VIZGEN

FINAL YEAR PROJECT UG 2019

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In the name of Allah Almighty, The Beneficient, The Merciful.

CERTIFICATE OF CORRECTNESS AND APPROVAL

It is certified that the work contained in this thesis entitled **"VizGen"** carried out by NC Maria Marrium, NC Rimsha Maryam, NC Ruhma Ali and NC Shahzad Latif under the supervision of Lt. Col. Dr. Hasnat Khurshid for partial fulfillment of degree of Bachelors of Electrical (Telecommunication) Engineering from Military College of Signals (MCS), National University of Sciences and Technology is correct and approved. The plagiarism index is _____ % and is attached at the end of thesis.

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Dated: _______________

ABSTRACT – VIZGEN

Paucity of water, depleting natural resources, health hazards in the primitive as well as the developed regions of the country are the main prompts which propel the idea of this project. VizGen aims at providing adequate water for domestic consumption. Using the apparently simple principle of compression and condensation, VizGen aims at creating reserves to fulfil domiciliary hydration necessities and with further improvements, even power small scale agricultural tasks. We have successfully developed a prototype, which fulfils all the envisaged goals and objectives. Employing equipment such as gas compressor, condenser, sensitive sensors to ensure the production of pure water, monitor temperature difference, measure humidity level of the environment, microcontroller to be interfaced with an Android application allowing consumers to take full control of the whole unit, filters to purify incoming surrounding air, we aim at constructing an efficient water generator.

DECLARATION

No portion of work presented in this dissertation has been submitted in support of another award or qualification either at this institute or elsewhere.

Dedicated to

Our Respected Teachers and Beloved Parents.

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ACKNOWLEGEMENT

We would like to express our gratitude towards our supervisor Lt Col Dr. Hasnat Khurshid for all the assistance, invaluable guidance, motivation, critique and generous support throughout the making of our final year project.

Our special acknowledgements go to all the faculty members and Staff ant NUST who helped us in one way or another in this process. We are truly indebted to NUST R&D Department for investing in our project without which, we would not have been able to achieve the milestones that we have.

We would also like to thank the analysts at GIST TECH-1 2019 for their comprehensive evaluation of our design which has played a huge part in optimization of our project. We extend our thanks to all the individuals who have helped us, in any capacity, towards the completion of our project and thesis.

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CHAPTER 1

INTRODUCTION

CHAPTER 1

1. INTODUCTION

1.1 Overview

Our final year submission is called VizGen, a Raspberry Pi Controlled Water Generator, devised in the light of the need of the hour- the deteriorating state of water reserves of the country. Pakistan is expected to run out of natural water reservoirs by the year 2025 [1]. This project envisages to extend the production to a commercial scale to benefit rural as well as the deprived urban masses. The seemingly straightforward scientific principle of condensation and gas compression is magnified to function this device which will produce enough water to drive an average household necessity threshold. Commercializing this concept is definitely our main future objective as this will be a vital solution to the exponentially increasing water shortage problems.

Many urban areas, not being an exception to the target of this problem, are as affected by the unavailability of fresh water as remote arid areas are. Our project focuses on a welfare entrepreneurial motive. This design is an exertion to improve said situation and provide the multitude with a cost efficient product which will be a profitable investment due to its production ratio and long lasting durability. The nature of this project is not exclusive to one prototype only. Advancements and modifications can be made in further models keeping in view the latest technologies and catering for the room for improvements in factors such as design, efficiency, power consumption etc.

1.2 Problem Statement

The inspiration of this project arises from the recent threats revealed regarding the gradually diminishing water reserves. It is no secret how factors like the eastern neighbors obstructing our water flow by forming dams and general global warming are affecting the water reservoirs in our country. According to recent IMF report, Pakistan currently stands at number three among countries facing water shortage [2]. Pakistan has the world's fourth highest rate of water use but is dependent on water from a single source – the Indus River basin in India. Pakistan is an agricultural country, which increases the water consumption accordingly, not to mention the rapidly increasing population and the proportionally elevated requirements. Another nested peril is the water contamination level in many areas of Pakistan. This issue has been reported to be as dangerous as fatal due to the bacteria infested in water that is used for human and animal consumption. Water, which is a basic necessity is being sold at very high rates in some parts of the country. Pakistan is in dire need of water conservation, purification and production. It is expected that our region will run dry of all water compounds by the next seven years. Different regions of Pakistan are facing droughts. Not only do we not have water for agriculture, industries, domestic and other miscellaneous uses, the basic purpose of drinking it is not being fulfilled as well.

1.3 Impact

- Ease in manufacturing
- Cost effective investment to suit the masses
- A solution to the national level water crisis
- Ease in deployment in very remote arid areas
- Main raw material being the environmental air, makes this idea resource-friendly
- Utilising electrical engineering skills to innovate design
- Encourage NGOs and other welfare government organisations to invest in this start-up for large scale deployment

1.4 Objectives

1.4.1 Design Objectives

- To devise efficient water generator and purifier
- To improve production to cost ratio
- To provide a robust device
- To ensure quality of the produced water and rendering it safe for consumption

1.4.2 Commercial Objectives

- To provide a solution to the rising water shortage threats
- To set up an entrepreneurial start up
- To reach out to NGO's and government bodies for mass deployment

1.4.3 Academic Objectives

- To design and develop hardware interface
- Diligently working in the field of control system design and analysis
- To go through the process of professional project development
- To polish monetary policy for profitable growth

1.5 Scope

- To develop a working prototype which will be well suited for supplying adequate water in arid areas
- Amount of water generated will be dependent on humidity in air and power rating of the device

1.6 Deliverables

The deliverable is a robust, fully functional appliance which will produce adequate drinkable water in arid urban and rural areas. It is equipped with multiple sensors and a Raspberry Pi microcontroller. The microcontroller is integrated with an Android Application, making it easy for the user to monitor the device and yield.

1.7 Salient Features

- **Operating Power:** 230 Watts
- **Water Production:**12 litre per day
- **Daily Power Consumption:** 5.52 kWh
- **Per liter Water Production Cost:** 3.68 PKR per liter
- **Dimensions (LxWxH):** (2x1.3x3.7)ft

1.8 Organization of Document

- Whole document consists of seven chapters:

Chapter 1	Includes Introduction and basics of the Project.
Chapter 2	Explains the motivation and background findings for the project.
Chapter 3	Summarizes the literature we have consulted regarding the project and the previous research/development on the topic.

Chapter 4	Emphasizes on the project requirement specifications and the detailed plan.
Chapter 5	Discusses the series of test conducted and their results.
Chapter 6	Includes future work/enhancement that can be introduced in the project and concludes overall work and progress of the project.

- In the Appendices we have added Equipment used, Project cost breakdown, Project timeline and sensor integration code.
- Then references and user manual were added respectively at the end.

CHAPTER 2

BACKGROUND STUDY

CHAPTER 2

2. BACKGROUND STUDY

2.1 Development Approach

Our research and development methodology is divided into multiple tiers and stages. Our product is a keenly thought-out design which is aiming to benefit the masses. The primary stage is planning and designing the prototype of our model keeping in view the scientific principles and miscellaneous complications. After having achieved an efficient proposal of the model, we move forward to the development stage where all relative components are fit together as per plan. With the assembly of our desired product executed, we move on to conducting numerous tests which challenge the throughput, robustness of the machine and its defense against negatively affecting environmental conditions and other such complications which can be met along the path. On receiving desired results and numbers, we will move on to the mass production and will pitch this idea to organizations as a startup to be deployed in a larger magnitude, thereby decreasing cost and increasing outreach.

2.2 Factual Analysis

As stated earlier in this document, our motivation for this project arises from the undeniable threat of water scarcity to Pakistan. We have carried out extensive research, garnering facts and data depicting the severity of this problem, a couple of which will be discussed in this subsection.

2.2.1 Drought Intensity

As evident from figure 2-1, many regions of the country, without the exception of relative urbanization, are under several levels of drought. This problem is found to be further aggravated when only consumable water bodies are considered. In many rural households, proximity of fresh water sources is far. Unprivileged people have to travel long miles on foot just to gather a few liters of water for their families. Even in developed parts of Pakistan, fresh water has to be bought for very high prices.

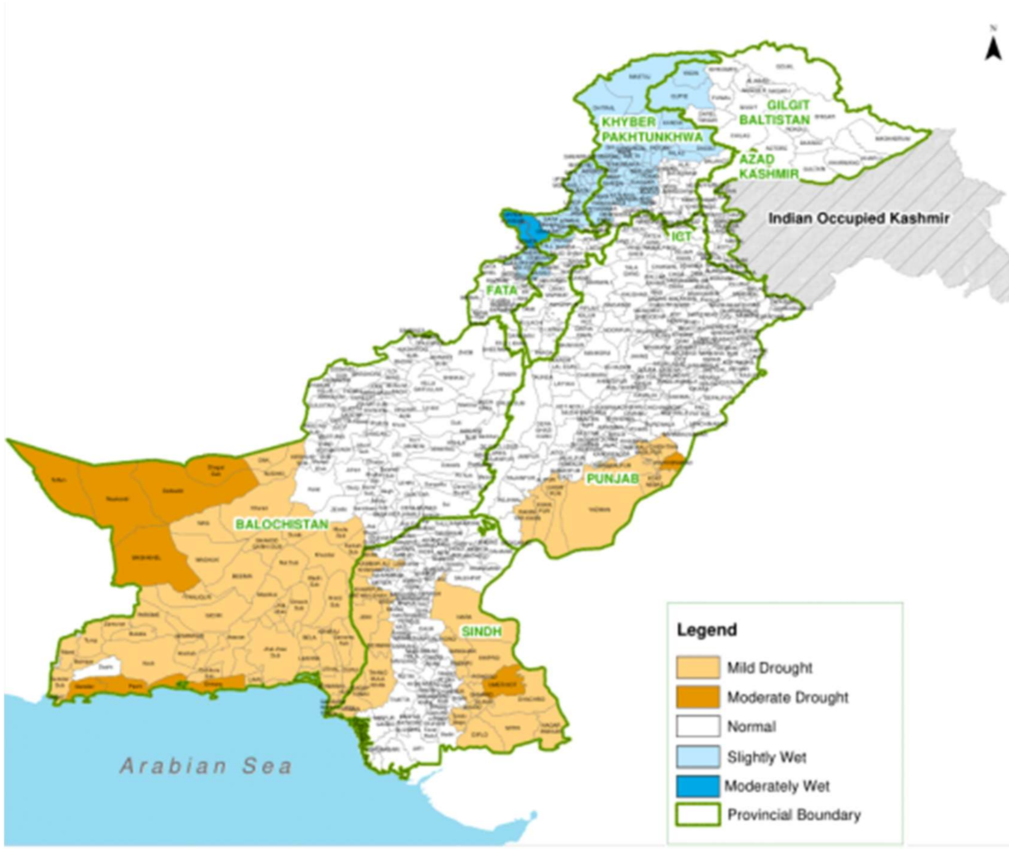


Figure 2-1: Drought Intensity Map of Pakistan [3]

2.2.2 Contamination Consequences

According to the pie-chart shown in figure 2-2, enlisted are the diseases which people drinking contaminated water are subject to. People from many backward areas of Pakistan only have access to water which is extremely unsuitable for consumption. These disorders can be as threatening as being a reason for death. As stated in a report from last year, approximately 30% of all diseases originate from impure water use and an alarming 40% of all deaths in the country are a result of this plight as well. These numbers are not negligible and solutions, such as VizGen, need to be proposed at an immediate priority.

2.3 R22 Gas Compressor

The most commonly used apparatus for refrigeration and air conditioning are the R22 Gas Compressors. R22 is short for halocarbon compound $CHClF_2$ (Mono Chloro di Fluoro Methane) which is the refrigerant element. Although this system is being phased

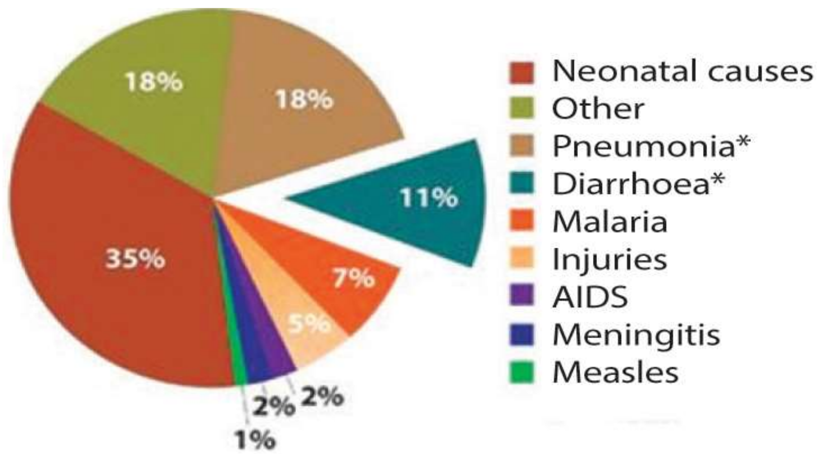


Figure 2-2: Diseases Caused by Drinking Contaminated Water [4]

out gradually with the advancement of manufacturing, it still suits our project the best due to its low boiling point and resultant low temperature applications. Moreover, R22 is non-toxic and non-flammable that makes it highly safe for our project's objectives and purposes.

Figure 2-3: R22 Gas Compressor [5]

CHAPTER 3

LITERATURE REVIEW

CHAPTER 3

3. LITERATURE REVIEW

According to our research following are some water generation methods in practice:

3.1 Using Thermoelectric Coolers

Peltier effect is being used in thermoelectric cooling to create a heat flux between the junctions of two different types of materials. A solid state active heat pump, known as Peltier cooler, heater, or thermoelectric heat pump, is which transfers heat from one side of the device to the other. It consumed of electrical energy, depending on the direction of the current. Dehumidifiers effectively use this module cut through the overall cost of dehumidifiers but they are not efficient enough to be used to commercially generate water from air.

A paper presented in International Conference on Recent Advancement in Air Conditioning and Refrigeration, RAAR 2016, 10-12 November 2016, Bhubaneswar, India titled as "Experimental investigations on a portable fresh water generator using a thermoelectric cooler" only 10 liters of water per day was produced using twenty Peltier modules.[6]

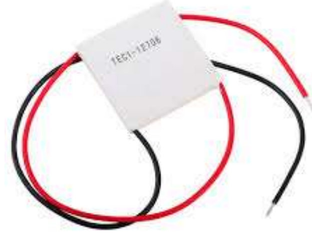


Figure 3-1: Peltier Module [7]

3.2 Using R22 Gas Compressor

After extensive research, we found that there are a number of such companies, originating especially from USA, already exist which are producing water generation from air units both for domestic and industrial purposes. But we could not find anything Pakistan-owned. Specifications of some of them are as follows:

3.2.1 Water from Air, USA [8]

3.2.1.1 Domestic Unit, AW3:

- **Water production:** 32 liters per days
- **Operating Power:** 450W
- **Purification:** 9 point filtrated, 3x UV sterilized
- **Working humidity:** 35-90%

Figure 3-2: Domestic Unit, AW3 [8]

3.2.1.2 Industrial Unit, WFA100:

- **Water Production:** 1000 liters per day
- **Purification:** Advanced filtration and UV sterilization
- Large stainless steel metal casing
- Mobile and can be transported easily

Figure 3-3: Industrial Unit, WFA100 [8]

3.2.2 WaterGen, USA [9]

3.2.2.1 Industrial Unit, GEN 350:

- **Water generation capacity:** Up to 600L/day
- **Integrated water tank:** 200L
- **Air filtration:** multi-barrier air filtration cascade
- **Water purification:** based on sediment filtration, mineralization and activated carbon as well microbiological treatment by UV lamp
- **Power:** 3-phase, 208/400 VAC, 60/50 Hz
- **Power consumption:** ~5.6kW/H
- **Dimensions (HxWxL):** 1.58 x 1.40 x 1.40 m
- **Weight:** 825kg (empty)

Figure 3-4: Industrial Unit, Gen 350 [9]

3.3 With Solar Power Option

Solar panels may be used to make the unit cost friendly and more efficient. We found one project that is using solar power to run their equipment:

3.3.1 NRZ Atmospheric Water Generator:

- **Water production:** 45 liters per day
- **Power supply:** 220 Volts / 50Hz or 110 volts
- **Purification:** 7 stage filtration

3.4 Implementation Algorithm

3.4.1 Mathematical Equations

Mathematical expressions (Equation 1 – 4) [10] were used to calculate saturated vapor pressure and dew point. So that all the experiments should be carried out in monitored environment.

$$\emptyset = U_w \div 100\% \quad [\,] \text{ --Equation 1}$$

$$p_s = C_1 \times \exp\frac{t \times C_2}{t + C_3} \quad [\text{mbar}] \text{ --Equation 2}$$

$$p_d = p_s \times \emptyset \quad [\text{mbar}] \text{ --Equation 3}$$

$$tp = \frac{-1 \; \frac{p_d}{C_1} \times C_3}{\ln\frac{p_d}{C_1} - C_2} \quad [°C] \text{ --Equation 4}$$

Where,

$\emptyset$ = Relative Humidity

U_w = Relative Humidity in %

p_s = Saturated water vapour pressure

t = Temperature in °C

$C_{1,2,3}$ = Magnus coefficient

p_d = Partial water vapour pressure

tp = Dew point temperature

CHAPTER 4

DESIGN AND DEVELOPMENT

CHAPTER 4

4. DESIGN AND DEVELOPMENT

4.1 Technical Specifications

After having tested numerous different technologies like Peltier modules, metallic linings and other similar techniques, we have come to a simple, easy to install design which can sustain harsh climate changes and transportation to far flung, remote areas.

4.1.1 Hardware Requirements

To allow for these objectives to be achieved, we have employed simpler apparatus including:

- R22 Gas Compressor
- Condenser
- Exhaust fan
- Copper coil mesh
- Sensors
    - Temperature sensor
    - Humidity Sensor
    - Water level sensor
    - Water quality sensor
- Filters
- Raspberry-Pi Module
- Relays

To operate the system efficiently, it is necessary that there be a proper understanding and matching between various components.

4.1.1.1 Gas Compressor

Since our design governs on the basic principles of compression and condensation, gas compressor is the most important part of the whole unit. A gas compressor is generally referred to as a mechanical device that increases the temperature and pressure of a gas by reducing its volume. There are various types of gas compressor depending on the displacement, working mechanism and construction.

- Reciprocating
- Rotary
- Screw
- Centrifugal
- Scroll

We are preliminary focusing here on the type that is being used in the proposed prototype.

4.1.1.1.1 Reciprocating Compressor

Reciprocating compressors, being the most widely used types of the gas compressors, have piston and cylinder arrangement just like the automotive engine. The refrigerant inside the cylinder is being compressed by reciprocating motion of the piston due to external power. Figure 4-1 shows the internal schematic of reciprocating compressor.

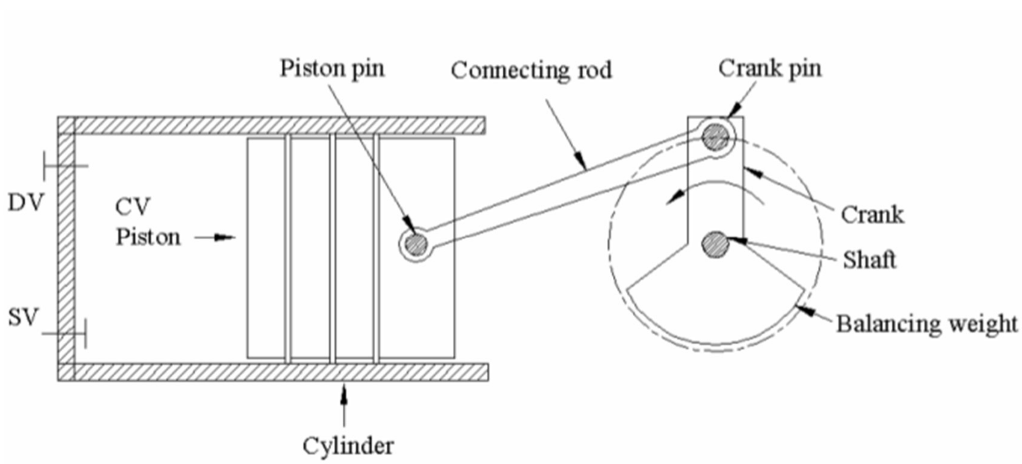


Figure 4-1: Internal Schematic of Reciprocating Compressor [11]

Figure 4-2 shows the external arrangement of the compressor. Pressure differences between the cylinder and inlet or outlet manifolds opens and closes the suction (inlet) and the discharge (outlet) valves respectively.

4.1.1.1.1.1 Performance Analysis

The most important performance analysis parameters are for a reciprocating compressor are:

a) m: mass flow rate (for a given displacement rate)
b) Power consumption
c) T_d: Temperature of the refrigerant (at compressor exit)
d) Performance under part load conditions

Figure 4-2: External Arrangement of Compressor [11]

The refrigeration capacity of the system is decided by the mass flow rate and depends on the volumetric efficiency of the compressor for a given compressor inlet condition.

There are further three types of reciprocating compressors:

- Hermetically sealed
- Semi-hermetically sealed
- Open type.

4.1.1.2 R22 Refrigerant

R22 refers to the halocarbon compound $CHClF_2$, which is used as the refrigerant for air conditioning and refrigeration. In its name, 'R' stands for 'refrigerant' and second 2 refers to the presence of 2 atoms of fluorine in $CHClF_2$. Before the use of this gas, it was ensured that it is:

- Non-toxic
- Non-flammable

Which makes it perfectly safe for domestic purposes. The other major advantages of R22 gas which also make it best suitable option are:

- Less effect on ozone layer
- Low compressor displacement

4.1.1.3 Condenser

The hot air that is being discharged from the compressor goes in to the condenser. Here it is converted to a liquid prepared for use in evaporator. This is accomplished by the removal of sufficient heat from the hot air, to make sure that it condenses at the pressure provided in the condenser. This is transformed to another form to cool the condense. Condensers can be classified to following types based on its design and working mechanism:

- Water-cooled
- Air-cooled
- Evaporative

We are using air-cooled condenser because they are easy to install and have low initial cost. Its circulation can be by natural convection and forced convection. Natural convection can only be used for a small-scale integration. Therefore, we are using forced convection in which an exhaust fan pulls the atmospheric air through the finned coils which are generally made up of aluminum or copper. Therefor it is also called coil condenser.

Figure 4-3: Gas Compressor and Condenser Assembly

4.1.1.4 Raspberry Pi Module

Raspberry-Pi module (version Pi 3B) is being for the integration of sensors with the device. Specifications [12] are:

- **Processor:** Broadcom BCM2837
- **CPU Core:** Quadcore ARM Cortex-A53, 64Bit
- **RAM:** 1 GB

- **Wireless Connectivity:** 802.11n wireless LAN (WiFi) and Bluetooth 4.1
- **Power Supply:** 2.5 A

Figure 4-4: Raspberry Pi Module [12]

4.1.1.5 Sensors

Since, water is being extracted from the moisture present in air, continuous tracking and monitoring of the moisture content is necessary. So that the production rate can be controlled accordingly. For this purpose, temperature and humidity sensor is being used. Water level sensor is also introduced in the storage tank so that user can switch on and off the device from the application based on amount of water present in the water storage tank. Our main aim is to provide the contamination-free water which meets the standard of drinking water. To examine this, water quality sensor, known as Mi TDS pen, is being used.

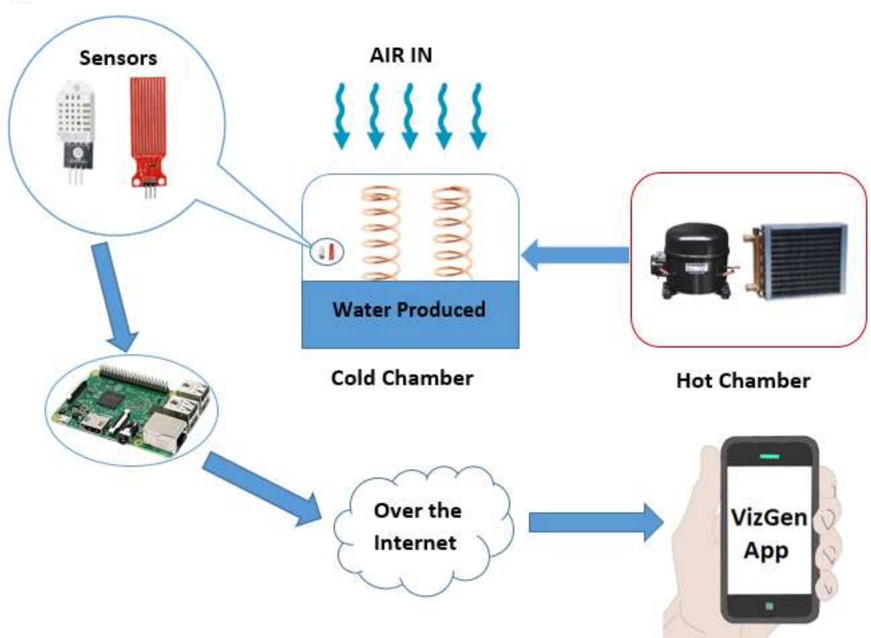


Figure 4-5: Sensors Placement in Project

4.1.1.5.1 Humidity and Temperature Sensor

DHT22 is a low-cost digital humidity and temperature sensor. It consists of two parts:

- Capacitive humidity sensor
- Thermistor

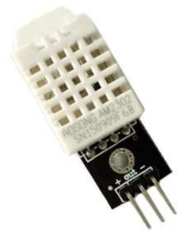


Figure 4-6: DHT22 Sensor [13]

Capacitive humidity sensor has two electrodes with moisture holding substrate between them. The conductivity of the substrate changes with the change in the humidity of the air. Or we can also say that the resistance between the electrodes change which is measured and processed by the IC and is set ready to be displayed by a microcontroller.

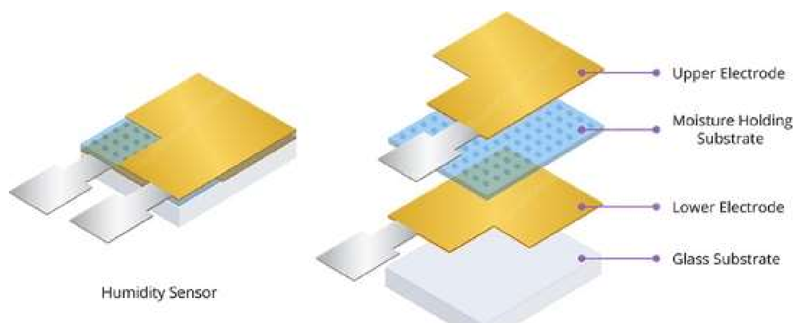


Figure 4-7: Internal Structure of Humidity Sensor [13]

A thermistor, on the other hand, is a variable resistor the resistance of which changes with the temperature. They are made with semiconductor materials such as ceramics or polymers so that small change in temperature results in large change in resistance. Following are some specifications of DHT22 Sensor being used [13]:

- **Temperature measuring range:** -40 to +125° Celsius (±0.5° accuracy)
- **Humidity measuring range:** 0-100% (with 2-5% accuracy)
- **Operating voltage:** 3-5 volts
- **Dimensions:** 15.1×25×7.7mm
- 4 pins with 0.1" spacing

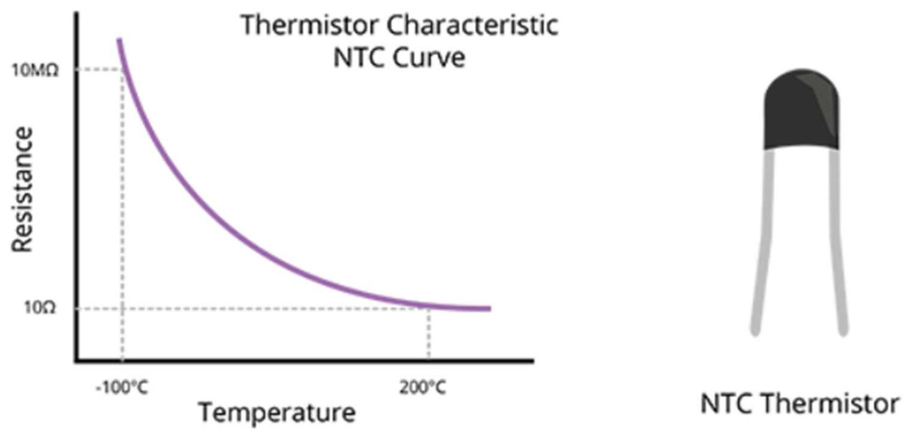


Figure 4-8: NTC Thermistor and its Characteristic Curve [13]

4.1.1.5.2 Water Level Sensor

Level sensor are used to detect the level of substances that can flow, in a storage container. Normally, an alarm is generated when the liquid level falls below some certain threshold. We will send this information to the application interface of the user, so that the related actions might be taken to always keep the water in the tank to a certain level. Figure 4-10 illustrates the working of the water level sensor.

Figure 4-9: Water Level Sensor [14]

4.1.1.5.3 Water Quality Sensor

Mi TDS pen is used for the systematic monitoring of total dissolved solids in the water. TDS is the measure of how many milligrams of dissolved solid in one liter of water. Its unit is mg/liter or ppm. Table 4-1 shows TDS Reference Table

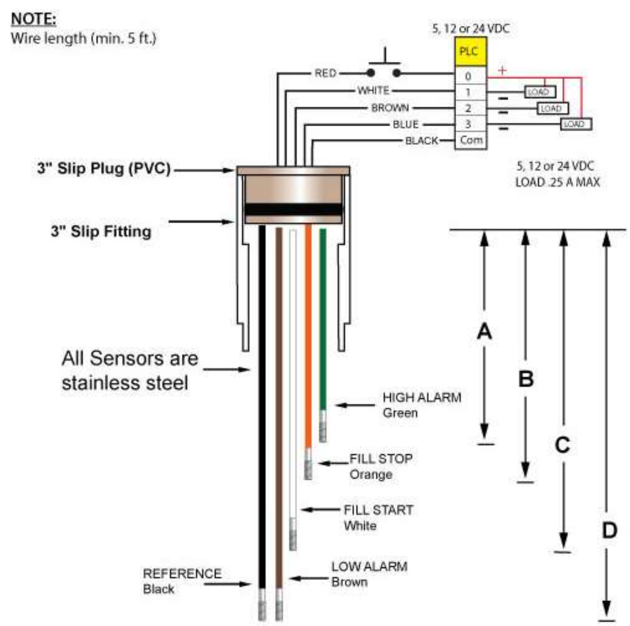


Figure 4-10: Working of Water Level Sensor [14]

TDS Level (mg/l)	Rating
Less than 300	Excellent
300-600	Good
600-900	Fair
900-1200	Poor
Above 1200	Unacceptable

Table 4-1: TDS Reference Table [15]

Figure 4-11: Mi TDS Pen [16]

4.1.2 Software Requirements

Following are software requirements:

- Raspbian Lite, Raspberry Pi OS
- Android Studio
- AutoCAD for project modelling
- Proteus
- PCB Wizard/Livewire

4.2 Design Summary

The air will be brought to pass through multi-barrier air filtration cascade before any further process to eliminate threatening contamination. The gas compressor will create a temperature contrast and a condenser will be used to act as a catalyst and speed up condensation process to produce water. The water generated is then filtered again to raise its quality, making it suitable for domestic and small scale agricultural use. This extracted water will be completely distilled and can be rendered suitable for drinking by the external addition of mineral and salt tablets in controlled amounts. A built-in water reservoir and treatment facility, circulating the generated water, will help to maintain the freshness of the water over time. Sensors will be deployed in the unit which will constantly ensure production efficiency by monitoring its purity, measuring environmental humidity and keeping tab of the temperature differential. Block diagram (figure 4-12) of the project further illustrates this mechanism.

4.3 Development Phase

Over time, we have changed the project design by conducting several experiments to reach our desired objectives. These series of trials have enabled us to work out the refined version of the unit.

4.3.1 Design Evaluation

Initially, unit was consisted of a glass chamber which will be divided into two parts indicating two different temperature domains. The temperature difference will be maintained at 20 degrees Celsius. The dimensions and other specifications of this design were:

- Dimensions (2x2x5.5)fts
- 250ml water per hour
- 230W per hour power consumption

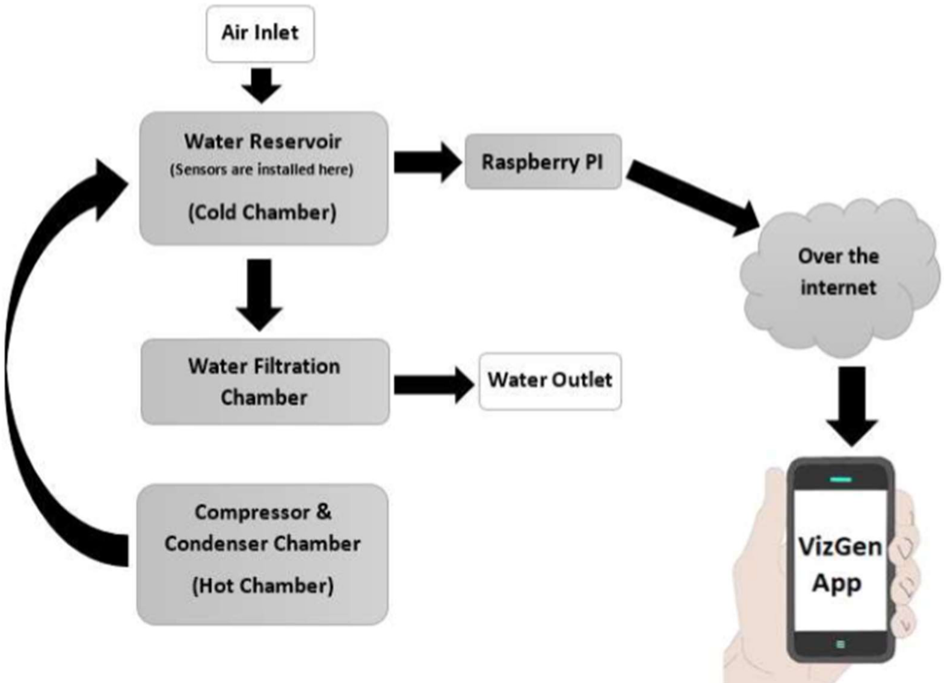


Figure 4-12: Block Diagram

Figure 4-13: Initial Project Design

This design proved to be a canvas for our experimentation but due to large dimension and less production rate, it wasn't meeting our requirements. Therefore, a new design a proposed with reduced dimensions to shape it into a more compact system with better aesthetics. Making technical modifications, we have also been able to increase our water generation output.

Figure 4-14: Final Project Design

4.3.2 DHT22 Sensor Integration with Raspberry Pi

It has four pins, VCC, GND, data pin and not connected pin. Data line is kept high, by using a 5K to 10K Ohms resistor, in order to enable communication between the sensor and Raspberry-Pi. Figure 4-15 shows DHT22 Integration with Raspberry Pi.

4.3.3 Introduction of Relay System

Another novel addition that we have amalgamated in the unit is the introduction of relay system. Our aim is to make this device as energy efficient as possible. By using relays, we are allowing the beneficiary to take full control of the operation of VizGen. Employing variable time durations, operator can specify periods of running according to quantity requirement and/or energy consumption thresholds. Figure 4-16 shows relay integration with raspberry pi.

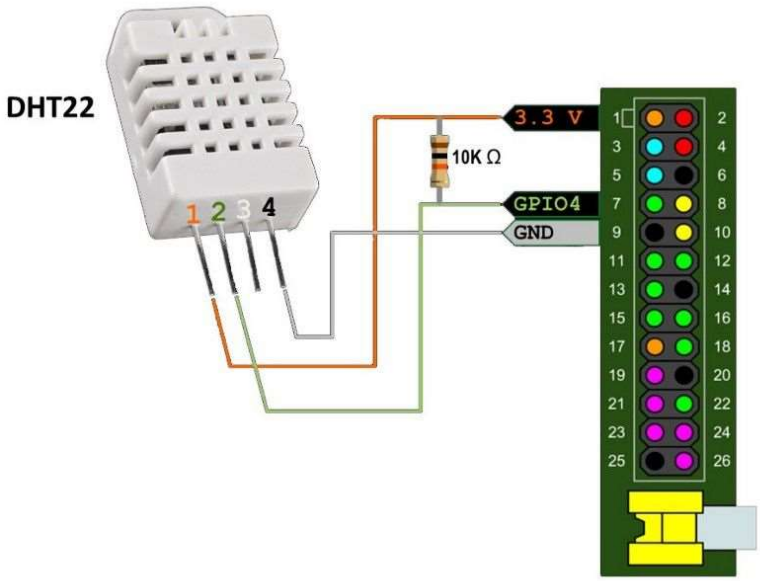


Figure 4-15: DHT22 Sensor Integration with Raspberry Pi [17]

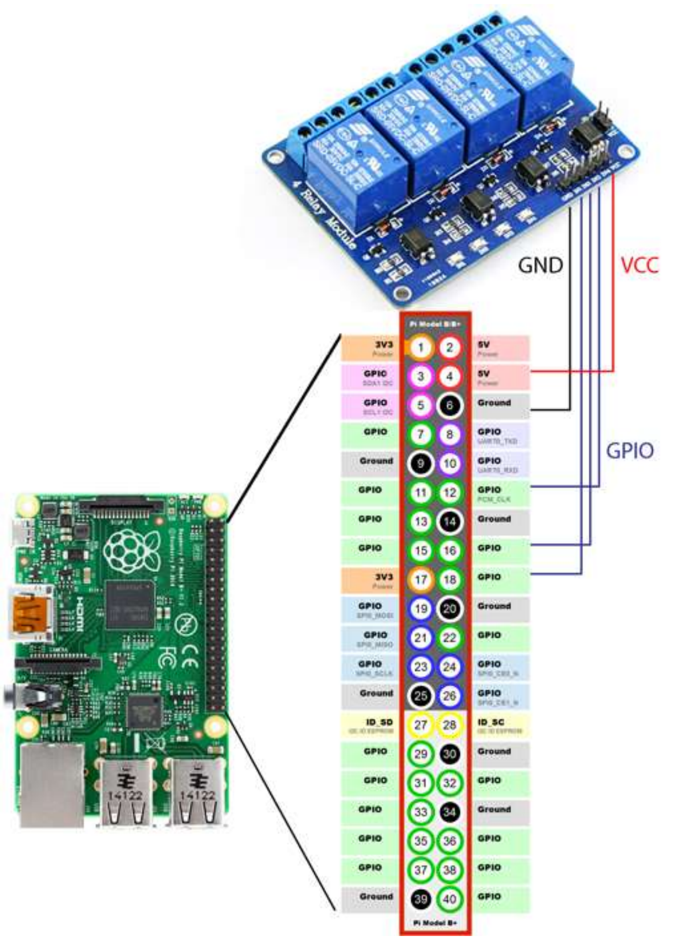


Figure 4-16: Relay Integration with Raspberry Pi [18]

4.3.4 Database Creation

We used MySQL to store the humidity and temperature data obtained from DHT22 sensor and calculated dew point data. A temperature, humidity and dew point logger was created and is shown in figure 4-17.

MySQL server is being hosted on the raspberry pi. Screenshot of database accessed from raspberry pi in windows 10 using MySQL workbench is attached as figure 4-18.

```
Database changed
MariaDB [vizgen]> select * from vizgen;
+---------------------+------------+----------+-----------+
| ts                  | temprature | humidity | dew_point |
+---------------------+------------+----------+-----------+
| 2019-03-10 08:16:01 |       25.2 |     38.1 |  -2.88889 |
| 2019-03-10 08:21:15 |       25.2 |     37.6 |  -2.90556 |
| 2019-03-10 08:21:17 |       25.1 |     39.1 |  -2.85742 |
| 2019-03-10 08:21:18 |       25.1 |     39.1 |  -2.85742 |
| 2019-03-10 08:21:20 |       25.1 |     39.2 |   -2.8544 |
| 2019-03-10 08:21:21 |       25.1 |     39.3 |  -2.85141 |
| 2019-03-10 08:21:23 |       25.1 |     39.3 |  -2.85141 |
| 2019-03-10 08:27:31 |       25.1 |     39.4 |  -2.84843 |
| 2019-03-10 08:28:42 |       25.1 |     37.7 |  -2.90217 |
| 2019-03-10 08:33:43 |       25.1 |     37.5 |  -2.90897 |
| 2019-03-10 08:35:59 |       25.1 |     38.2 |  -2.88563 |
| 2019-03-18 06:49:38 |       19.4 |       67 |   -2.4291 |
| 2019-03-18 06:50:10 |       19.3 |     66.9 |  -2.42991 |
| 2019-03-26 08:21:22 |       22.9 |     52.1 |  -2.58894 |
| 2019-03-26 08:32:40 |       22.5 |     52.9 |  -2.57772 |
| 2019-04-07 09:24:20 |       26.8 |     39.5 |  -2.84548 |
| 2019-04-07 09:29:46 |       27.6 |     36.2 |  -2.95602 |
| 2019-04-07 09:35:12 |       27.6 |       36 |  -2.96372 |
| 2019-04-07 09:40:37 |       27.6 |     36.1 |  -2.95985 |
| 2019-04-07 09:46:03 |       27.5 |     36.1 |  -2.95985 |
| 2019-04-07 09:51:29 |       27.5 |     36.7 |  -2.93732 |
+---------------------+------------+----------+-----------+
21 rows in set (0.00 sec)

MariaDB [vizgen]>
```

Figure 4-17: Database

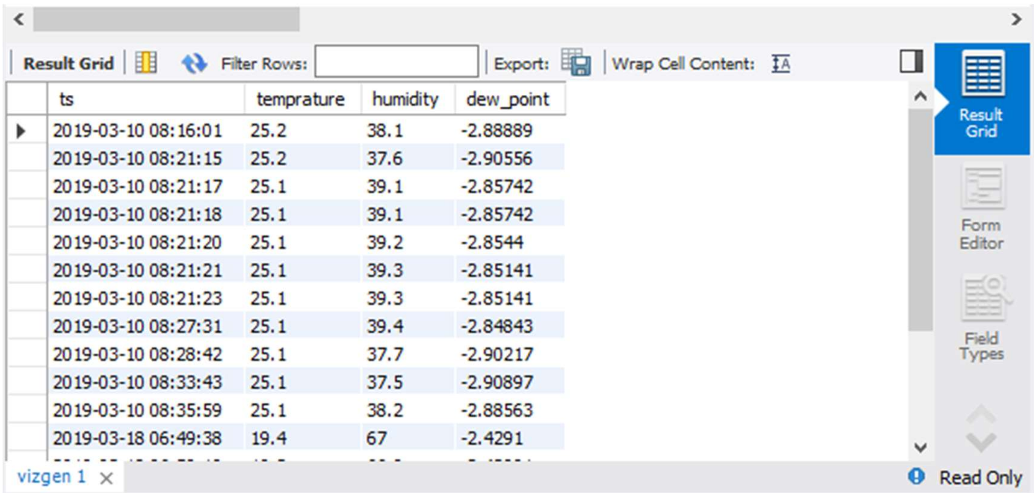
4.3.5 Android Application Development

We have developed an android application using which the user can monitor the real time temperature, humidity and dew point of the environment at this stage. And provide user with a TDS Reference Chart.

4.3.5.1 Application Functionality

VizGen android app is designed to provide the full control of the system to the beneficiary by monitoring the environmental conditions. The beneficiary just simply need to run the app and can check the Humidity, Temperature and Dew Point of the surroundings of the system where it is placed.

When the beneficiary run VizGen app, it will make a connection to the database server and retrieve the required data from it and display it to the user.



ts	temprature	humidity	dew_point
2019-03-10 08:16:01	25.2	38.1	-2.88889
2019-03-10 08:21:15	25.2	37.6	-2.90556
2019-03-10 08:21:17	25.1	39.1	-2.85742
2019-03-10 08:21:18	25.1	39.1	-2.85742
2019-03-10 08:21:20	25.1	39.2	-2.8544
2019-03-10 08:21:21	25.1	39.3	-2.85141
2019-03-10 08:21:23	25.1	39.3	-2.85141
2019-03-10 08:27:31	25.1	39.4	-2.84843
2019-03-10 08:28:42	25.1	37.7	-2.90217
2019-03-10 08:33:43	25.1	37.5	-2.90897
2019-03-10 08:35:59	25.1	38.2	-2.88563
2019-03-18 06:49:38	19.4	67	-2.4291

Figure 4-18: Database Server

VizGen Application consists of three tabs namely; Monitor, About and Contact. The **'Monitor'** has all the functionality of monitoring VizGen system. Connection to the database is established in this tab. This tab consists of four Clickable TextViews (A Clickable TextView is a TextView but it also have the functionality of Button and it is done by setting clickable attribute in the android xml true). These TextViews shows Temperature, Humidity, Dew Point and TDS Chart when clicked. **'About'** tab shows the user information about the product and the team. **'Contact'** tab tells the user how he/she can reach out the team in case of any query/problem.

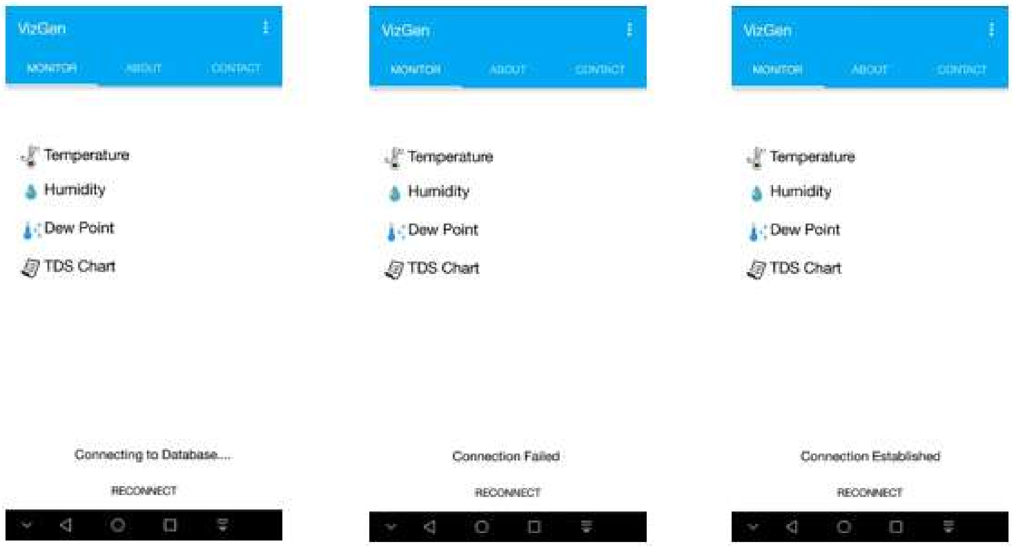


Figure 4-19: Application Layout - I (Monitor Tab)

Figure 4-20: Application Layout - II (About Tab)

Figure 4-21: Application Layout - III (Contact Tab)

By clicking on Temperature the user can monitor the temperature of environment.

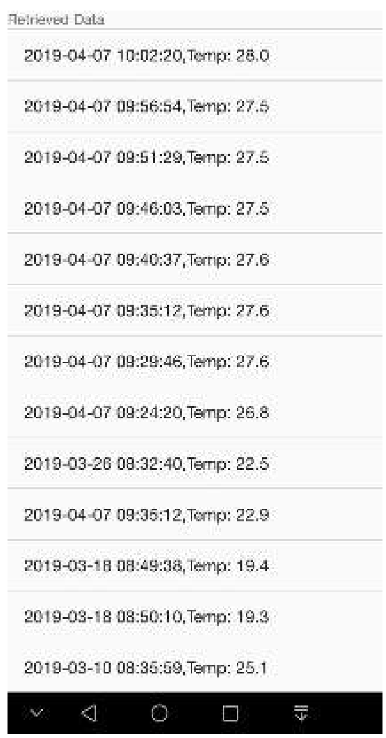


Figure 4-22: Retrieved Temperature Data

By clicking on Humidity the user can monitor the humidity of environment.

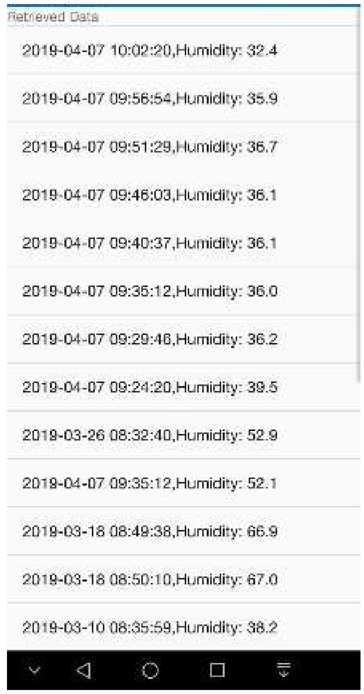


Figure 4-23: Retrieved Humidity Data

By clicking on Dew Point the user can monitor the dew point of environment.

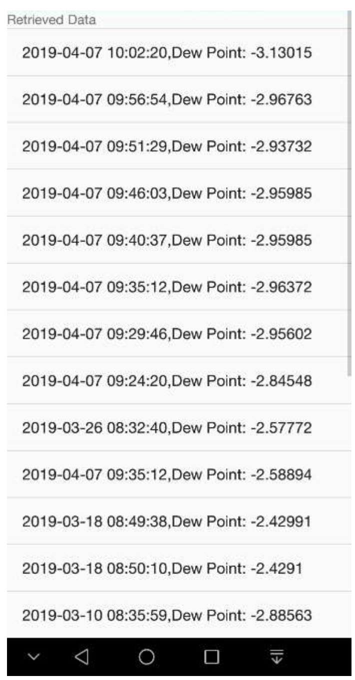


Figure 4-24: Retrieved Dew Point Data

By clicking on TDS Chart the user can check out TDS reference chart.

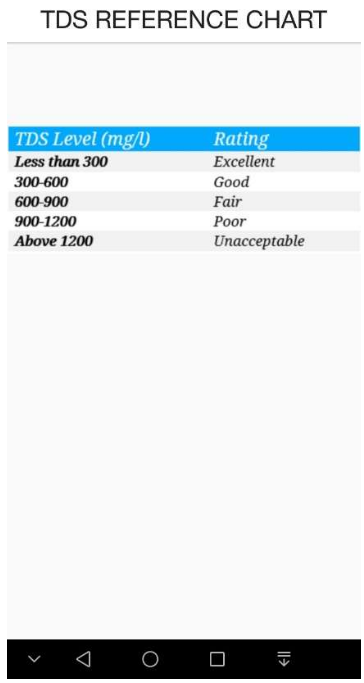


Figure 4-25: Retrieved TDS Reference Chart

4.3.5.2 Application Design

VizGen Android Application is designed on an Open Source platform, Android Studio. This app has Tabbed Activity. The Package name of VizGen Android App is**: "com.maria.vizgen"**

VizGen is supporting minimum API level of 17. As mentioned earlier this app has three Tabs. These Tabs are designed using Fragments.

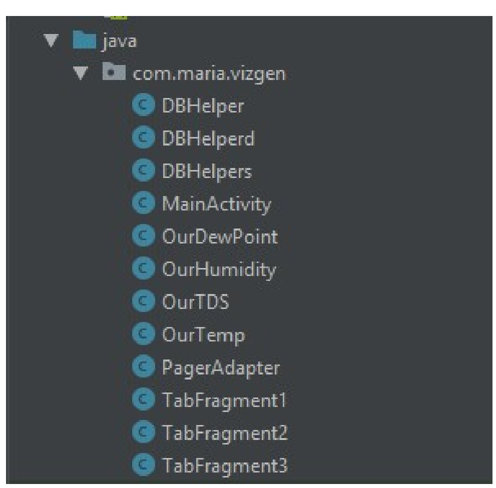


Figure 4-26: Java Classes Used

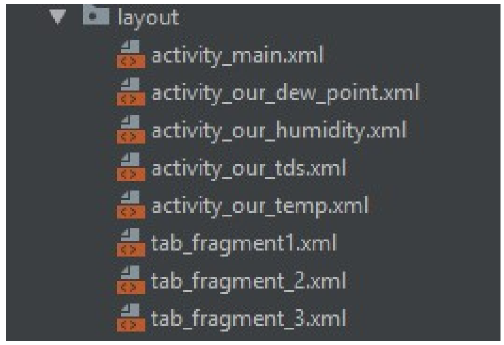


Figure 4-27: Application Layout

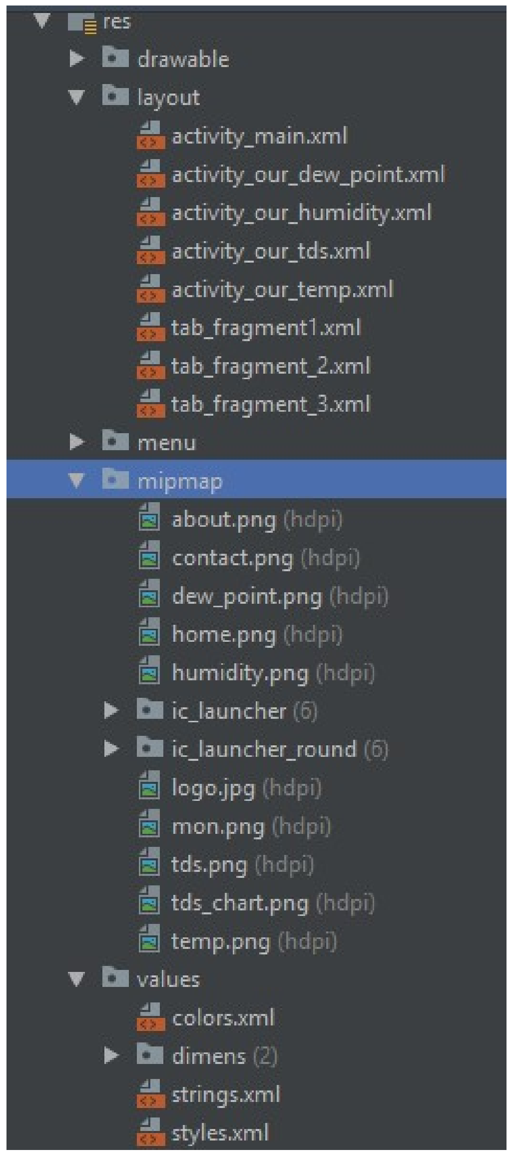


Figure 4-28: Resources Used

CHAPTER 5

TESTING AND ANALYSIS

CHAPTER 5

5. TESTING AND ANALYSIS

5.1 Introduction

Testing and analysis is successive part of designing a system to check whether it is fulfilling the desired goals or not. Multiple experiments were performed under different conditions to achieve the present design and specifications of VizGen. The first test was conducted in a laboratory having the environmental conditions likes of a living room. At the time of experiment the temperature of laboratory was 16.1 degree Celsius whereas humidity level was 62.4%. In these conditions, the production rate of our device was unbelievably fast. Water droplets started to appear on the copper coils in just five minutes and we first drop of water was fallen in the water tank after 8 minutes. Water production rate of our unit at this stage was just average and was certainly not enough to fulfill the targeted water production rate. Our previous system could produce only 5 to 6 liters of water daily making the unit a costly and uneconomical solution for the users of system. Then we performed a series of tests to elevate the production rate of our unit to make it both cost effective and economical solution. Details of these test and their respective results are explained in the section 5.2.

5.2 Testing

5.2.1 Test at Normal Environmental Conditions

The first test was conducted without turning on the fans in the laboratory and it was fully closed. In the second test we turned on the fans to lower the temperature of laboratory so that when this colder air strikes the pipes, it takes less time for it to condense, hence taking lesser time to produce water. But this test was also not so helpful.

5.2.2 Test Using Aluminium Foils

In the next test we decided to increase the surface area of our cold section. For this, we used the principle of heat transfer of two metals i.e. when two metals are in contact with each other, their temperatures are transferred to and fro till the temperature of both metals becomes same and they attain equilibrium. To conduct this test, the first challenge was to search for a metal which will be used in this system. As many metals when in contact with water, contaminate it causing many diseases. The metal selected for this test was aluminum foil because it is already used for food packaging like that of milk containers and also has very high ability to repel heat.

When we carried out this test, instead of increasing the surface area and production rate it actually lowered both. So, when the increased surface area by adding aluminum foil was connected with the copper pipes there was little to no water generated and also it increased the production time of our device.

5.2.3 Test Using Copper Foils

In the next test, we decided to use the copper foils. When this copper foil was in contact with the copper pipes of cold section, the temperature of this foil was not lowering down and it was also creating problems for our device to produce water.

When all these tests couldn't produce envisaged results, there was no choice but to continue working with the same technique of our system. All these tests took around 1 month of our time and imposed a constraint on our budget. So, we decided to change the design of our device. We were not in the condition to take a risk again, so we planned a completely new design which can surely increase the production rate and also can lower the production cost, so that it must be cost friendly for the consumer.

5.2.4 Design Modifications

We planned a new design in which we reduced the dimensions of our system and it was more compact so that it could be rendered portable, making it easy to move it from one place to other. In this design we increased the length of copper pipes, hence the surface area of cold chamber. This pipe is curled in two water bottles which also act as water containers. When we started conducting tests on this design, the production rate increased and also the cost of per liter also lowered down to 3.68 Rupees per liter. The production rate of our device is now 12 liters of water at the cost of Rs. 3.68/liter. This production quantity is not the final as it can be increased by increasing the power rating of the device.

5.2.5 Water Quality Test

The next test we conducted was to check the quality of produced water. This test was performed to check whether the produced water is drinkable or not. The device used for this purpose was the TDS meter of MI. When this test was conducted the TDS of the produced water came out to be 219 ppm/liter, which was highly suitable and safe for drinking.

5.2.6 Testing DHT22 Sensor

Figure 5-1 shows the successful test result of DHT22 sensor.

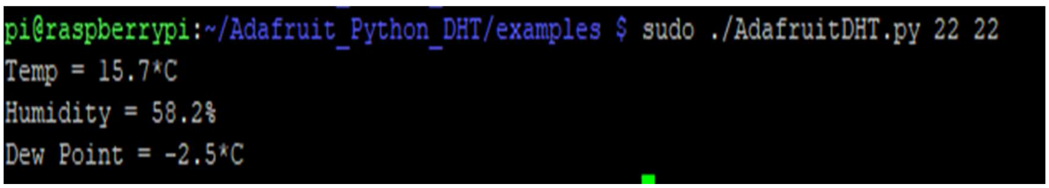


Figure 5-1: DHT22 Sensor Output

5.2.7 Final Observations

By increasing the power rating of the device, that is, by using heavy compressors and condensers, the production rate and quantity can be further increased. The yield will also increase when humidity factor in air is more than the humidity in the laboratory or other enclosed environments. With the increment of both said factors, cost per liter would further decrease, making the unit more economically efficient.

5.3 Real Time Implementation

All the above mentioned tests were conducted in real time and their results were verified by the Supervisor. All the changes in the project design were made after a thorough discussion and advice of the project Supervisor. The environment monitoring is the main real time implementation of our project. To meet this purpose we used different sensors like humidity, temperature and water sensors.

These sensors are used to sense and record the environmental conditions in real time. By using the recorded data i.e. humidity level and temperature, we are calculating the dew point of the air at the given time. These environmental conditions are stored in the database and are used to make the unit efficient in terms of energy consumptions. Users can easily monitor these conditions using VizGen Android Application.

CHAPTER 6

CONCLUSION AND FUTURE WORK

CHAPTER 6

6. CONCLUSION ANDFUTURE WORK

6.1 Conclusion

The device is now ready to use which can easily extract enough drinking water for 3 persons in 24 hours at very low cost. All the conducted tests have ensured safe consumption of the produced resource with the best possible efficiency. This device named VizGen, we can proudly say, can cater the water shortage problems of Pakistani households.

6.2 Future Enhancements

Our device can only generate enough drinking water to meet the needs of a family not more than three to four persons. So, we can all the developed unit as a domestic unit. In future we can increase the water production rate of our device by increasing the power rating of our device. By power rating we mean installing a larger compressor. Aside from The units can also be installed at larger scales i.e. Industrial Scale to decrease the water production cost and for a noticeable increase in production rate. If an individual have enough funds then he/she can set an industrial plant based on discussed technique to provide water to people in the form of water bottles.

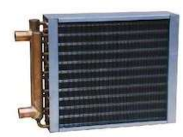
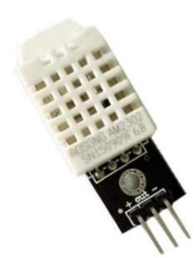
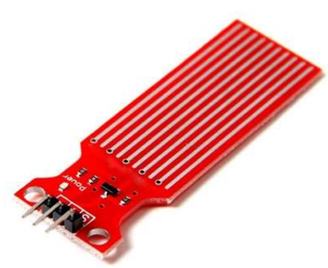
As the mobile app VizGen is only used to monitor the environmental conditions and user has no control of the device is this app. For future enhancement control functions can also be added in the VizGen app to enable remote control operation of the unit.

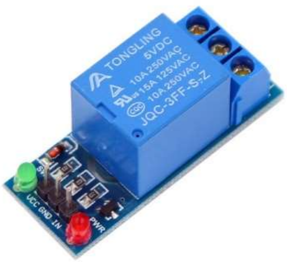
APPENDICES

APPENDIX A

Equipment Used

Table A-1: Equipment Used

Compressor	
Condenser	
Raspberry Pi	
DHT 22 Sensor	
Water Level Sensor	

Relay Module	
Mi TDS Meter	

APPENDIX B

Total Project Cost Breakdown

Table B-1: Project Cost Breakdown

S/No	Nomenclature	A/U	Qty	Amount
a.	Compressor	5000/-	1	Rs. 5000/-
b.	Condenser	2000/-	1	Rs. 2000/-
c.	Exhaust Fan	1500/-	2	Rs. 3000/-
d.	Raspberry Pi	5500/-	1	Rs. 5500/-
e.	SD Card	950/-	1	Rs. 950/-
f.	DHT 22 Sensor	450/-	2	Rs. 900/-
g.	Copper Pipe (per ft)	40/-	20	Rs. 800/-
h.	Iron Frame (Purchase + welding Labor + Transportation)	7130/-	1	Rs. 7130/-
i.	Male to Female wire	1/-	50	Rs. 50/-
j.	Double Pin Female Header	20/-	1	Rs. 20/-
k.	MCP 3008 IC	350/-	1	Rs. 350/-
l.	Empty Bottles	620/-	2	Rs. 1240/-
m.	Electric Equipment (Wire, Switch, Socket etc.)	560/-	1	Rs. 560/-
n.	Nut and Bolts	25/-	4	Rs. 100/-
o.	Pipe Filter Capillary	2500/-	1	Rs. 2500/-
p.	Gas Filling	1700/-	1	Rs. 1700/-
q.	Compressor Fitting Charges	7000/-	1	Rs. 7000/-
r.	Paint	300/-	1	Rs. 300/-
s.	Acrylic Sheets (per ft)	140	10	Rs. 1400/-
			Total	**Rs. 40,500/-**

APPENDIX C

Project Timeline

Figure C-6-1: Project Timeline

APPENDIX D

Complete Project Code

#Importing all the Required Libraries

```
import argparse
import logging
import logging.config
import math
import sys
import time
import pymysql
from datetime import datetime
import os
import Adafruit_DHT
import RPi.GPIO as GPIO
```

#Setting Up Log Handler

```
logging.config.dictConfig({
 "version": 1,
   "disable_existing_loggers": False,
   "formatters": {
      "simple": {
         "format": "[%(asctime)s] %(levelname)-8s: %(message)s"
      },
   },
   "handlers": {
      "console": {
         "level": "DEBUG",
         "class": "logging.StreamHandler",
         "formatter": "simple"
      },
      "logfile": {
         "level": "INFO",
         "class": "logging.handlers.RotatingFileHandler",
         "filename": "vizgen.log",
         "maxBytes": 1024 * 1024 * 100,  # 100 MB
         "backupCount": 10
      }
   },
   "loggers": {
      "": {
         "handlers": ["logfile" if os.getenv("DISABLE_CONSOLE") else "console"]
```

```
        }
    }
})
```
#Database table Creation Function
```
def init_database(connection):
    with connection.cursor() as cursor:
        # Create database if doesn"t exists
        cursor.execute("SET sql_notes = 0;")
        cursor.execute(
            "CREATE TABLE IF NOT EXISTS vizgen ( "
            "  ts TIMESTAMP NOT NULL, "
            "  temprature FLOAT signed NOT NULL,"
            "  humidity FLOAT unsigned NOT NULL,"
            "  dew_point FLOAT signed NOT NULL"
            ");"
        )
        cursor.execute("SET sql_notes = 1;")
```
#Dew_point Calculation Function
```
def calculate_dew_point(humidity, temperature):
    if temperature > 0:
        c1 = 6.10780
        c2 = 17.08085
        c3 = 234.175
    else:
        c1 = 6.10780
        c2 = 17.84362
        c3 = 17.84362
    ps = c1 * math.exp((c2 * temperature) / (c3 * temperature))
    pd = ps * humidity
    dp = (-math.log((pd / c1) * c3)) / (math.log((pd / c1) - c2))
    return dp
```
#Relay Integartion
```
CHANNEL=21
GPIO.setmode(GPIO.BCM)
GPIO.setup(CHANNEL,GPIO.OUT)
GPIO.output(CHANNEL,GPIO.LOW)
time.sleep(10)
GPIO.output(CHANNEL,GPIO.HIGH)
time.sleep(1800)
def tick(connection, args):
    logging.info("Reading from DHT22...")
    GPIO.output(CHANNEL, GPIO.LOW)
    humidity, temperature = Adafruit_DHT.read_retry(Adafruit_DHT.DHT22,
args.dht22)
```

```
    logging.info("humidity: %s, temperature: %s" % (humidity, temperature))
    if not humidity or not temperature:
        return
    dew_point = calculate_dew_point(humidity, temperature)
    logging.info("Dew Point: %s" % dew_point)
    time.sleep(360)
    GPIO.output(CHANNEL,GPIO.HIGH)
    with connection.cursor() as cursor:
        logging.info("Writing to database...")
        cursor.execute(
            "INSERT INTO vizgen(ts, temprature, humidity, dew_point) VALUES (%s,
%s, %s, %s)", (datetime.now(), temperature, humidity, dew_point))
    time.sleep(900)
```

#Main Function

```
def main():
    parser = argparse.ArgumentParser()
    parser.add_argument("--dht22", required=True, type=int, help="DHT22 GPIO pin
number")
    parser.add_argument("--relay", required=True, type=int, help="Relay GPIO pin
number")

    parser.add_argument("--mysql-host", default="localhost", help="MySQL host")
    parser.add_argument("--mysql-user", default="vizgen", help="MySQL username")
    parser.add_argument("--mysql-password",
default=os.getenv("VIZGEN_MYSQL_PASSWORD"), help="MySQL password")
    parser.add_argument("--mysql-db", default="vizgen", help="MySQL database
name")

    parser.add_argument("--interval", default=5 * 60, type=int, help="Interval between
readings in seconds")

    parser.add_argument(
        "-v", "--verbosity", default=2, choices=[0, 1, 2, 3],
        help="Verbosity level; 0=minimal output, 1=normal output, 2=verbose output,
3=very verbose output"
    )

    args = parser.parse_args()
    # Set logging level
    logging.root.setLevel((4 - args.verbosity) * 10)

    logging.info("Connecting to Database...")
    connection = pymysql.connect(
        host=args.mysql_host,
```

```
        user=args.mysql_user,
        password=args.mysql_password,
        db=args.mysql_db,
        charset="utf8",
        autocommit=True
    )
    with connection:
        logging.info("Initializing Database...")
        init_database(connection)

        while True:
            tick(connection, args)
            time.sleep(args.interval)


if __name__ == "__main__":
    main()
```

APPENDIX E

Key to Abbreviations and Symbols

kWh	kilo Watt hour
PKR	Pakistani Rupees
DHT	Digital Humidity and Temperature Sensor
L x W x H	Length x Width x Height
UV	Ultra Violet
TDS	Total Dissolved Solid
Hz	Hertz
VAC	Volts Alternating Current
Kg	Kilogram

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USER MANUAL

USER MANUAL

VizGen

Military College of Signals, NUST

May, 2019

TABLE OF CONTENTS

1. GENERAL INFORMATION

1.1 System Overview

VizGen will be a fully automated water generator which can be employed in any environment to produce adequate amount of water to power domestic tasks. Employing the principles of compression, temperature differential and condensation, we aim to achieve our objectives and provide impurity-free water.

1.2 Organization of the Manual

The User Manual is divided in six main sections:

- First section includes the overview of the system and some basic information
- Second section gives you information about the system specifications and system components.
- Third section enlists some safety and installation instructions to be ensured. Ignorance of these instructions may result in unrepairable damage.
- The fourth section tells the user how to use the system.
- In the last section we have included some common problems user may face when using the system and how to resolve them

1.3 Acronyms and Abbreviations

kWh	kilo Watt hour
PKR	Pakistani Rupees
DHT	Digital Humidity and Temperature Sensor

2. SYSTEM SUMMARY

2.1 System Specifications

- **Operating Power:** 230 Watts
- **Water Production:** 12 litre per day
- **Daily Power Consumption:** 5.52 kWh
- **Per liter Water Production Cost:** 3.68 PKR per liter
- **Dimensions (LxWxH):** (2x1.3x3.7) fts

2.2 System Components

The system includes following components:

- Compressor
- Condenser
- Exhaust Fan
- Raspberry Pi
- DHT22 Sensor
- Water Level Sensor

3. SAFETY AND INSTALLATION INSTRUCTIONS

3.1 Safety Instructions

- Read all the instructions carefully before using the VizGen.
- **DO NOT** install the unit indoor or poorly ventilated areas.
- **DO NOT** turn on and off unit frequently to protect compressor and avoid any kind of explosion.
- To avoid electrical shock ground the unit.
- If the power supply cord is damaged or broken it must be changed/repaired before plugging it in.

3.2 Installation Instructions

- To meet the rated water production it is advised to install the VizGen unit outdoor or a place with proper ventilation.
- It is advised to install the unit at a perfectly levelled place.

4. OPERATIONS

4.1 VizGen Unit

STEP 1: Place the VizGen unit on perfectly leveled outdoor or properly ventilated place.

STEP 2: Supply Electrical power to the unit using power supply cord and ENJOY!

4.2 VizGen Android Applications

STEP 1: Download the VizGen Android Application from the following link:

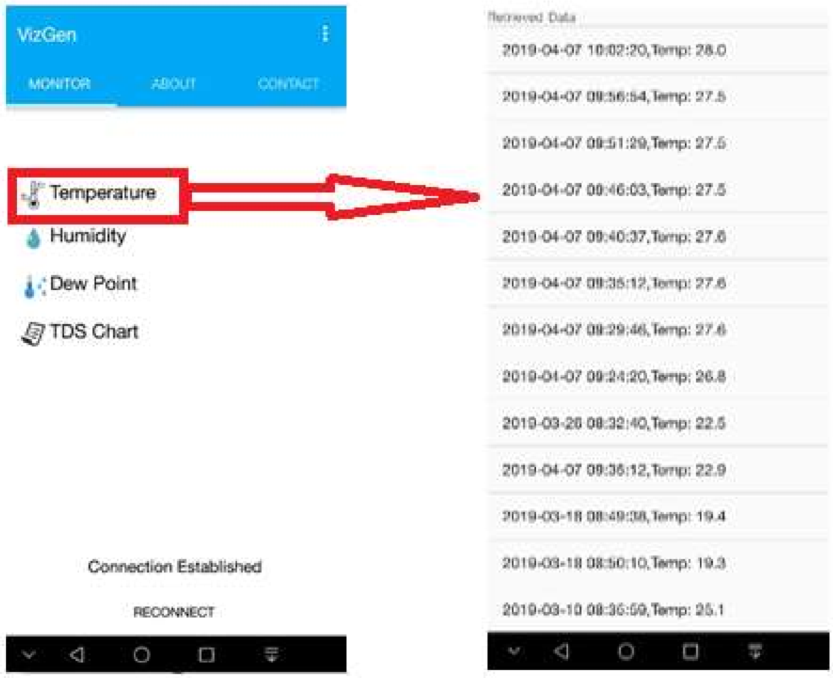
https://drive.google.com/open?id=1ZRp8Dd-ShiRY0b_TL-bcXSPSZ2C94hUY

STEP 2: Install the Android Application on your device.

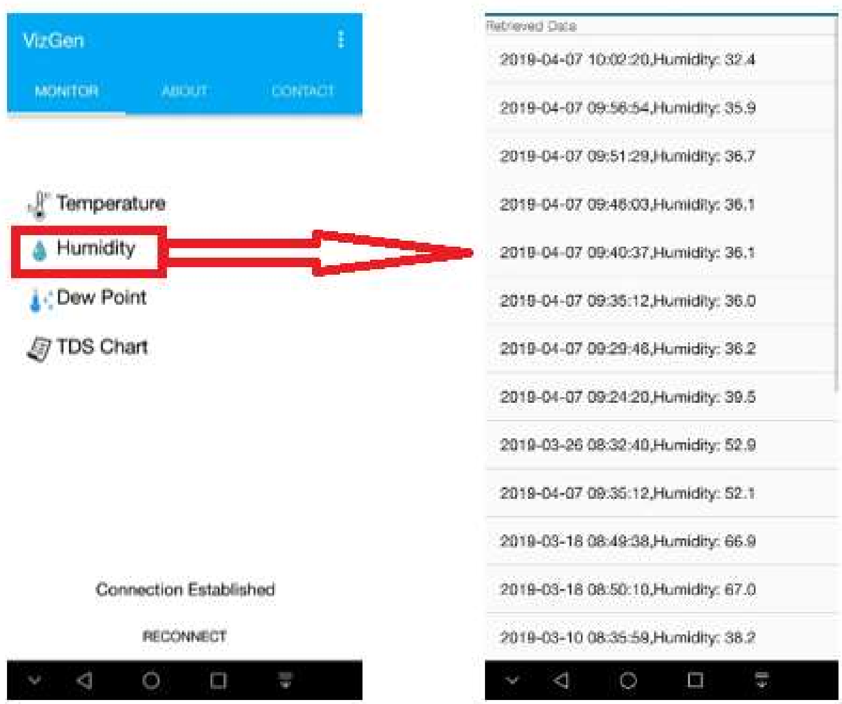
STEP 3: You can monitor the current temperature, humidity, dew point in 'Monitor Tab' by simply clicking the respective TextView. Users can also access drinking water TDS chart.

Figure: Application Layout - I (Monitor Tab)

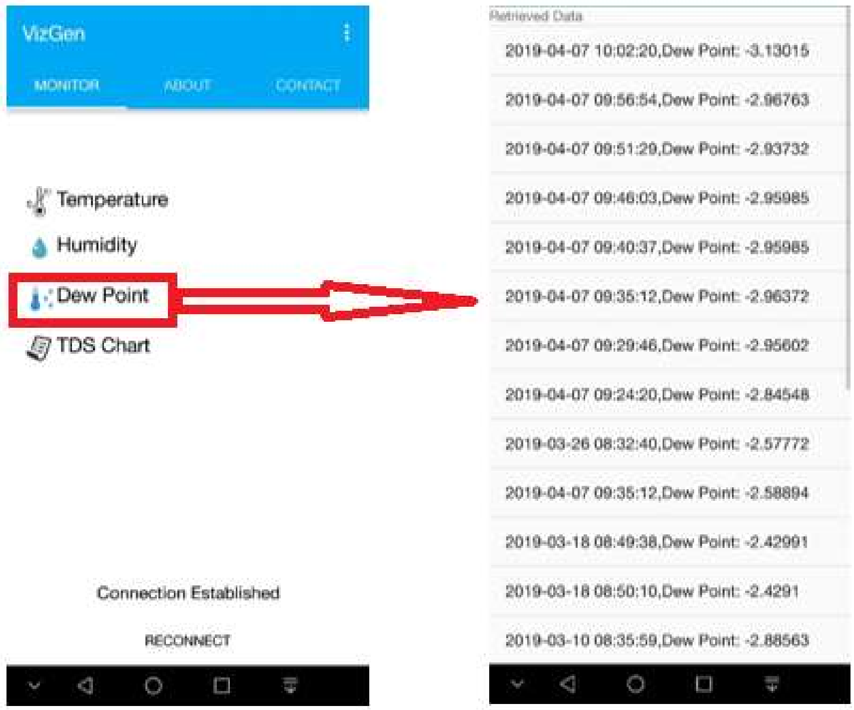
By clicking on Temperature the user can monitor the temperature of environment.



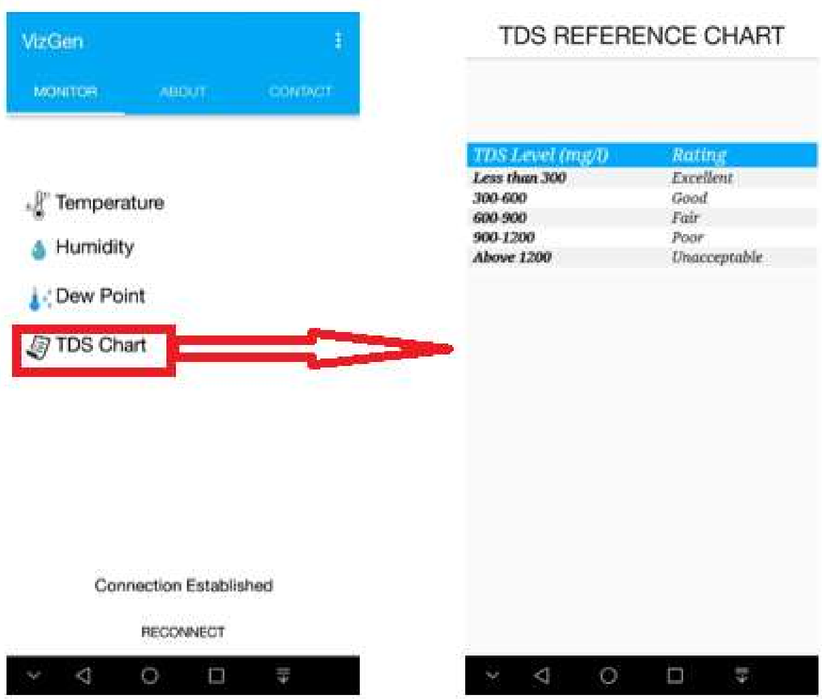
By clicking on Humidity the user can monitor the Humidity of environment.



By clicking on Dew Point the user can monitor the dew point of environment.



By clicking on TDS Chart the user can check out TDS reference chart.



5. TROUBLESHOOTING

You can solve many of the common VizGen problems by trying the suggestions outlined below. If the problem persist feel free to reach us.

VizGen does not operate
• Not Plugged in
Vibrations
• Make sure VizGen is placed in a balanced manner
Water production less than the rated production
• Humidity level must be greater than 25-30% for the unit to reach rated production level • Check the humidity of the place where the unit is installed
Compressor turns on and off frequently
• Temperature is too high
VizGen is making a lot of noise during operation
• Check to assure the unit is placed level

VizGen

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