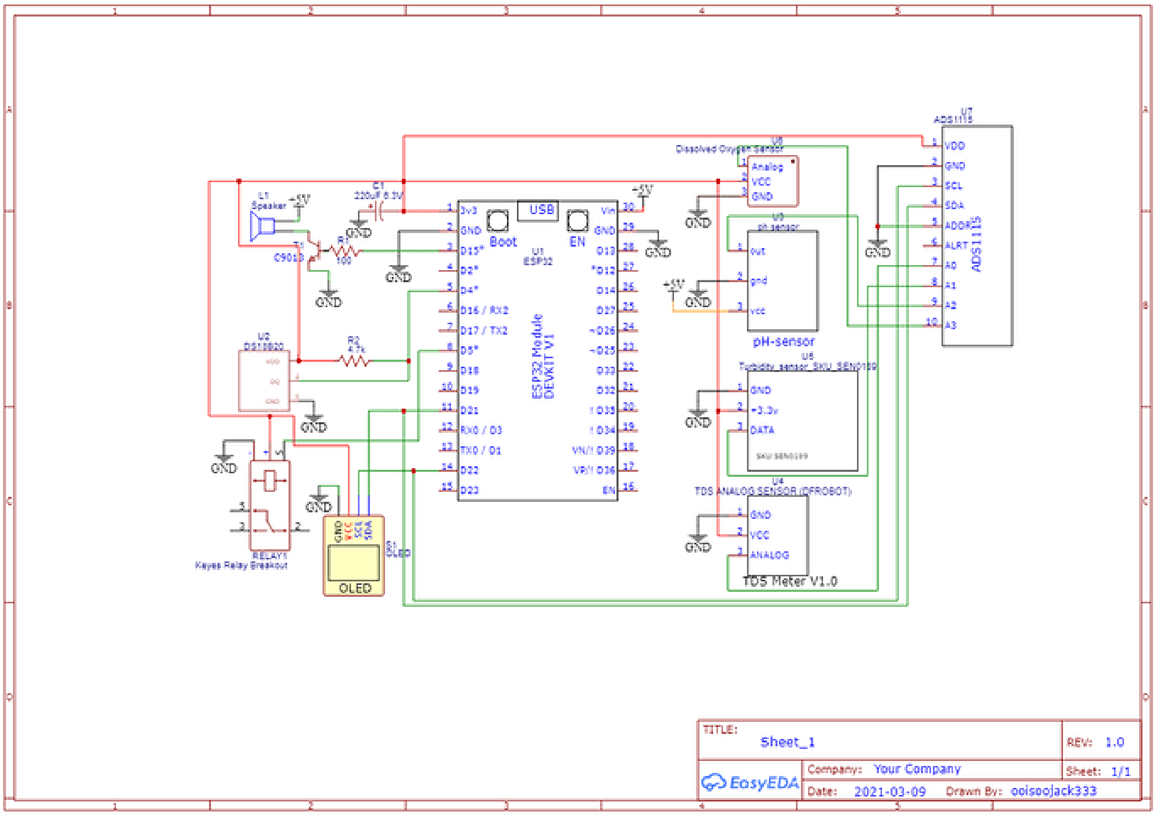


**Figure 5 Schematic Diagram (Source: Yun & Yuxin, 2010).**

The Smart Blinky is the most sophisticated and secure battery-watering monitor on the market thanks to microprocessor technology. Power, current, voltage, thermometer, and brightness graphs are displayed using real-time observed values by the monitoring system, which also makes it simple to track and browse the database file for historical data analysis. The ESP32 microcontroller board with a Wi-Fi adapter was utilized in this system to enable IoT connectivity with IoT platforms like the Blynk application.

### 3.1 Hardware Components

**A. Node Microcontroller ESP8266**

Open-source prototyping board designs are available for the open-source firmware Node Microcontroller (Fernandez, 2020). The software A development kit and open-source firmware called MICROCONTROLLER is used to prototype or create Internet of Things (IoT) products. It contains hardware based on the ESP-12 module and firmware that runs on the ESP8266 Wi-Fi system on chip (SoC) from Espressif Systems. The Lua programming language is employed by the firmware. It was created using the Espressif Non-OS SDK for ESP8266 and is based on the eLua project. It has a Wi-Fi Module ESP-12E module built in, which is comparable to the ESP-12 module but includes six more GPIOs.

**B. Arduino Mega**

An open-source electronics development platform called Arduino Uno is built on adaptable, simple hardware and software. It is a compact, affordable, and dependable computer-on-module (COM) that is controllable by any software program you want. With a huge user community of more than 10 million registered programmers globally, it contains upwards of 3,000 free Arduino libraries. The Arduino platform can be used in conjunction with a variety of sensors and actuators to carry out functions including human presence detection, step counting, and real-time data logging.

A microcontroller board for Arduino is based on the ATmega328P. It has a 16 MHz quartz crystal, 6 analogue inputs, 14 digital input/output pins (of which 6 can be used as PWM outputs), a USB port, a power jack, an ICSP header, and a reset button. Everything required to support the microprocessor is included. The IDE for Arduino was the standard release; more recent versions are now available. The Uno board is the first in a line of USB Arduino boards and serves as the platform's standard model. For a comprehensive list of all current, previous, and out-of-date models, visit the Arduino index of boards.

**C. Wifi module**

A identity SOC with an integrated TCP/IP stack, the ESP8266 WiFi Module allows any microcontroller to connect to your WiFi network. The ESP8266 is capable of offloading all Wi-Fi networking tasks from another underlying hardware or hosting an application. An AT control set firmware is pre-programmed into each ESP8266 module. The Microcontroller is a very affordable board with a sizable and expanding community.

**D. Target board**

The target board is a piece of equipment with built-in microprocessor, ADC, DAC, crystal oscillator, etc. The two target boards used in the suggested approach are the NodeMCU and Arduino Mega. It is a solderless tool for electronic temporary prototypes and test circuit architectures. The majority of computer devices in electronic circuits can be connected by slipping their leads or terminals into the corresponding holes and, where appropriate, creating connections using wires.

**E. Turbidity sensor**

By detecting the amount of cloudiness or haziness in the water, turbidity sensors can identify the quality of the water. By monitoring dispersion rate and light transmittance, which vary with the total amount of suspended solids in the water, it may identify suspended particles in the liquid. Water's turbidity is a gauge of how cloudy it is. The level of turbidity will show how much transparency has been lost by the water. It will be regarded as a reliable indicator of water quality.

**F. Temperature sensor**

The water temperature will show how hot or cold the water is. The DS18B20 temperature probe has a range of -55 to +125 °C. The temperature probe is a digital model, therefore the reading is precise.

**G. pH sensor**

pH sensor is a device to measure the level of acidity or alkalinity of a solution; the pH scale ranges from 0 to 14 The pH indicates the concentration of hydrogen [H] + ions present in certain solutions. It can accurately be quantified by a sensor that measures the potential difference between two electrodes: a reference electrode (silver/silver chloride) and a glass electrode that is sensitive to hydrogen ions. This sensor gives an output in the form of an analogue signal.

**H. Flow sensor**

The flow sensor is used to measure the flow of water through the flow sensor. This sensor consists of a plastic valve body, a rotor and a Hall Effect sensor. The pinwheel rotor rotates when water/liquid flows through the valve and its speed will be directly proportional to the flow rate.

**I. Data Display**

Blynk's application GUI will be used to display the result. The GUI displayed the pH value and turbidity value with cloud charts that store its data. The chart will be updated every second whenever the reading changes.

## 4.0 Conclusion

The paper examines and makes recommendations regarding the usage of an automatic watering model in a water battery system for improving water battery quality by verifying that a sufficient volume of water is present. The information can be distributed and kept in consolidated or cloud virtual datasets. The current laboratory-based systems cannot provide the same level of real-time public safety as these online water measurement techniques due they improve effective answers.

When the system is used, there is no need for a schedule, and less time is wasted because the system is always in operation. The collected data will also tell the consumer about the availability and acceptability of the drinkable water and offer localized information on water amount and quality at the point of usage. Beyond the use of this system for water batteries, water surveillance can be helpful in disaster response as an early stage of the warning system, particularly in flood disasters where it can provide early warning alerts for evacuation, emergency preparedness, and other actions to the nearby residents.

# REFERENCES

Afanasov, M., Bhatti, N.A., Campagna, D., Caslini, G., Centonze, F.M., Dolui, K., Maioli, A., Barone, E., Alizai, M.H., Siddiqui, J.H., & Mottola, L. (2020). Battery-less zero-maintenance embedded sensing at the mithræum of circus Maximus. Proceedings of the 18th Conference on Embedded Networked Sensor Systems.

Anang Othman, N.A., Zolkapli, M., Hairuddin, M.A., Hassan, H., Manut, A., Zoolfakar, A.S., & Abdullah, N.E. (2021). The Development of an IoT-based Solar Battery Monitoring System. 2021 IEEE Regional Symposium on Micro and Nanoelectronics (RSM), 34-37.

Assaouy, M., Zytoune, O., & Ouadou, M. (2020). Battery Recovery-Aware Optimization for Embedded System Communications. *Wireless Personal Communications*, *110*, 1929-1946.

Assaouy, M., Zytoune, O., & Ouadou, M. (2020). Battery Recovery-Aware Optimization for Embedded System Communications. Wireless Personal Communications, 110, 1929-1946.

Blakers, A & M Stocks, M. (2017). '100% renewable electricity in Australia', Energy, 133, 15, 471–482.

Brar, P. S., Shah, B., Singh, J., Ali, F., & Kwak, D. (2022). Using Modified Technology Acceptance Model to Evaluate the Adoption of a Proposed IoT-Based Indoor Disaster Management Software Tool by Rescue Workers. Sensors (Basel, Switzerland), 22(5), 1866.

Budiarti, R.P., Tjahjono, A., Hariadi, M., & Purnomo, M.H. (2019). Development of IoT for Automated Water Quality Monitoring System. *2019 International Conference on Computer Science, Information Technology, and Electrical Engineering (ICOMITEE)*, 211-216.

Chi, T., Chen, H., Chen, S., & Abu, P.A. (2021). A High-Accuracy and Power-Efficient Self-Optimizing Wireless Water Level Monitoring IoT Device for Smart Cities. Sensors (Basel, Switzerland), 21.

Encinas C, Ruiz E, Cortez J and Espinoza A (2017). Design and implementation of a distributed IoT system for the monitoring of water quality in aquaculture Proc. of the Wireless Telecommun. Symp.(14), 1–7

Fowler, S. ( 2016). Samsung's Recall – The Problem with Lithium Ion Batteries". The New York Times. New York.

Hlaing, W. (2017). Implementation of WiFi-Based Single Phase Smart Meter for Internet of Things (IoT) 5th Int. Electr. Eng. Congr., 1–4

Jamaluddin, A., Sihombing, L., Supriyanto, A., Purwanto, A., & Nizam, M. (2013). Design real-time Battery Monitoring System using LabVIEW Interface for Arduino (LIFA). 2013 Joint International Conference on Rural Information & Communication Technology and Electric-Vehicle Technology (ICT & ICeV-T), 1-4.

Karmakar, S., Pramanik, A.K., Kumbhakar, P., Sarkar, R., & Kumbhakar, P. (2021). Development of environment-friendly water-based self-rechargeable battery. *Renewable Energy*.

Kwak, J., & Lee, J. (2020). Minimizing Capacity Degradation of Heterogeneous Batteries in a Mobile Embedded System. IEEE Embedded Systems Letters, 12, 25-28.

Mali, P.P., PatilArti, S., GavadePratibha, S., ManeMrunal, A., & PatilAniket, A. (2022). IoT Based Battery Monitoring System for Electric Vehicles. International Journal of Advanced Research in Science, Communication and Technology.

Max Blog(2022). Storage power. storing renewable energies efficiently. Retrieved from https://www.mbrenewables.com/en/water-battery-concept/

Min, X., Xiao, J., Fang, M., Wang, W., Zhao, Y., Liu, Y., Abdelkader, A.M., Xi, K., Kumar, R.V., & Huang, Z. (2021). Potassium-ion batteries: outlook on the present and future technologies. Energy and Environmental Science.

Pan, AQ; Li, XZ; Shang, J; Feng, JH; Tao, YB; Ye, JL; Yang, X; Li, C; Liao, QQ (2019). The applications of echelon use batteries from electric vehicles to distributed energy storage systems. 2019 International Conference on New Energy and Future Energy System (IOP Conf. Series: Earth and Environmental Science). Vol. 354. IOP Publishing Ltd

Pasika, S., & Gandla, S.T. (2020). Smart water quality monitoring system with cost-effective using IoT. Heliyon, 6.

Pauling, L. (1988). Oxidation-Reduction Reactions; Electrolysis. General Chemistry. New York: Dover Publications

Santos, J.M., Caeiro, J.J., Martins, J.C., Santos, J.F., & Palma, P. (2020). Physical and chemical water quality parameters sensing IoT systems for improving water productivity.

Soylu, E., Soylu, T., & Bayir, R. (2017). Design and implementation of soc prediction for a li-ion battery pack in an electric car with an embedded system. Entropy, 19, 146.

Thokar, R.A., Gupta, N., Niazi, K.R., Swarnkar, A., Sharma, S., & Meena, N.K. (2020). Optimal Integration and Management of Solar Generation and Battery Storage System in Distribution Systems under Uncertain Environment. International Journal of Renewable Energy Research.

Tripathi, S. & Vishwakarma, L.(2019). Analysis of factors influencing adoption of internet of things: A system dynamics approach. *Theoretical Economics Letters*. 09. 10.

Yun, M. & Yuxin, B (2010). Research on the architecture and key technology of the Internet of Things (IoT) applied on smart grid Int. Conf. on Adv. in Energy Eng. (China) pp 69–72

Wang, X., Zhang, L., Sun, Q., Yang, R., Liu, L., & Jin, J. (2020). Design of Lithium-ion battery monitoring system with the diagnostic interface. *2020 11th International Conference on Prognostics and System Health Management (PHM-2020 Jinan)*, 186-191.