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Internet of Things Based Transducer Application to Harness Tidal Energy from coastal and offshore Pakistan

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Abstract:

This paper aims to transform tidal energy into rotation energy for electricity generation and in the course evaluating sea parameters. This is accomplished by integrating the Internet of Things with tidal energy off the coast (and in a home environment), which further enhances the capabilities of this prototype project to remotely monitor sea-like parameters to enable energy production using tidal energy. As South Korea is transducing tidal energy with a total installed tidal power capacity of above 500MW, Pakistan and Middle Eastern countries can benefit from its vast coastal line. This paper proposes a sustainable design that makes the turbine rotate at high speed. A vertical design is chosen, which is bi-directional. The design of the turbine consists of 3 blades, each occupying a 2 square feet area supported by an iron-rod frame. During the experimentation, an average voltage of 5V was generated, whereas the speed of the turbine generated was 75 RPM. It is the first known attempt of its kind supported by indigenous resources. It is proposed that this type of prototype can be scaled, to the coast to produce electrical energy to meet the energy production needs of the region.

Keywords: *Arduino; dc motors; internet of things; sensors; tidal energy; transducers; tidal turbines; underwater technology; wi-fi module.*

1 Introduction

Sourcing energy from renewable sources is presently a key subject in modern society [1]. It is known that more than 70% of the earth is covered with water [2]. We can use water as a renewable source for energy extraction. The electricity demand is growing, and global warming also pressurizes human life [3]. Ocean energy in many forms is being investigated as a potential source [4]. Ocean current energy, tidal energy, wave energy, and offshore wind energy are some of them. Tidal energy is still considered a new alternative energy type. In Pakistan, this energy is still immature it may play a key role soon. This pollution-free source of energy is very cost-effective for generating electricity [5]. The relative motion of the earth, the sun, and the moon can be used to generate tidal energy [6]. The distribution of power by using modern technology (IoT-based system) in different ways, can be designated small, medium, and large scales via different renewable or nonrenewable sources. Tidal power has enormous potential due to the

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size of oceans and the predictability of tides. The main objectives of the paper are:

1. To demonstrate the concept of tidal energy as a source of green energy for developing economies.

2. To understand measurement parameters above the water surface and below it.

3. To demonstrate the usefulness of this emerging technology for coastal communities (radio beacons, search and rescue nodes, night light, etc.).

With a width of one and a half feet and a height of two feet, it can produce enough power. The vertical design of turbines makes the project more predictable to gain most of the force from all sides and mold the turbine in a single direction, even if the tide comes and hits the turbine from any direction. Thus, the unique vertical design of the turbine is very suitable for the seashore tides.

Pakistan has 990 km long coastline. The tidal power is more predictable and reliable than solar or wind energy both of which are dependent on the sun and air which makes it less predictable. Another point is that water is denser than air, therefore, tidal energy produces more energy compared with wind turbines. Tidal energy is inexpensive to maintain, it doesn't produce direct greenhouse gases or other waste. The tidal energy transducer could also be installed on the river barrages. To install the tidal energy transducers the selection of existing barrages and search of new areas, where barrages can be constructed across tidal rivers bays, and estuaries. The turbines in the barrage converts the power of tides in a similar way a river dam harness the power of a river. The gates of the barrages gates open when the tide rises. At high tide the barrage gates close, creating a pool or tidal lagoon. There are six existing barrages on the Indus river which are: Sukkur Barrage, Kotri Barrage, Guddu Barrage, Taunsa Barrage, Chashma Barrage and Jinnah Barrage. In those barrages the tidal energy transducer could be installed.

It is a project that can easily be operated and installed over the long coastal line of the country. For installation, the best possible areas we have assumed to test the project are Sonmiani Beach, Kalamata beach, and Seaview Karachi. Furthermore, it can easily be implemented over the Indus River in Sindh.

2 Literature Review

Kramer et al. [7] used the Sensor Cloud-based economic project to design water quality monitoring for rural areas. This article describes the whole process of water quality monitoring, embedded design, sensors, and data dissipation procedure. The roles of the government, network operators, and locals in ensuring adequate data dissipation are also discussed. It also looks into the Sensor Cloud Domain. Because automatically improving water quality is not feasible at this time, efficient and enhanced technology, in addition to economic practices, is assumed and suggested to improve water quality and public awareness. Sun et al. [8] discussed an efficient energy management framework to provide satisfactory QOI in IoT sensory environments. In contrast to previous efforts, it is transparent and compatible with lower-level protocols in use, preserving long-term energy efficiency without sacrificing any QOI levels [9]. The new idea of QOI-aware "sensor-to-task relevancy" clearly analyses a sensor's sensing capabilities in the IoT sensory environment, as well as the QOI criteria required by a task. [10]. Under the constraint of service delay, an energy management decision is made dynamically at runtime as the best option for long-term traffic data [11]. Finally, an extensive case study is proposed based on the utilization of sensor networks to monitor water levels. A simulation depicts the performance of the suggested algorithms to demonstrate the ideas and techniques given in this work.

2.1 Underwater Sensors

Heidemann et al. [12] suggest Wireless data transmission in the deep ocean/sea is the emerging technology used for ocean-based observational structures. The use of underwater sensor networks has made it relatively easy to control pollution, monitor the climate, record instruments, and predict natural disasters. The study of marine life is another achievement of using underwater sensors. Also, the data collected is utilized to search more and survey different missions. Because they cover miles of ocean range, underwater wireless sensing structures are well understood for stand-alone applications. The development of underwater sensor networks is driven by the necessity to sense the underwater world [12]. Fixed or mobile applications, as well as short and long-range applications, may all have quite distinct requirements. As a result, such requirements can result in demanding distinct designs. The types of underwater sensor network deployments vary as needed, such as mobility and density differences in areas. Underwater sensors structures are often static and attached to docks or tied to the seafloor.

2.2 Surface Water Sensors

The framework of water technologies implemented by Maroli et al. in [13] showed that the above surface water sensing system is a dynamic wireless network architecture that combines multiple communication technologies and solutions to let people and other things to interact. This advanced technology paves the way for the creation of unique applications for so-called smart ocean weather inspection. In the case of water management, the utilization of above surface water sensors allows for monitoring weather parameters in the ocean, such as pressure air, temperature, and airspeed. The implementation of an above-water sensing system also provides an enabling facility to keep the constant check at sea- level. These essential above-surface water sensors can be valuable tools in this context because they allow multiple technologies to store and analyze data from various real-time sensors.

2.3 Review of IoT enabling technologies

Internet of Things is assumed to have a strong influence in distinct evolving technologies such as clouds computing, wireless sensor networks security protocols, search engines, big data, web services, embedded systems, and the Internet [14].

Wireless sensor networks (WSN): It is made up of various sensors that are linked together to monitor various types of data [15].

Cloud Computing: It is also known as On-demand computing, is a type of Internet-based computing that allows computers and other devices to process and share data on demand. It can take many different forms, such as IaaS, PaaS, SaaS, DaaS, and so on.

Big Data Analytics: It is the process of evaluating large data sets that contain various types of data. Big data, for example, can be used to uncover hidden patterns, market trends, customer preferences, and other useful business data.

Communication protocols: It serves as the backbone of IoT systems, allowing for connectivity and application integration. As these protocols enable data exchange formats, encoding, and communication data addressing, they make data exchange over the network easier.

Embedded Systems: It's a type of computer system that combines hardware and software to accomplish specific tasks A microprocessor/microcontroller, RAM/ROM, network components, I/O units, and storage devices are all part of the system.

2.4 Methods of tidal energy extraction

Following are the five approaches of tidal energy extraction.

2.4.1 Tidal barrages

Tidal barrages are structures that are commonly built over the mouth of an estuary through which all of the water streams flow through the basin [16]. The tidal barrages are equipped with conduit entryways that allow water to flow into and out of the basin [17].

During elevated tide, water stream into the sound, and the water is held back by closing the floodgate entryways as low tide approaches which can be seen in Fig. 1. Knowing the area's flow extent and working it at the right times of the flow cycle constrains the flood doors. When the floodgates are allowed to open during low tide, turbines located at the conduit entryways generate electricity [18]. Authors have used this rule to reference a variety of energy extraction methods, including ebb generation, flood generation, ebb and flood generation, pumping, two basin plans, and so on. The advantage of using the barrage technique to generate power over petroleum products is that it reduces greenhouse gas emissions.

Fig. 1. Tidal Barrages

2.4.2 Tidal stream energy

Mendi et al. [19] emphasized that tidal power was centered on harnessing the tidal flow and generating energy through potential storage rather than the tidal stream. Tidal stream innovations have made huge strides toward in the most recent decade. In UK waters identified with flowing stream energy, extensive exploration is underway. The UK has an objective to accomplish 20% of its power necessity through sea assets. Around 40 energy-converting machines are being developed, with prototypes being built in UK labs and waters (Irena, 2014) [20]. There are no standardizations for flowing stream energy because it is still a developing technology [21]. However, an assortment of gadgets is being created to utilize the water stream to separate power. However, the effectiveness of each device must be thoroughly evaluated through extensive testing in order to select the most appropriate device for a specific application.

2.4.3 Tidal Fences

In [22], tidal fences are installed within the fence framework. These fences are made up of individual and vertical turbines and are also called caisson. A turning channel blocks the entire flow of water and just lets it pass through these fences. These tidal fences are also used in vast basins. Like channels between offshore islands and mainland or two islands, these tidal fences can be installed as shown in Fig. 2. As these fences do not require basin flooding, they leave a negligible impact on the environment. These fences are cheaper and easy to install. In barrages, the entire framework is needed to be installed before any electricity production; these fences have vital advantages of being able to produce power as soon as the initial implementations are installed.

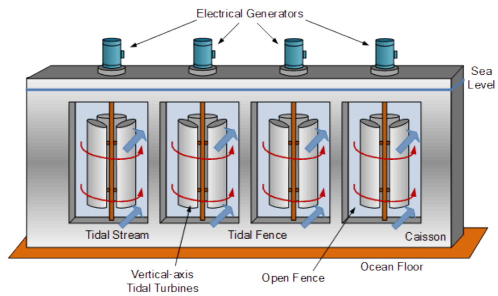

Fig. 2. Tidal fences [23].

2.4.4 Tidal lagoons

In [24], tidal lagoons are considered the modification of barrages. Just like standard barrages, tidal lagoon produces power by conventional hydro-turbine. The difference between tidal lagoons and conventional barrages is that those conventional barrages‟ design used the natural coastal line to decrease the barrages‟ lengths. Nonetheless, tidal lagoons require blocking the river without regarding how deep that is. That's why the cost increases considerably. Wherever there are high-range tides, a lagoon of low cost can easily be installed. These lagoons cause a little visual impact as they appear like a conventional sea wall at lower tides and are below the high tide mark in water [25]. By using demolished structures and loose clusters found in different quarries, these tidal lagoons can be built. Entire debris would be dumped as long as the confined wall is completed. As far as any debris can be used to construct the confined wall, the cost of building a lagoon can easily be restricted. By using the cheapest materials, the price of installing these structures can be decreased. This beneficial technique of construction created an opportunity of constructing an artificial reef. For fishes and birds, a small and warm water lake can also be built in middle. They can easily swim around without any interruption and cause harm to turbine sluices.

2.5 Tidal energy around the world and Pakistan

The need to decrease co_2 emissions combined with a slow increase in the price of petroleum, has resulted in a significant increase in interest in tidal energy [26]. Today, this energy is increasingly being considered as a viable option for a long-term power source around the world. Extraordinary tides can be found all over the world. The Pentland Firth, Scotland; the Severn Estuary; the Aleutians; Norway's fjords; the Philippines; the Straits of Messina, Italy; the Bosporus, Turkey; the English Channel; Indonesia; and Alaska and British Columbia's waterways are just a few of them.

Tidal energy has many benefits compared to other sources of energy it is a clean, renewable, sustainable resource that is not utilized in its full capacity. It has huge potential to meet the global growing energy requirements in the current challenging period and in the future. Arsalan in [27] studied the GIS based approach to analyze the sustainable use of the estimated tidal energy potential in Pakistan. They further suggested potential sites and from those sites the energy could be distributed to the metropolitan city in an easy way. Pakistan has huge potential for renewable energy production and the severe shortage of electricity due to its heavy reliance on imported fuels [28]. Rahem et al. [28] reviewed the alternative sources of energy and their distribution strategies. Neil et al. [29] studied the impact of tidal energy arrays in the regions of tidal asymmetry and suggested that that energy extracted with respect to tidal asymmetries will have important implications for large-scale sediment dynamics. Rauf et al. [30] has overviewed the energy status of Pakistan and discussed major aspects of energy sector of Pakistan. In their research work they suggested based on the reports from National institute of oceanography reports that 170 km area of creek system of Indus delta has a huge potential of tidal energy.

In 1967, a large hydroelectric plant was commissioned that harnessed the power of the tides to generate electricity. It generated about 540,000 kW of electricity [24]. According to studies, the European regional waters have 106 areas for separating flowing energy, which would produce 48,000 Giga Watts of power per year. Around 50,000 MW of introduced limit is estimated to be reachable just along the coasts of British Columbia. There's also the possibility of extracting around 90,000 MW of electrical energy off Russia's northwestern coast, and around 20,000 MW at the inlet or Mezen stream and the White Sea.

TABLE I. HIGHEST TIDES OF THE OCEAN ON A GLOBAL SCALE [31]

Site	**Country**	**Tidal Elevation (m)**
Bay of Fundy	Canada	16.2
Severn Estuary	England	14.5
Port of Ganville	France	14.7
La Rance	France	13.5
Puerto Rio Gallegos	Argentina	13.3
Bay of Mezen (White Sea)	Russia	10
Penzhinskaya Guba (Sea of Okhotsk)	Russia	13.4

Table 1 shows the height of available tides in some of the regions where tidal power stations could be built. In some of these locations, tidal power plants have already been built, while others are still in the planning stages. Table 2 lists the main characteristics of four large-scale tidal power plants that were built after WWII and are still operational [32].

TABLE II. EXISTING LARGE TIDAL POWER PLANTS DISTRIBUTIONS [33].

Site	Country	Bay area (km2)	Avg. tide (m)	Installed power (MW)
La Rance	France	22	8.55	240
Annapolis	Canada	15	6.4	18
Jiangxia	China	1.4	5.08	3.9

3 System Methodology

The architecture of the IoT-based tidal energy transducer is designed such that the entire structure of the prototype occupies roughly an area of 9 square feet with a height of 5 feet. The turbine structure is based on three blades each of 1x2 feet in size. The turbine is supported by an iron rod which supports the entire prototype and the IoT underwater and above-water sensors. Three generators are fixed at the top of the turbine, which is supported by a frame welded to an iron rod. The turbine pulley has a circumference of 25 inches whereas the generator's‟ each pulley has 1 inch of circumference. So, one rotation of the turbine generates 25 rotations of a single turbine. But there are three turbines fixed so each rotates 25 times. It shows, if the speed is increased it will generate more power. Furthermore, a potentiometer is fixed to carry out the voltage and current of all three generators combined. As the tide hits the turbine, it moves in an anti-clockwise rotation. It doesn't matter if the tide is coming forth or going back, since the design of the turbine is vertical; it makes it always rotate in a single direction. The IoT structure is based on Arduino ATMega328p, the microcontroller, and is programmed concerning the sensors attached. All four sensors, which include turbidity sensor, water flow sensor, pH sensor, and the BME280 (temperature, humidity, and air pressure) sensor, are connected to Arduino via a wire, and the microprocessor is supplied 5 Volts from a battery fixed at the top. Sensors sense the data and send it to Arduino then Arduino in which the Wi-Fi Module ESP8266 is connected, regulates the data, and transfers data to the destination source, which could be a cellphone or laptop connected to the internet. The data on the destination source can be seen by using an application (can be downloaded via play-store).

The pH sensor, turbidity sensor, BME280 atmospheric sensor, and water flow sensor are all connected to Arduino, as shown in Fig. 3. Then, to transfer data between the microcontroller and the output source, a Wi-Fi module is connected to Arduino.

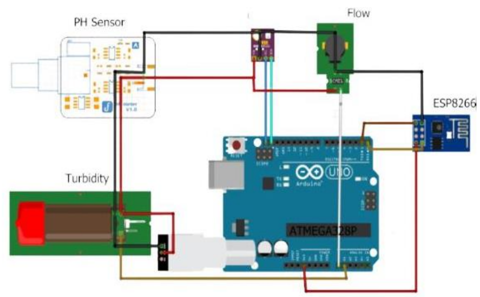

Fig. 3. Arduino connected to IoT sensors

3.1 Architecture of IoT based Tidal Energy Transducers

All four sensors are connected to Arduino, as shown in Fig. 4. Arduino supplies a voltage of 5 v, and it is linked to a cloud where data is stored. This also works as a source between the output device and the microcontroller. Data logger links the cellphone to the Arduino.

3.2 Tidal energy Calculations

The energy due to the tidal stream (kinetic energy) and the energy due to the release of the stored water in the basin make up the total tidal energy (potential energy). It is also true that an increase in tidal variations or tidal stream energy leads to a significant increase in energy extraction.

Following notation are used in this model:

ρ The density of seawater $\left(\frac{kg}{m^3}\right)$

cp power coefficient

A The cross-section area of the channel (m^2)
V current velocity $\left(\frac{m}{s}\right)$
∈ turbine efficiency
P power generated (W)
h vertical tidal range (m)
Þ The density of water 1025 $\left(\frac{kg}{m^3}\right)$
g gravity $\left(\frac{m}{s^2}\right)$

1. Kinetic energy: The kinetic energy of a stream flow passing through a cross-section at a given velocity is given in (1):

$$P = \frac{1}{2}\rho v^3 \quad (1)$$

2. The turbine's power output, also known as its efficiency "∈" depends on the design of the turbine [19, 34]. The power output for a turbine from these kinetic systems can be obtained by (2) as follows:

$$P = \frac{\in v^3}{2} \quad (2)$$

3. Potential energy: The potential energy is mainly dependent on the tidal prism of the basin. Potential energy obtained due to the stored water can be calculated as in (3):

$$E = \frac{\mathrm{Ag}h^2}{2} \quad (3)$$

From (3), it can be seen that the potential energy varies with the square of the tidal range. So, a barrage should be placed in such a location where it is possible to achieve maximum storage head.

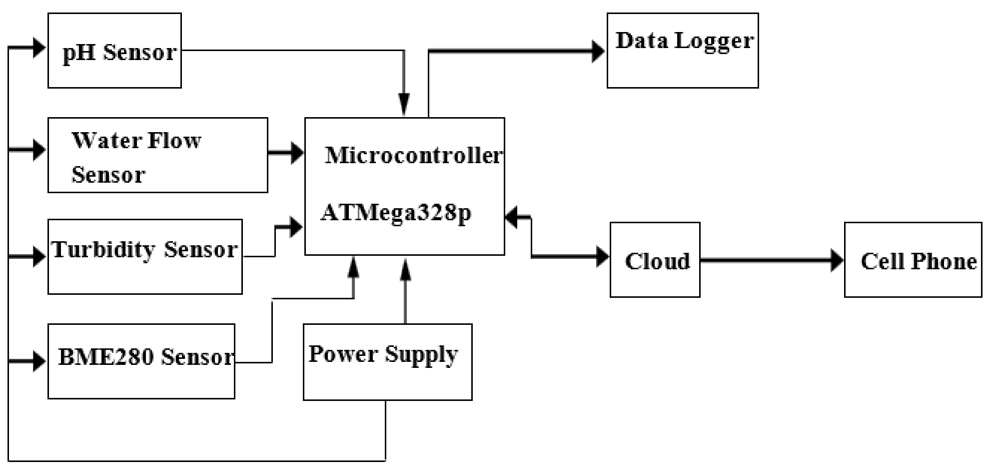

Fig. 4. Microcontroller connected to data logger, sensors and power supply

3.3 Tidal energy generation design

This prototype model enables us to generate electricity using both types of tides, the flood, and the ebb tide. The main advantage of this type of model is that the turbine works in one way does not matter from which side tide is coming. All tides force is utilized to generate another force that would move the turbine in a single direction. Three wings have been installed on an area of 2 square feet to get maximum power. The Tidal turbine design is shown in Fig. 5. The diameter of each Turbine Wing Arc is 3 feet. Two bearings are fixed at the two ends of the turbine to reduce the friction force, which provides smooth rotation with no certain friction [35]. The whole vertical design is supported by a pipe of 2 cm diameter, which works as an axis of turbine around which it rotates. It also strengthens the entire structure to remain stable during tides striking. This pipe provides a path for the underwater sensors wires so that they can easily be connected to the Arduino that is present in the upper box. The upper box holds the BME280 Atmospheric Sensors, ESP2866 Wi-Fi module, and an ATMega Arduino. Whereas, the lower box holds three different sensors: pH sensor, turbidity sensor, and Water flow sensor, which are connected via wires. Three sensors present in a lower box are connected via wires, which go through the axis pipe of the turbine. Then, these sensors are connected to the microcontroller. The upper box sensors have the same installation as they are connected via wires to the Arduino. The whole structure is based on an iron frame, and the turbine is designed from an iron sheet. Furthermore, it is covered with paint to prevent from getting iron rust as the turbine is in constant contact with water.

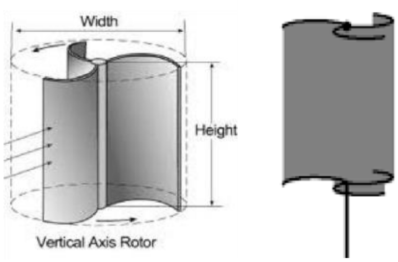

Fig. 5. Tidal turbine design.

The entire design is smooth and friendly for marine life as well. The arc of each turbine wing has a 1-foot length. The lower box is kept into a thin filter so that nothing except water enters the box and harms the sensors. The entire structure heights 4 feet. The lower three feet remain in the sea as the turbine keeps gaining tidal force and underwater sensors keep inspecting seawater. One foot stays out of the water so that the upper water sensors check the required parameters, and the microcontroller stays out of the reach of the water.

3.3.1 Above-water sensor

The BME280 is a combined digital pressure, temperature, and humidity sensor. It has small dimensions, low power consumption, high precision, and stability that allow the implementation in the forecast, environmental monitoring, altitude detection, and IoT application. In this prototype project, the BME280 sensor is connected directly to the microprocessor via wires. Both the microcontroller and the BME280 sensor are connected to the upper box. The python programming of the sensor is installed into the Arduino. It senses the surroundings and then sends data to Arduino, which is connected to a 5v battery. Then, the microcontroller sends the data via the ESP8266 Wi-Fi module. This ESP8266 Wi-Fi module is a self-contained SOC with an integrated TCP/IP protocol stack that can give microcontrollers access to Wi-Fi networks. Each ESP8266 module comes pre-programmed with an AT command set firmware. After processing the data is transmitted through a Wi-Fi module, and is shown at the output application. It can be seen on destination sources such as mobile or laptops. The connection of BME280 sensors is located at the top of the rod so that it can easily inspect the environment without any interruption. Along with that, the Arduino AT-Mega and Wi-Fi module are also connected via wires. Two DC generators are installed at the upper pulley. These generators are supported by a rubber stripe, which is firmly roped around the generator's pulley and the main pulley to make enough grips for rotation. As the turbine rotates, the generators keep rotating in the anti-clockwise direction. One complete rotation of the turbine makes generators rotate about 25 times. Thus, it engenders more rotations in generators making them produce higher power.

3.3.2 Underwater sensor

The underwater system includes a pH sensor, turbidity sensor MJKDZ Model, water flow sensor YF-5201 Model, and the turbine itself. These three sensors are installed in the lower box just below the turbine. Three of them are installed and attached in a way that they can gain maximum input and witness most of the seawater inspection. The seafloor is majorly unexplored, so this prototype presents a handful of opportunities to inspect the seafloor. The sensors are programmed with Python language. All sensors are attached at the bottom and connected via wire, which goes through the turbine's axis pipe. The pH scale is a logarithmic scale whose range is from 0-14 with a neutral point being 7. If values are above 7 it indicates a basic or alkaline solution, and if values are below 7, it would indicate an acidic solution. It works on a 5V power supply and is easy to interface with Arduino. The water flow sensor measures the rate of flow of water. This rate of flow of water is measured in cubic meters or liters per hour. This also consumes 5v. The turbidity sensor measures how clear the water is. It indicates the degree to which the water loses its lucidity. The 2 sq feet Turbine is vertically attached to the rod, and it rotates anti-clockwise. The bidirectional attitude of the wave doesn't affect the turbine's speed as it is vertically designed to accumulate the tide the force of any direction.

4 Results and Discussion

The result and discussion section consist of testing, results, and comparisons.

4.1 Testing

1. Implementation of IoT Based Tidal Energy Transducer was carried out at Sea View Karachi as shown in Fig. 6.
2. The whole prototype project was set in the water at a distance of 25 meters into the sea.
3. The entire iron- frame was first fitted into the ground, and then the sensors boxes were attached. All the arrangement of microcontroller and sensors was already installed.
4. First, the turbine was locked, and the stability of the project was checked to see if it was stable at sea. After attaching each required part, the turbine was allowed to rotate.
5. With each rotation, the turbine generated electricity. Other sensors were fitted in upper and lower boxes. The upper box carried BME280, a Wi-Fi module, and an Arduino ATMega. Along with that, the upper box also carried a 12Volts lead battery. This was supposed to provide a power source to the microcontroller and other sensors.
6. After allowing the project to execute its desired function, the results were carried out. The output of power and sensors data can be seen in Table 3.
7. The multimeter fixed at the upper box provided the reading regarding the generation of power whereas the cellphone worked as the destination source for showing outputs of sensors‟ values.
8. The BLYNK APP, which is an android application designed for ultimate outputs of projects on Arduino, showed the data of each sensor.
9. In every 5 seconds, the data was collected, thus each time data varied in very small fractions. pH and BME280 sensor did not show much variance in output. However, turbidity and water-flow sensors‟ results varied in some fractions, since each tide hit the sensors at different speeds and allowed water of different turbidity.
10. Finally, the implementation of the entire project was carried out successfully, and all desired results were noted down.

TABLE III. ENERGY GENERATION OF TURBINES

Experiment No	At home		At sea	
	Efficiency	Power	Efficiency	Power
1	10.83 %	1.3 W	33.3 %	4.0 W
2	21.66%	2.4 W	33.8 %	4.17 W

4.2 Results

After completing the project its inspection, as well as testing, was carried out. The values of various parameters were discovered using the designed tidal energy turbine and Internet of Things (IoT) based sensors, which were installed at the site. The entire prototype was carried into the sea for the test, and it was supported by a thick iron rod. The underwater sensors were installed into a box so that the seawater does not harm the sensors. Above water, sensors were right above the structure tightened by an iron- frame, and there the battery, as well as the microcontroller, was set. All the sensors were connected to the microcontroller by a thin wire and the Wi-Fi module transferred the data to the cellphone with the help of cloud computing. The entire structure of the prototype was fixed in the sea, and then the experiment was carried out. The test of energy generation of the project was done at the Seaview site of Karachi, and its inspection was also tested at home to check if all the equipment was working accurately.

Fig. 6. IoT based Tidal Energy Transducer at the Arabian Sea

TABLE IV. ENVIRONMENT SENSOR RESULTS OBTAINED FROM PROTOTYPE AND VALIDATED WITH WATER QUALITY MONITORING SYSTEM IN [36].

Exp. No	**Results obtained from the project referred in [36]**			**Results obtained from this project**		
	pH Sensor	**Turbidity Sensor**	**Temperature Sensor**	**pH Sensor**	**Turbidity Sensor**	**Temperature Sensor**
1	8.4	50%	28 °C	9.08	60%	27.82 °C
2	7.9	50%	28 °C	9.38	74%	27.65 °C
3	6.5	40%	27 °C	9.07	32%	28.02 °C

The experiment of IoT-based inspection of seawater parameters was carried out at sea, as the results are shown in Table 3. Three different readings were taken in different areas. The time of the three experiments was also different as there was a gap of 20 minutes between each experiment. Every time experiment was carried out in real-time and results were noted down at the same time as shown on the output source.

The voltage and current generated were calculated by a millimeter fixed at the upper box. Firstly, the turbine was tested at home with airspeed provided by a fan. The efficiency of the experiment at home was low, as shown in Table 3. Due to the low force of air, the turbine rotated at a lower speed, thus, producing lower power. Again, when the turbine was tested in the sea, the efficiency turned out to be normal. The tidal force created enormous speed in the turbine and thus it produces power of above 4 watts. The expected power was 6 watts as the generators installed have 6 watts power-producing capacity. It was quite hard to achieve the ideal condition where the turbine can move at an ideal speed. However, the outcome of the turbine in seawater was quite normal as per the expectations.

4.3 Results Comparison

A project based on the smart solution for water quality monitoring systems was designed. Using IoT, that project enabled real-time water quality monitoring, and the results are given and compared to this project in Table 4.

5 Conclusion

To seek alternatives of energy resources has always been the need and interest of humans. Since humans have always wandered in their surroundings to acquire cheap and reliable energy resources. Tidal energy is one such source that requires no big human efforts once the stage is set and starting installation is finished. This energy is present on earth in the form of ocean tides in an unimaginable amount. In Pakistan, this prototype project can be utilized to define energy production at a major level leveraging the energy sector of the country. Aside from that, this project will inspect the ocean water and its various parameters such as pH, turbidity, viscosity, and water flow after working on deep-sea surveillance by installing IoT sensors. The humidity of the air in the surrounding area is also measured. In the future, this project can be designed to improve and enhance more surveillance of the deep sea by calculating and inspecting different parameters using advanced sensors, to make the seawater more sustainable for the surroundings including rechargeable batteries and relay beacons. In short, the whole project is a prototype of the energy generation at a small level that can be transformed into a major tidal energy generation plant.

Author contribution

Suresh Kumar: Conceptualization, Methodology, Software Danish: Data curation, Writing- Original draft preparation. Alveena Aslam: Visualization, Investigation. Dr. Irfanullah Khan: Writing- Reviewing and Editing. Dr. Muhammad Imran Majid: Supervision. Software, Validation.

Conflict of interest

The Author(s) declare(s) that there is no conflict of interest.

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