Memorial University of Newfoundland

(Faculty of Engineering and applied science)

Design, Analysis and Remote Monitoring of a Solar Powered Orphan Oil Well Pumping System in Nigeria

M.Eng. Student: **Ms. Chidolue Onyinyechukwu**

Supervisor: **Dr. Mohammad Tariq Iabal**

Background Study and Overview

- This thesis solves the issues of abandoned oil and gas well,which releases methane (GHG)
- Identifies cost-effective strategies to mitigate the impact of abandoned wells using renewable technology,
- The study recommends the use of solar-powered pumps to for AOG. PVsyst for pump sizing and system efficiency , HOMERpro for system Optimization and cost- effective system monitoring using PLX-DAQ and LoRa Technology

Orphaned Oil Well and its Effect to the Environment.

- What are stripper well ?
- In the United States, there is an extensive number of abandoned oil and gas wells, totaling over 3.2 million and 380,000 of stripper wells and to have released 281 kilotons of methane into the atmosphere.
- However, it is still an uncommon practice for renewable energy to be used in the oil and gas sector as a way of plugging orphaned wells

Orphaned Oil Well and its Effect to the Environment.

- The cost associated with methane extraction from wells rely on the emission rate.

- Methane emissions from AOG accounts for 98% of the total leakage volume .

- The cost of plugging AOG wells can range up to $1,000,000 per well in Canada

- This thesis will identify cost-effective strategies to mitigate the impact of AOG wells

Ways in which Methane has been Extracted:

- Plugging is blocking/filling the oil well. (note: doesn’t totally solve leakage)
- Flaring involves burning methane, converting it into CO2 and water,
- Recovery/utilization ; include using methane directly as a fuel, connecting it to natural gas pipelines for off-site use,
- All the methods mention is either economically intensive or requires a lot of technology and labour for extraction.

Abandoned Oil well in Nigeria

- ln 2021 there was a leak from three oil mining leases . Oil Mining Lease (OML) 18, OML 29, and OML 63,
- The leak, lasted for 32 days, impacted the Santa Barbara River in Bayelsa, affecting farming, fishing, and drinking water in three kingdoms of Bayelsa State.
- The oil leakage issue at OML 18,29 and 63 root cause has not be found and no solution has been implemented.
- It is worth noting that there are up to 800,000 barrels of oil well reserves in Nigeria which are currently producing less crude oil than before.
- There is a potential of having more stripper oil wells in the future

Oil and Gas Sector in Nigeria

- Nigeria stands as one of Africa's largest countries in terms of its oil and gas reserves.

- As of 2020, the country's crude oil reserves were measured at 86.9 million tonnes, while its natural gas reserves were approximately 49.4 billion cubic meters (bcm).

- Nigeria produces low-sulfur crude oil, which is highly sought after globally. Due to the increasing demand for products by refineries worldwide there is an expected surge of this demand over time.

Abandoned Site Characteristics - Oloribiri Oil Field

- The Oloibiri Oilfield is **the first oilfield in Nigeria** is located in Oloibiri in Bayelsa State, Nigeria.

- It falls within **Oil Mining Lease 29** which was one of the mining lease that was leaking in 2021 and covers an area of approximately **13.75 square km**

- Currently, the field is managed by the Shell Petroleum Development Company of Nigeria Limited (SPDC).

The Oil Well Development History

- In the process of developing the Oilfield, four oil wells were first drilled between June 17 and November 27 1958 .
- A Total of 11 oil wells were operating 1956, and 1958 with a rapidly declining production rate
- 9 years after operation, **the Oloibiri-17 well** was drilled in June 1967; and was considered a **stripper well**,

The Exploitation and Effects of the Abandoned Oil Field in Oloibiri

- The marine ecosystem has suffered irreparable damage, leading to the extinction of aquatic life and suitable drinking water.
- Indigenous fishing industries have been affected, and erosion has become widespread.
- Even after 60 years, the community continues to rely on a polluted creek for water supply.
- The environment, rivers, air quality and soil have been affected, making fishing and farming difficult due to the oil leakage and has damaged the community's means of sustenance.

Figure 1: Current state of Oloibiri Community

- Oloibiri 1 was drilled to a depth of 3,660m , with an initial prod.rate of **5,000 barrels** per day
- This operation lasted between late **1957** and early **1958**, with an average flow rate of **4,928** barrels of oil per day
- Oloibiri-2, was drilled to a depth of **2932 m** on June 26, **1956**.
- However, after nine years of production, the Oloibiri-17 well drilled on to a depth of **3816**m

Figure 2: Current Oil well State of Well

Figure 3: Oil well 1 in the oilfield of oloibiri used as historical figure

Solar energy in Nigeria and daily consumption

- The country has a well-distributed solar energy, with the northern regions receiving a higher proportion.
- On average, Nigeria experiences **approximately 5 hours of daily sunshine,** leading to a solar radiation value of about 19.8 MJ/m^2.
- The duration of sunshine ranges from **9 hours in the far north to 3.5 hours** towards the coast.
- The nation receives an average **25.2MJ/m^2 per day of solar radiation**
- **It is estimated that solar energy potential is 5.0 ×〖10〗^14 KJ of usable energy per year,**
- **That amount of energy is equivalent to 258.62 million barrels of crude oil and 4.2×〖10〗^5 GWh of electricity annually**

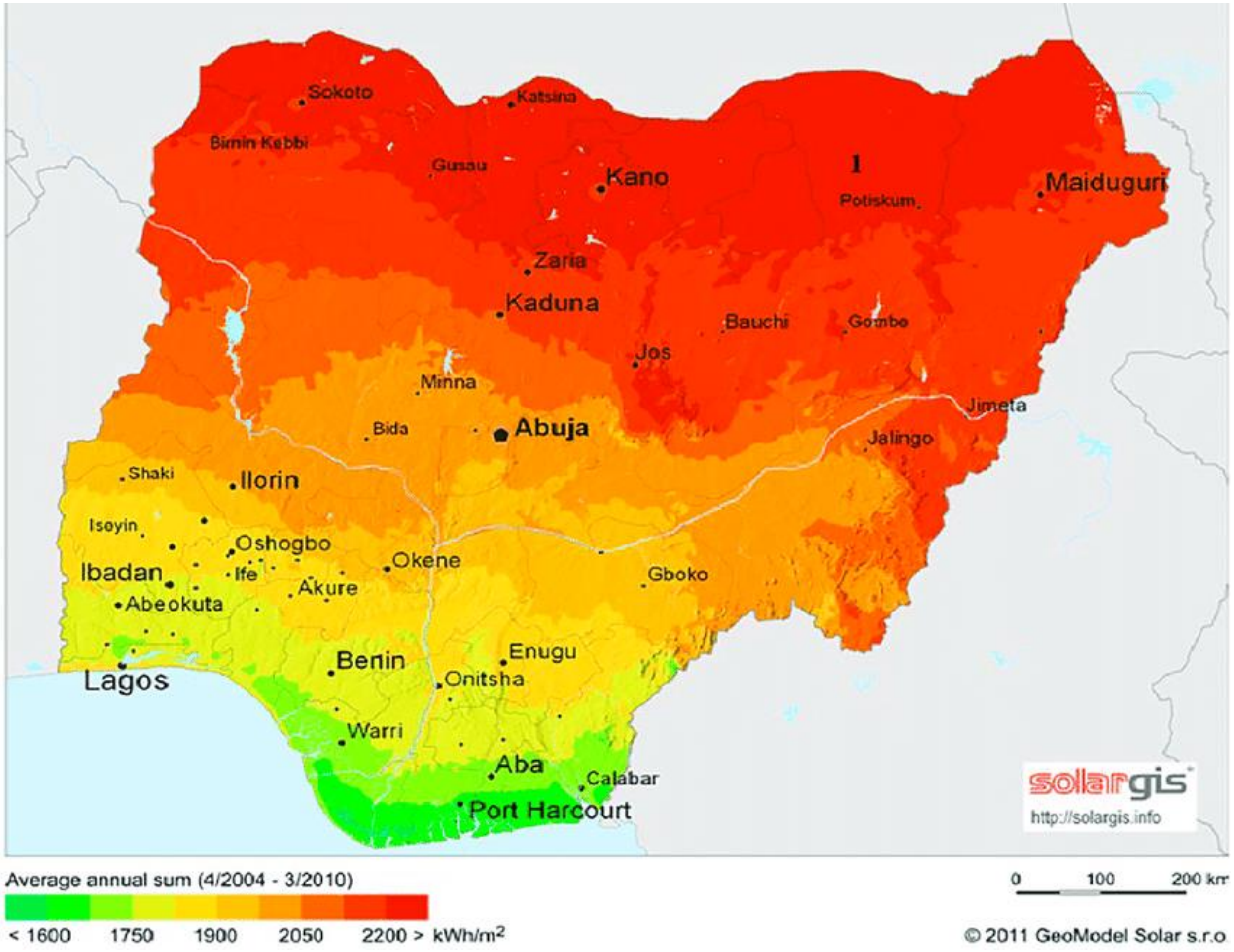


Figure 4: The geographical solar irradiance range in Nigeria

Research Objectives

- Investigate oil well pumping in the oil and gas industry and develop a configuration for a solar-powered pumping system.
- Design the most efficient model using PVsyst and optimize the system sizing using HOMER.
- Implement a cost-effective real-time system monitoring solution for the oil pump's control unit.
- Design a remote system monitoring setup using LoRa Technology that is independent of the network system, considering the site's location.

Recent Application of Solar Powered Pump in Oil Drilling

- Santo has totally transition to 100% renewable for their overall operations in liquified natural gas in supporting their 5% carbon reduction objective. to increase system uptime and production
- In Aztec Willson K property which currently operates five wells at flow of 5 barrel/day
- Due to high expense of installing electricity lines at the site location, a solar powered oil pump is used and a real time system monitoring is implemented but utilizes a cloud-based software.
- The solar-powered oil pumping systems designed by Solar Lighting International is a low speed Crank Rod Pump designed specifically for low-flow and shallow well.

Recent Application of Solar Powered Pump in Oil Drilling

- Utilizing solar-powered diaphragm pump to inject chemical into the oil well for separation from particles shows an efficiency 95% percent using renewable source

- Chevron Corp. has totally introduced solar technology in the oil well pumping and about 7,981 barrel-per-day is being pumped by solar energy since April 2020 in Lost Hills oil field.

- In the existing literature review, only a few studies on solar-powered oil pumps were found, and none of them provided comprehensive design details and methodologies used.

Different stages of oil field's extraction can utilize renewable technologies, which can be categorized into three phase:

- **Primary recovery**: In this phase, the well pressure is sufficient for extraction. Artificial lift techniques like rod pumps and electric submersible pumps are mostly used. Only 5%–15% of the total reserves can be extracted .
- **Secondary recovery** : the reservoir pressures decrease. To increase the reservoir's pressure, gas or injection fluids are used. Only 10%–20% of the reserve can be extracted
- **Tertiary recovery** : involves implementing various techniques to further boost flowrate. It is possible to retrieve up to 20% or more

Electric pumps in the Oil and Gas for Renewable Energy Integration

- Electric submersible pump are effective for high volume oil well with these characteristics: low bottom hole pressure, low gas/oil ratio, low bubble point, high water cut, or low API gravity fluids.

➢ **Artificial lift technologies**

Mostly used to enhance production flow. Artificial lift systems are necessary in wells where the reservoir's pressure is insufficient to bring the liquid to the surface.

➢ **Plunger lift technologies**

Commonly used in oil wells to extract relatively low volume of high gas/liquid ratio oil and gas well. it uses the pressure of the oil to lift the oil .

System Design Calculation

Site Description

- The pumping level was set at a depth of **3800m** to prevent any damage to the pump caused by potential foreign bodies.
- The oil well's **total depth** is **3816m**
- **Total dynamic head** of approximately **3820**m
- Static water level of **3710m** from the ground.
- The daily oil production at this site amounts to about **15 barrels**, which is equivalent to **2.4 m^3 / day**.

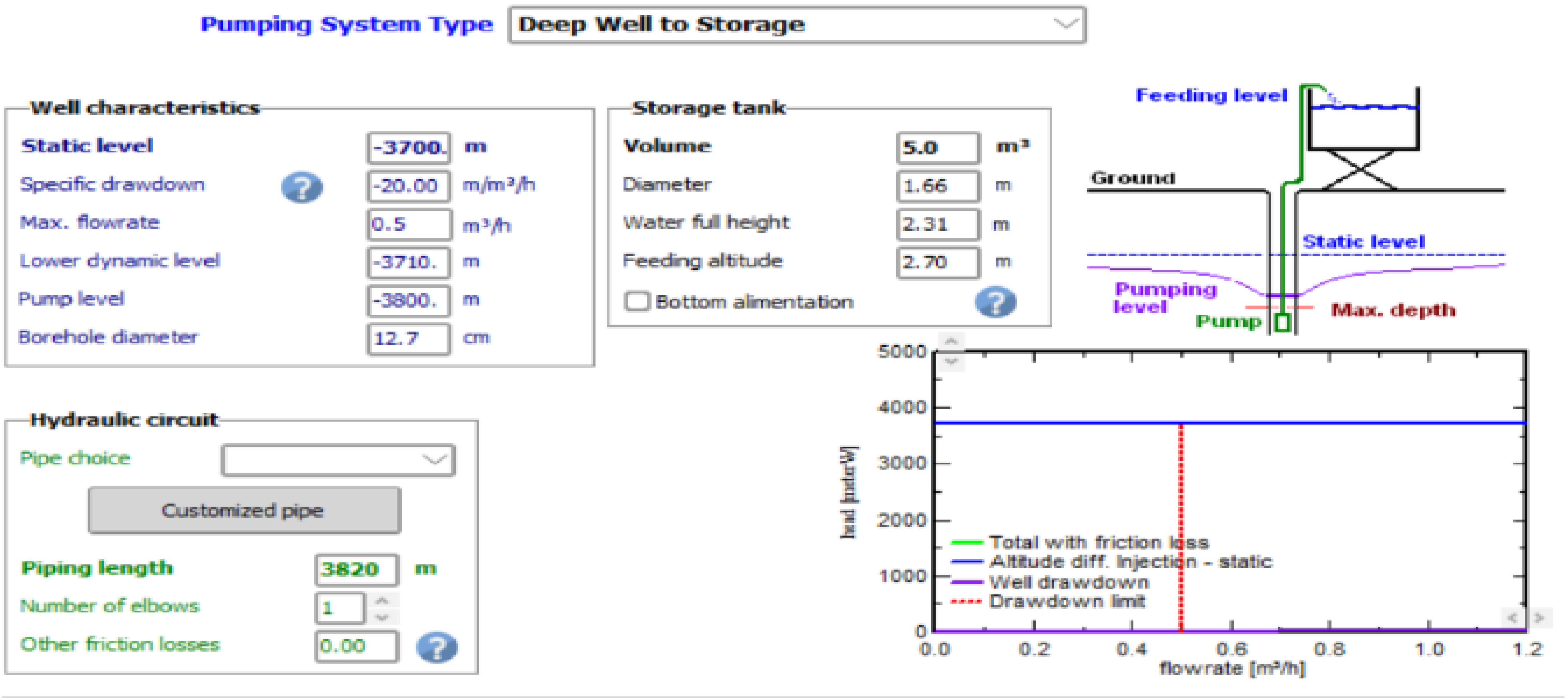


Figure 5: Pvsyst parameters for the sizing

Under these specified conditions, we will analyze and compare the performance of the two pumping systems.

- Condition A: the system runs for 5 hours daily when it is sunny. Flow rate per second = 2.4/(5×60×60) = 0.00013m^3/s (0.5 m^3/h).
- Condition B; system is running for 24 hours, irrespective of solar irradiance, the flow rate per second = 2.4/(24×60×60) = 0.000027m^3/s (0.1 m^3/h).
- TDH = 3816 + [(0.9 x 1) + 5] x 0.2 = 3817m. However, 3820m is the estimation for the total dynamic head.

Pump Sizing

- Shaft power = (hydraulic power)/efficiency
- Also, hydraulic power = $\rho \times g \times H \times Q$

➢ Hand calculations

Assuming a pump efficiency of **30%** .

- Heavy crude oil's density is **925kg/m^3**.
- Since the oil will be heated at that depth, **its viscosity is low** the density becomes nearly equivalent to that of water, which is **1000kg/m^3**
- Condition A: Operates for 5 hours per day, TDH: 3820 m, with a maximum flow rate of **0.00013m^3/s**.

- Condition A:the calculated hydraulic power is **4,506 W,** and a shaft power of **15 kW**
- Condition B: Maximum flow rate of **0.000027m^3/s**, the calculated hydraulic power is 934.96 W. shaft power of 3.11 kW is sufficient to deliver the required amount of oil.
- Although the above calculation provides a preliminary idea of the system design, a comprehensive system sizing is conducted using Pvsyst.

➢ Solar Pump Design by Pvsyst

- The customized delivery pipe material for this site in Oloibiri is made of **medium-pressure seamless steel** with an inner diameter of **200mm** and an outer diameter of **217mm**.

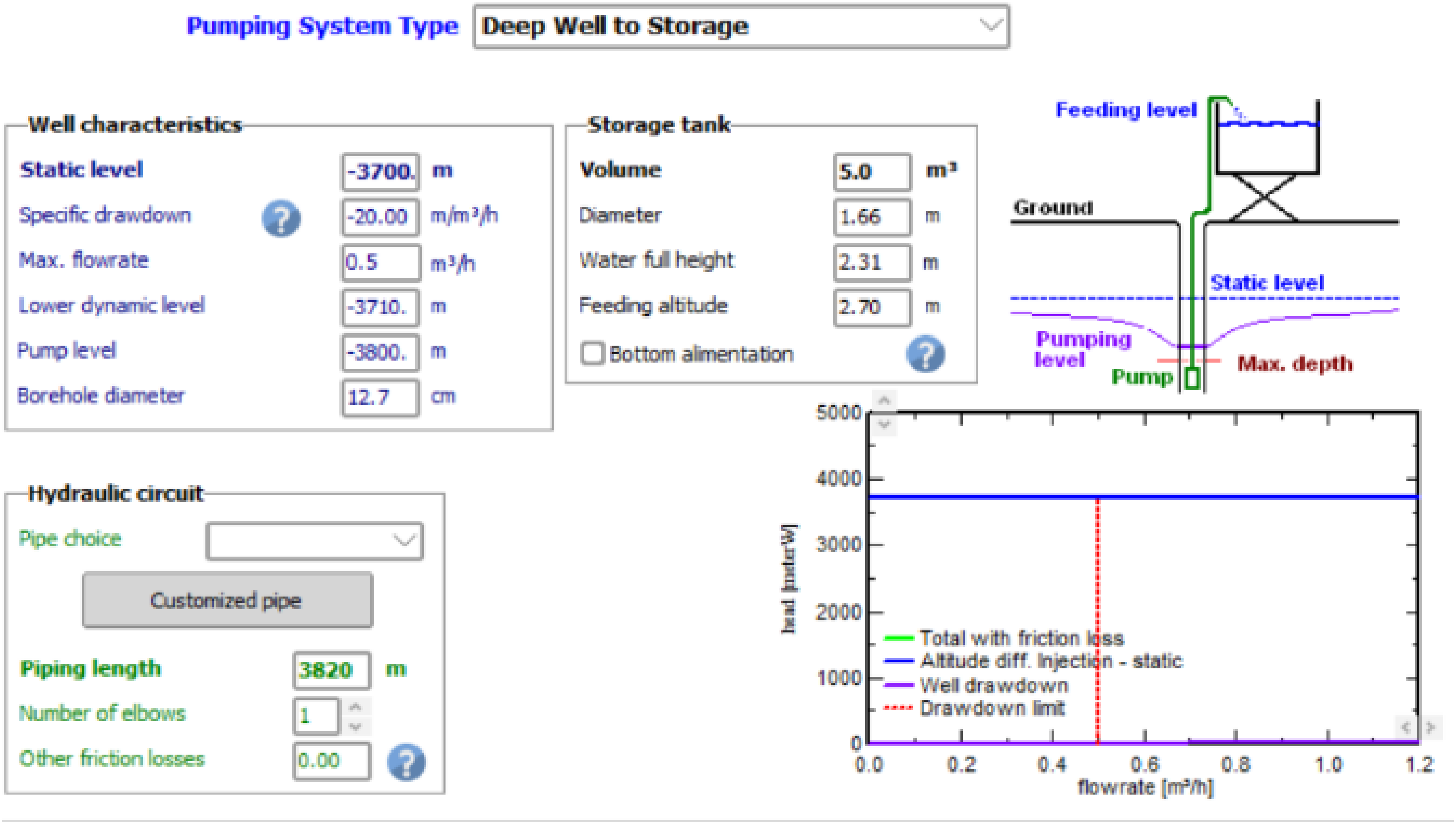
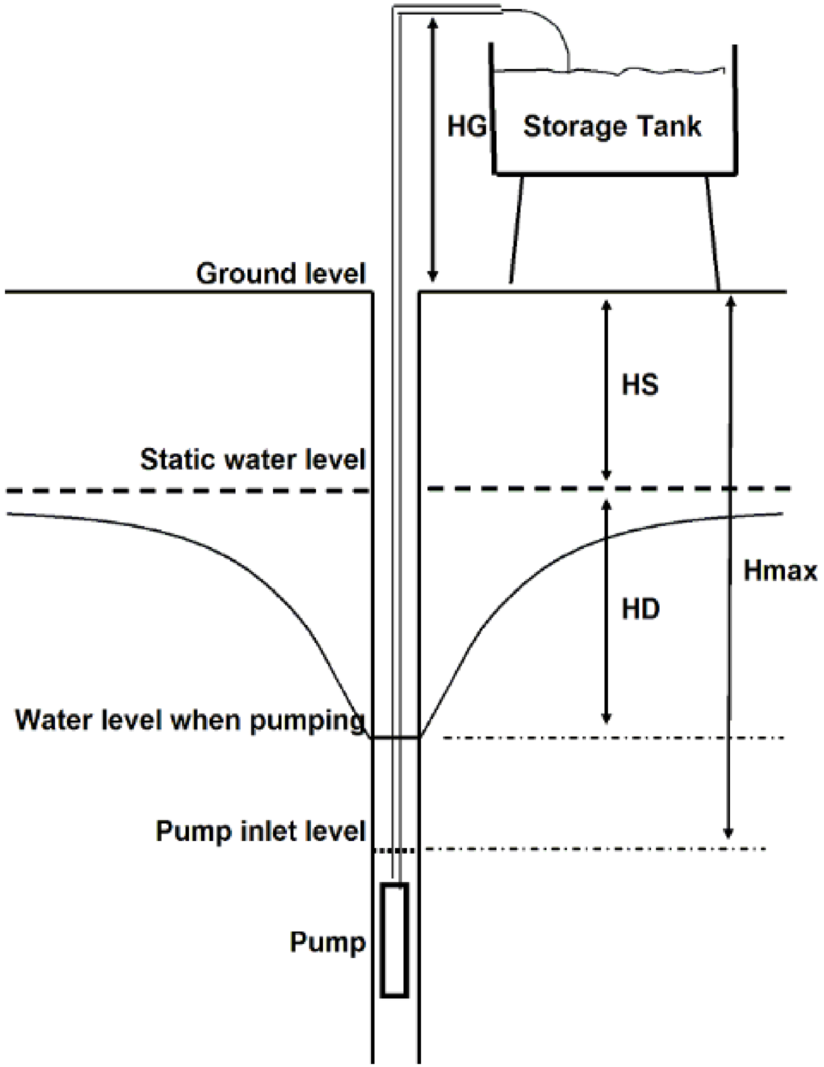


Figure 7: Input parameter for the system in PVsyst



HG = head due to the height of the outlet pipe above the ground = 2.70m

HS = static head due to the depth of the water level in the well, in absence of any pumping.= 3700m

Lower Dynamic Level= 3710m

HD = dynamic "drawdown" head: 10m
in a borehole well, the effective water level is dynamically lowered by the water flow extraction

Hmax = Pumping Level Head = 3800m

Pump Sizing for a Running Time of 5 hours/day

- PVsyst software analyzed the system sizing and determined that the oil has a ***minimum head of 3702.7 meters*** and a ***maximum head of 3712.7 meters.***
- The hydraulic power was calculated to be ***4850W***, and PVsyst recommended a pump power of **18.2kW** and a PV system capacity of **23kW-peak**.

Figure 8: PVsyst system sizing Suggestion

Pump Sizing for continuous running time (non-stop)

- PVsyst software provided similar pump parameters. When a flow rate of **$0.000027m^3/s$ was input.**
- PVsyst recommended a pump power of **18.5 kW,** a *PV power* of **23.4kW-peak** and Hydraulic Power of **4,844W** and a tank storage capacity of $9.6m^3$ to meet the load demand for **continuous operation.**

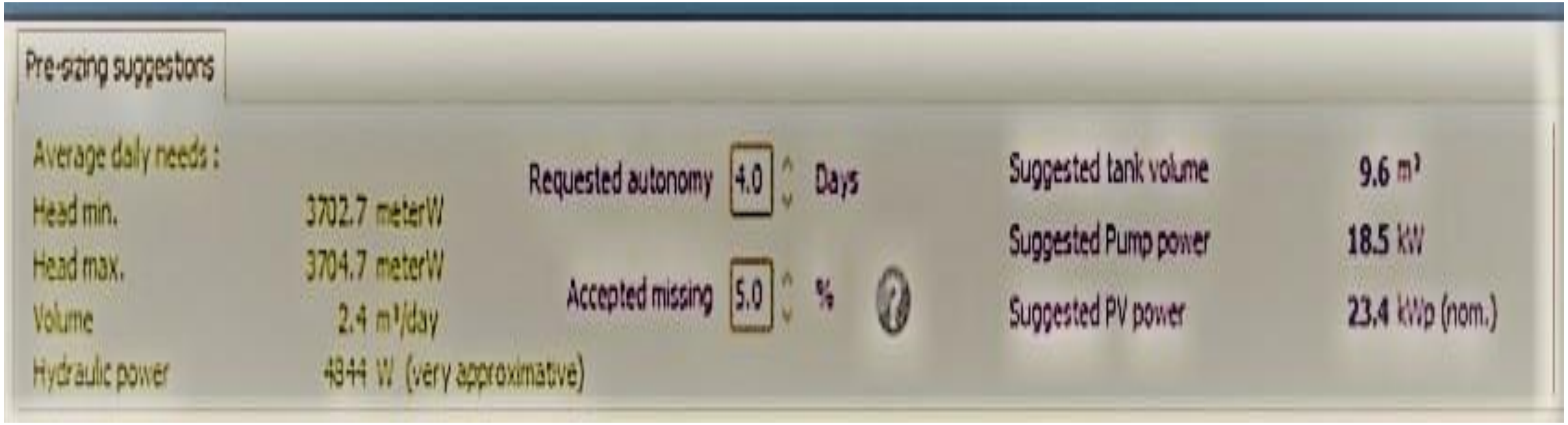


Figure 9: PVsyst system sizing Suggestion

PV Sizing by Homerpro Software

- The system is **intended to be used fully during its operating window of 11 am to 4 pm** when solar irradiance is at its highest. Figures below show the system design for 5 hours of running time in HOMERpro.
- With an **average load** of **100kWh/day**.
- **Peak load =Pvsyst Pump load + Miscellaneous Load**
- For the system design, a 22.3kW converter, a **50kW** of 370W 24V Solar panel, **40 (970Ah, 12V) batteries**, with One string of **20 batteries has a bus voltage of 240V** is used.

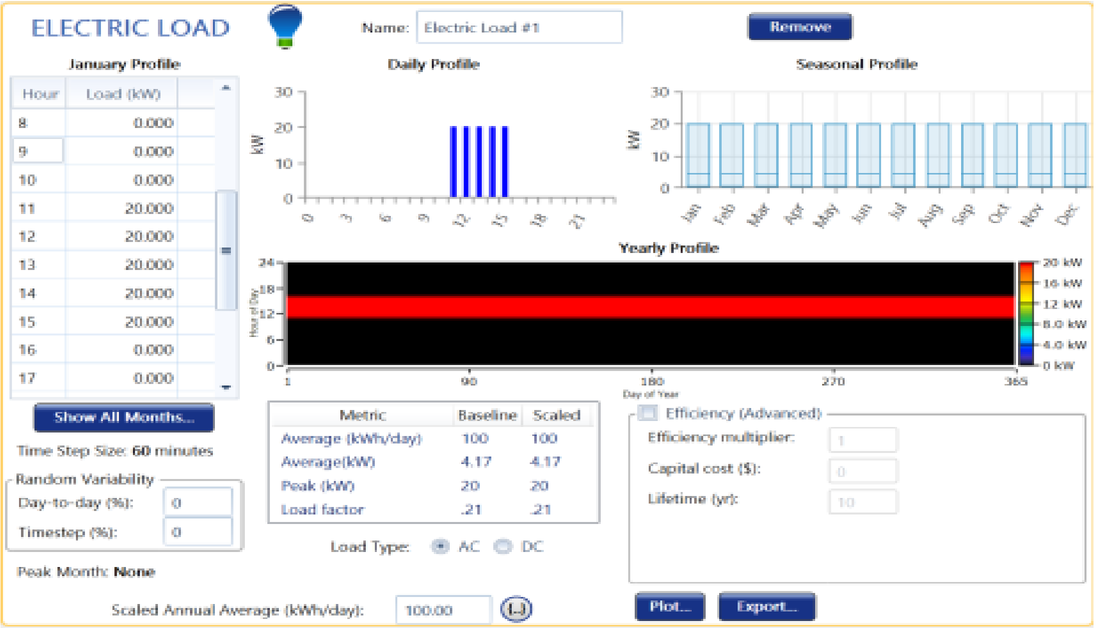


Figure 10: Load Profile for Condition A

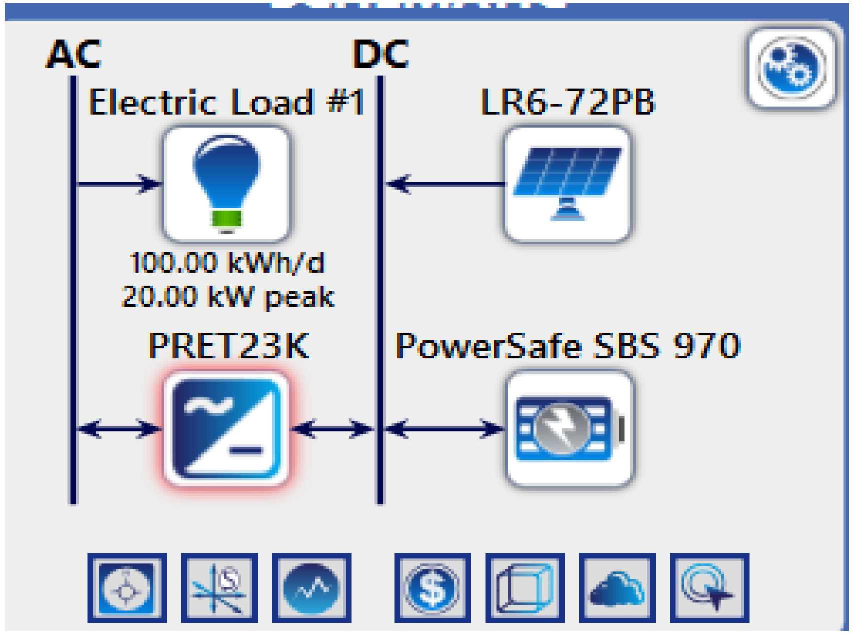
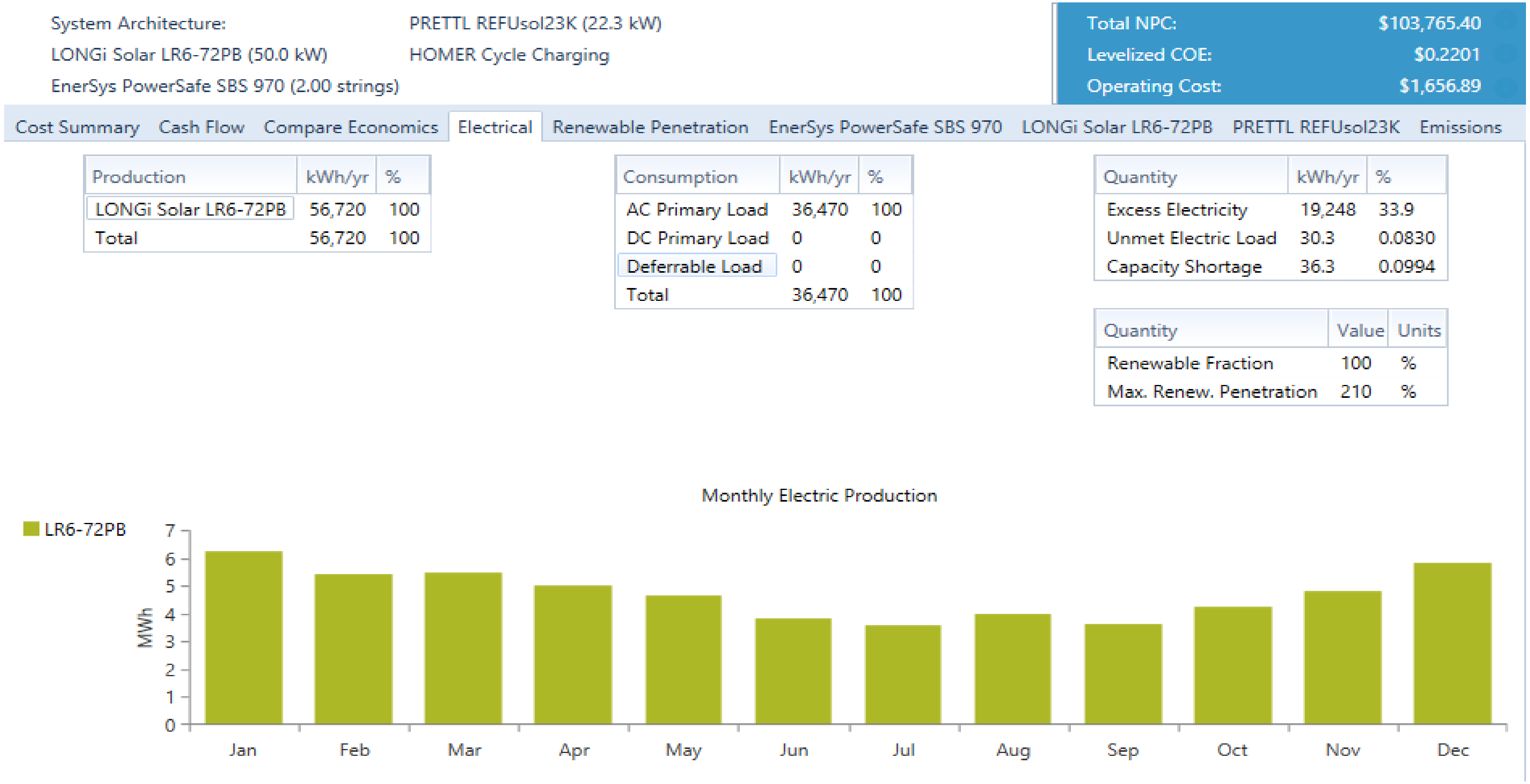


Figure 11: System Sizing Architecture

The Figure shows the renewable fraction of 100%, 33.9% of the electricity being in excess, and 0.08% of the load being unmet and 0.09% of the capacity shortage. **For a 5 Hours running time**



Production	kWh/yr	%
LONGi Solar LR6-72PB	56,720	100
Total	56,720	100

Consumption	kWh/yr	%
AC Primary Load	36,470	100
DC Primary Load	0	0
Deferrable Load	0	0
Total	36,470	100

Quantity	kWh/yr	%
Excess Electricity	19,248	33.9
Unmet Electric Load	30.3	0.0830
Capacity Shortage	36.3	0.0994

Quantity	Value	Units
Renewable Fraction	100	%
Max. Renew. Penetration	210	%

Figure 12: Simulation result details

- PV sizing for the system that operates **continuously under the same system component** as under condition A.
- The system design includes a 5.88 kW converter, 40 (970Ah, 12V) batteries, and **54.9 kW** of 370W, 24V Solar panels.

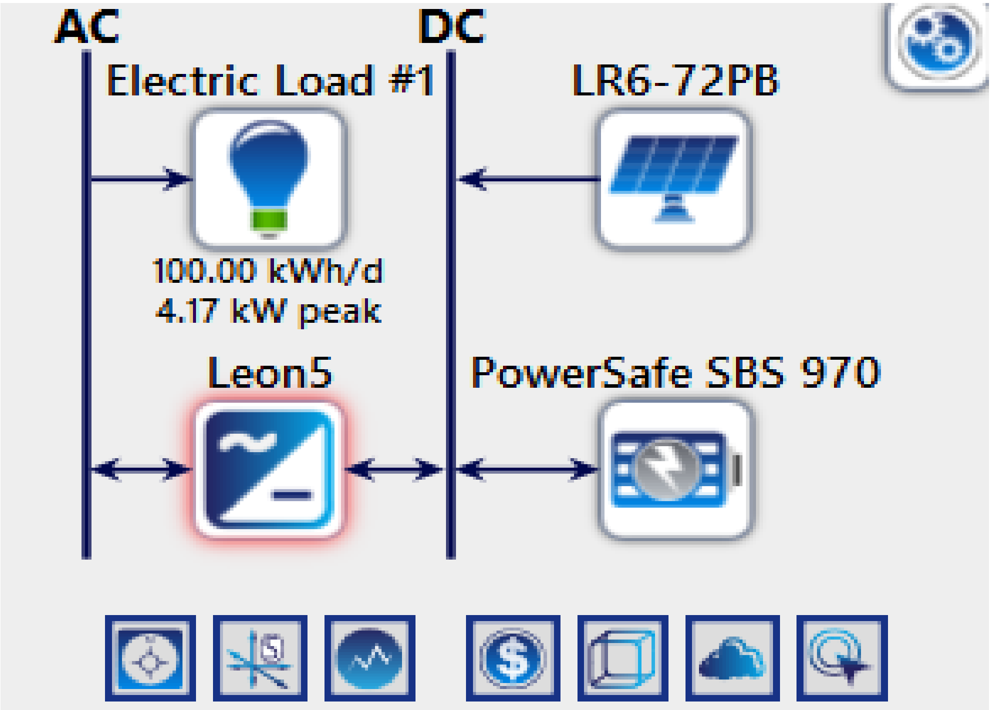


Figure 13: System Sizing Architecture

Figure 14: Condition B Load profile

- Figure below depicts a 100% renewable percentage, with 38% excess electricity, 0.8% of the electric load being unmet and 0.09% of capacity being short.
- The **system's 24-hour operation results in a higher PV capacity and surplus electricity when compared to condition A.**

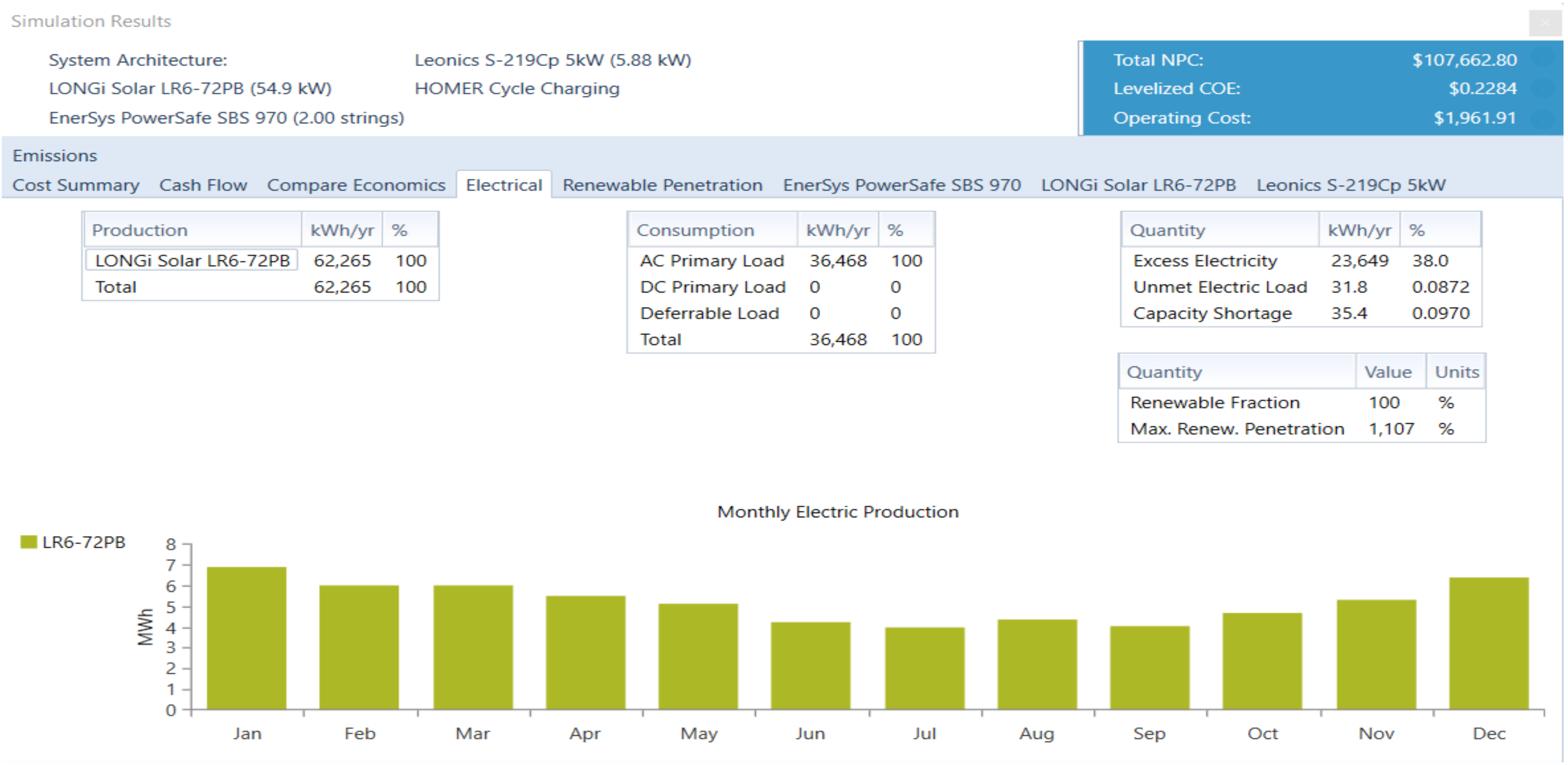


Figure 15: Simulation result details

Battery Performance

- However, the state of charge began to decrease gradually between **June and September. For the *system running for 5 hours***.

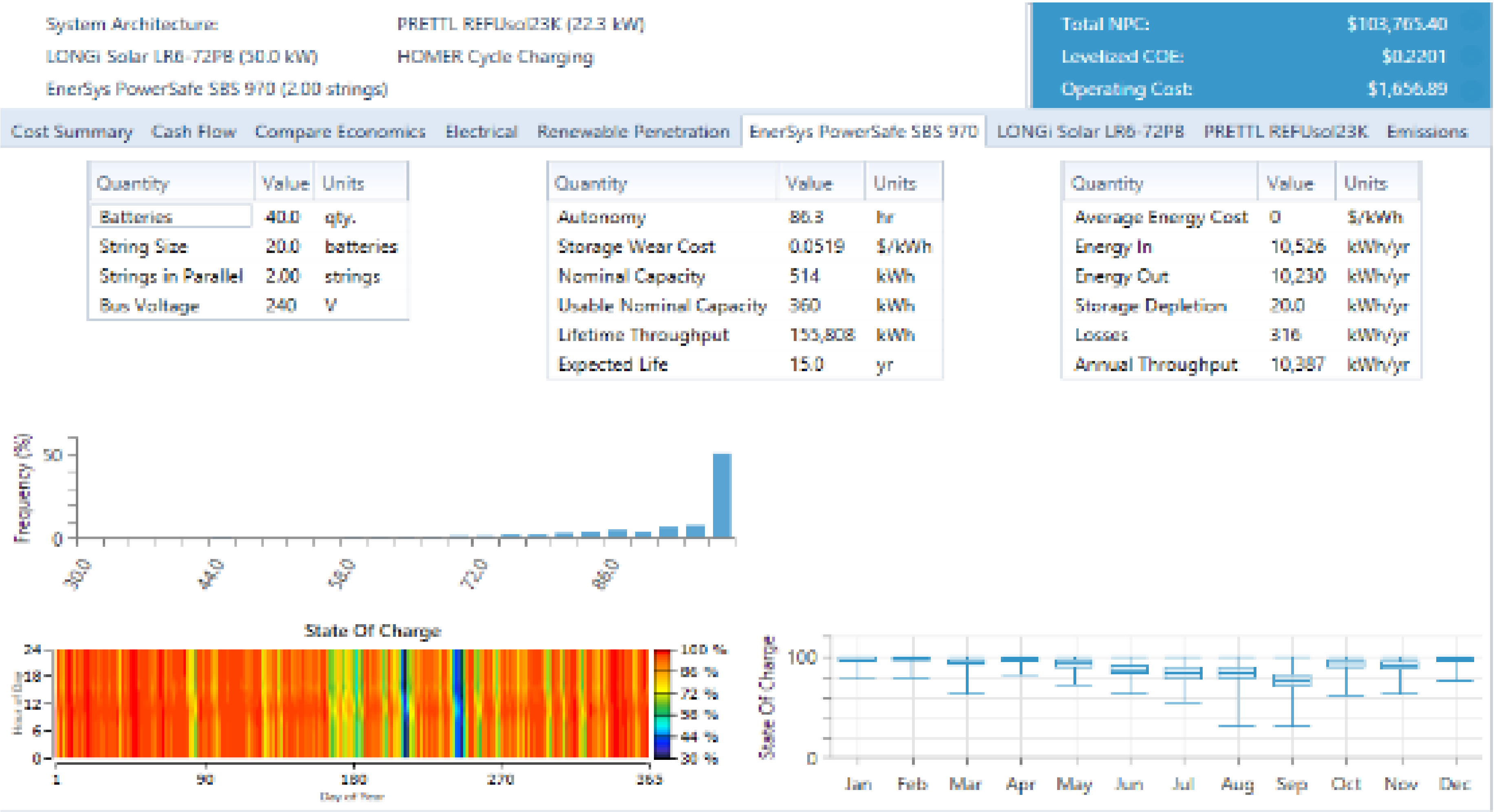


Figure 16: Battery performance details

- For a continuous running time: the state of charge rapidly depleted in August to the ZERO state and was steady till September.

- The reasons for this depletion is due low solar irradiance in the location around July to September . In comparison to the battery performance of both conditions, the system running for 5 hours will perform better during that period

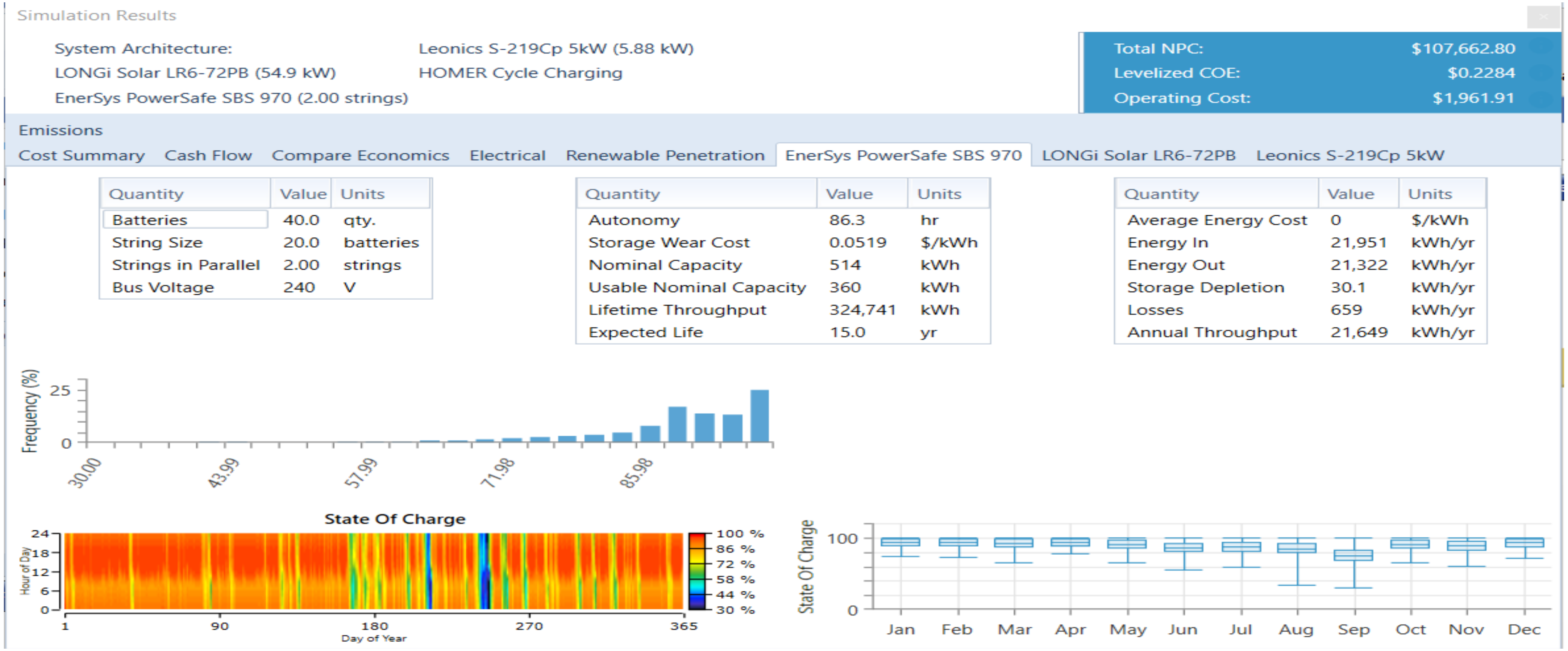


Figure 17: Battery performance details

Overall System and Pump Efficiency

- The oil well depth is too deep for PVsyst to evaluate the pump dynamics.
- As a result, the maximum head is set at 100metres, and the static head and dynamic level are set at the same level position as the site characteristics.
- In order to account for the TDH of 3820m, the system's sizing result will multiply by by 38.2 .
- Choice of Pump was based on the depth of the well and flow rate

➢ **Condition A** :

- Pump performance efficiency is **37.9%,** and the overall system efficiency is **11.4%**. And about ***30% of the reserve were extracted***

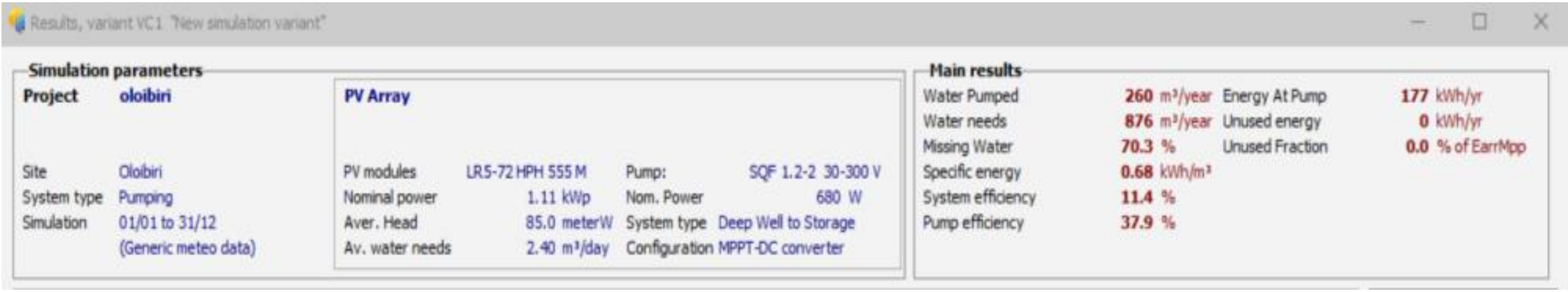


Figure 18: Pre-sizing parameter, simulation parameters and results

- **Condition B** :
- Indicates that the pump efficiency is 11.4%, overall efficiency is 5.6%, and there is 97.7% missing oil.

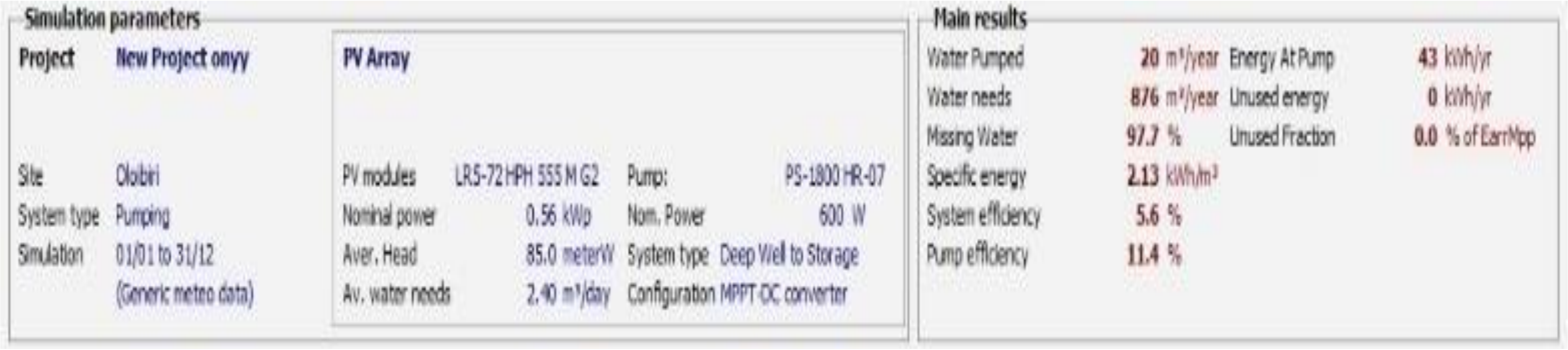


Figure 19: Pre-sizing parameter, simulation parameters and results.

- 5 hours running time is best suited for the location. The optimized system consists of a 22.3kW converter, 40 (970Ah, 12V) batteries, and a 50 kW of 370W 24V Solar panel.

- With a Pump efficiency of 37.9% and about 30% of the reserve being extracted.

System Monitoring And Data Logging Using Plx-daq

- To monitor and evaluate the operating performance in real time since PLX DAQ is an add-on of excel. Automatic data analysis will be done , showing trends of the performance.
- To show why solar-powered systems require real-time monitoring
- To introduce a cost-effective instrumentation and measurement of the entire solar system essential for remote areas using PLX DAQ.

Methodology

- This real-time instrumentation system can measure the oil level and how the energy flows from the PV passing through the schematics as shown below.

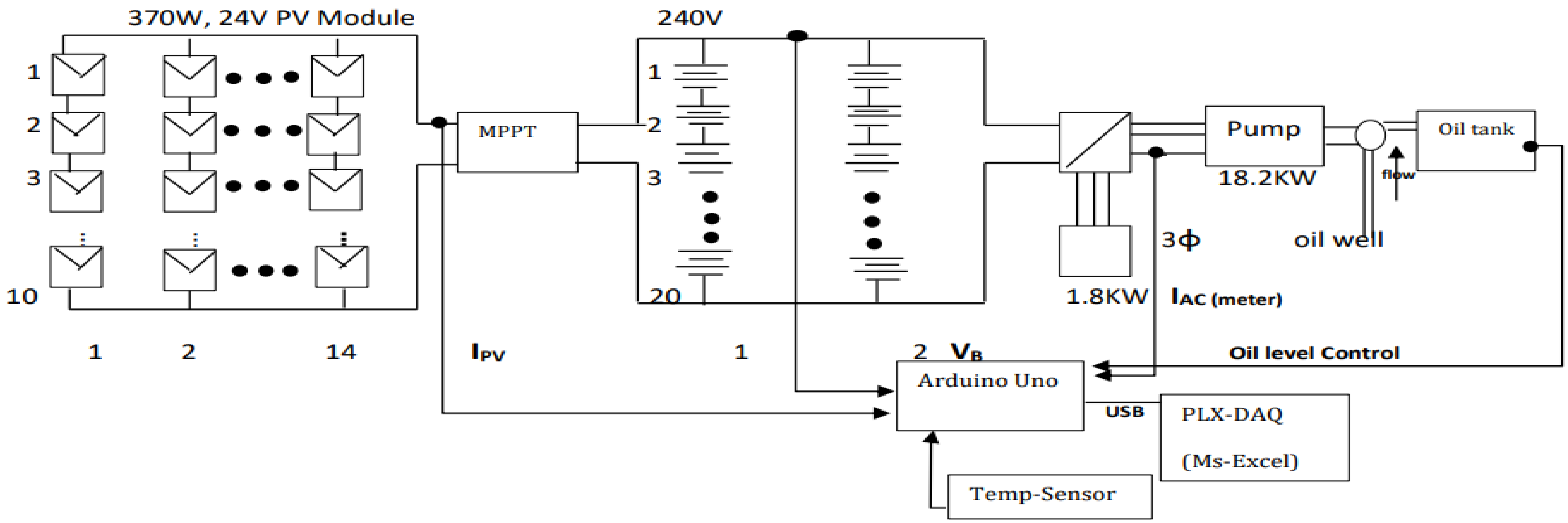


Figure 20: Instrumentation Block Diagram

P.L.X. - D.A.Q. and Syntax

- PLX-DAQ is an add-on tool of Microsoft Excel that connects any device that supports serial port protocol to Microsoft Excel.
- The command **Serial.println("CLEARDATA")** erases all information from the Excel sheet, including the labels. This command should be the initial command in the setup function, and it cleans out any logged data from previous project.
- **Serial.println("LABEL,DATE,TIME,")** is the designated labels for the Excel sheet's top row.
- The most fundamental command in PLX-DAQ is **Serial.print("DATA, DATE, TIME,"),** which is to transfer data from Arduino to Excel and print it excel sheet.
- When putting data into the rows of Excel sheet, the data should be separated by commas with **Serial.print(",");** denoting a separation between item.

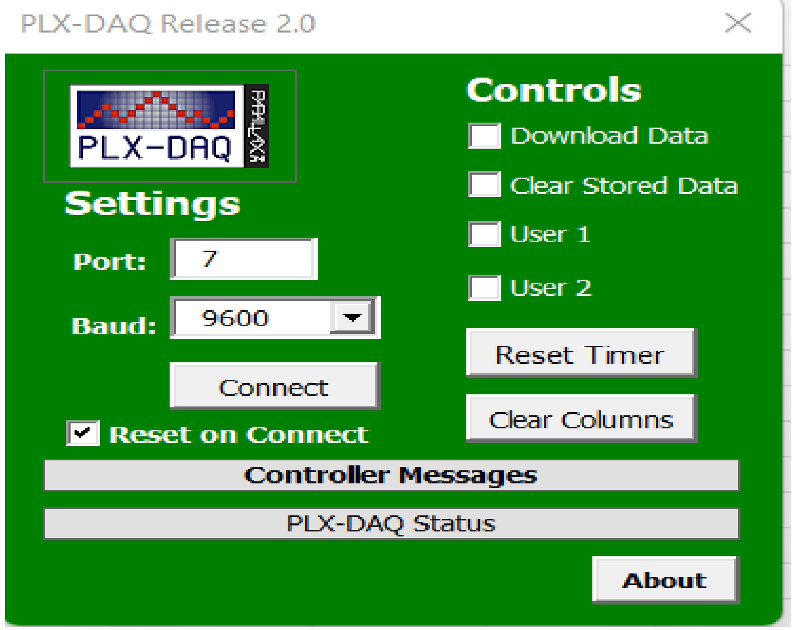


Figure 21 : PLX DAQ User interface

Real-time instrumentation Circuit diagram and material

- Current sensor and voltage sensor are **connected to feed from one source**, an LED is connected to the current sensor through *a 470 ohms* resistor in order to measure the current flowing in it.
- A lighting indicator with a float switch for the oil level control.

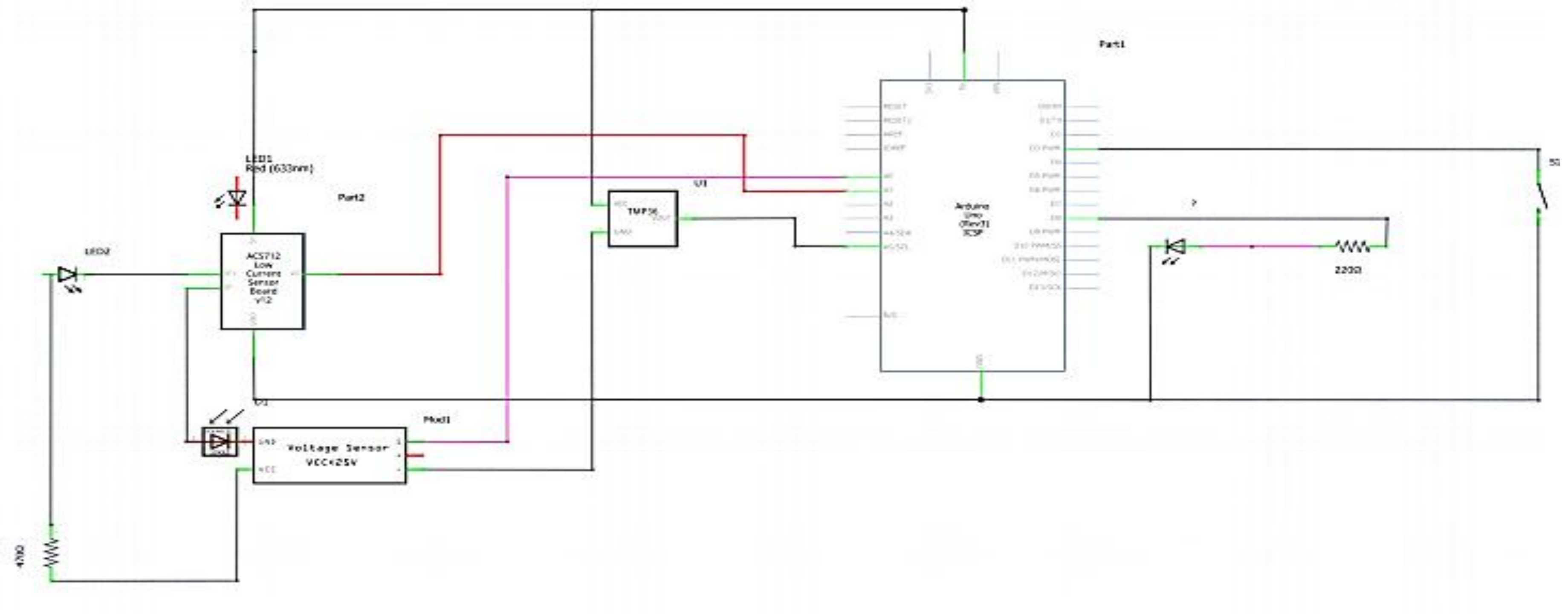


Figure 22: Circuit Diagram Schematic

The Following Hardware are Used for the Implementation.

- **Arduino *UNO***

- This hardware is a microcontroller board with digital and analog pins. The ***Arduino UNO with ATMega328 chip microcontroller is use as the membrane for the control***.

- **Voltage sensor**

- The voltage sensor module measures the voltage from the power supply.

- Voltage range between 0 and 24V,

- For this circuit, the **F031-06 voltage** sensor module is use

- **Current sensor**

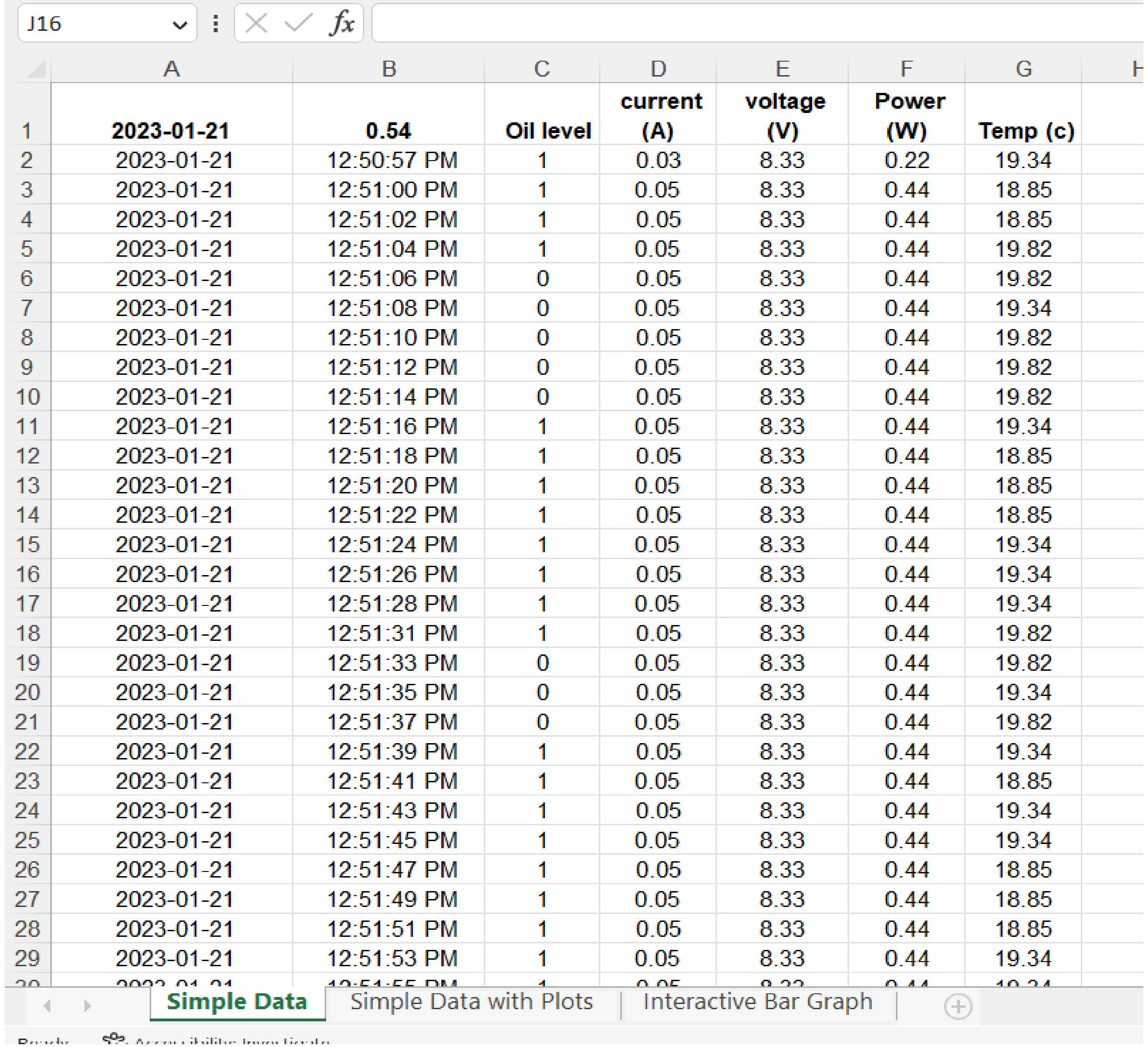
- The ACS712 chip uses the Hall Effect to measure DC/AC**. <<5A Range**
- ACS712ELCTR-05B-T model is used with a sensitivity of **185mV**
- Sensor sensitivity means when the input current increases by 1 amp, the sensor's output voltage increases by about **185 mV**

- **Float Switch**

- To determining the oil level in an oil tank
- Functions like an **electromagnetic ON/OFF switch**, with magnetic float sensor

Results from Plx Daq

- The simulation limitation is that the current sensor is limited to 5A, the voltage sensor is limited to a range << 25V and the temperature sensor TMP36 measures between -40°C and 125°C.
- For practical demonstration, the results shown below were carry out using a 9V battery, and the temperature sensor was varied under different environmental conditons.
- One major limitation for PLXDAQ is that the Float switch outputs read between 1 and 0.
- **Serial.print(buttonState)** will only give the digital indication of 1 when the oil level is high and 0 when the oil level is low.
- One Advantage of a PLX-DAQ is that it an excel tool which can be further used for data analysis and trends



1	2023-01-21	0.54	Oil level	current (A)	voltage (V)	Power (W)	Temp (c)
2	2023-01-21	12:50:57 PM	1	0.03	8.33	0.22	19.34
3	2023-01-21	12:51:00 PM	1	0.05	8.33	0.44	18.85
4	2023-01-21	12:51:02 PM	1	0.05	8.33	0.44	18.85
5	2023-01-21	12:51:04 PM	1	0.05	8.33	0.44	19.82
6	2023-01-21	12:51:06 PM	0	0.05	8.33	0.44	19.82
7	2023-01-21	12:51:08 PM	0	0.05	8.33	0.44	19.34
8	2023-01-21	12:51:10 PM	0	0.05	8.33	0.44	19.82
9	2023-01-21	12:51:12 PM	0	0.05	8.33	0.44	19.82
10	2023-01-21	12:51:14 PM	0	0.05	8.33	0.44	19.82
11	2023-01-21	12:51:16 PM	1	0.05	8.33	0.44	19.34
12	2023-01-21	12:51:18 PM	1	0.05	8.33	0.44	18.85
13	2023-01-21	12:51:20 PM	1	0.05	8.33	0.44	18.85
14	2023-01-21	12:51:22 PM	1	0.05	8.33	0.44	18.85
15	2023-01-21	12:51:24 PM	1	0.05	8.33	0.44	19.34
16	2023-01-21	12:51:26 PM	1	0.05	8.33	0.44	19.34
17	2023-01-21	12:51:28 PM	1	0.05	8.33	0.44	19.34
18	2023-01-21	12:51:31 PM	1	0.05	8.33	0.44	19.82
19	2023-01-21	12:51:33 PM	0	0.05	8.33	0.44	19.82
20	2023-01-21	12:51:35 PM	0	0.05	8.33	0.44	19.34
21	2023-01-21	12:51:37 PM	0	0.05	8.33	0.44	19.82
22	2023-01-21	12:51:39 PM	1	0.05	8.33	0.44	19.34
23	2023-01-21	12:51:41 PM	1	0.05	8.33	0.44	18.85
24	2023-01-21	12:51:43 PM	1	0.05	8.33	0.44	19.34
25	2023-01-21	12:51:45 PM	1	0.05	8.33	0.44	19.34
26	2023-01-21	12:51:47 PM	1	0.05	8.33	0.44	18.85
27	2023-01-21	12:51:49 PM	1	0.05	8.33	0.44	18.85
28	2023-01-21	12:51:51 PM	1	0.05	8.33	0.44	18.85
29	2023-01-21	12:51:53 PM	1	0.05	8.33	0.44	19.34

Figure 22: Data readings collected in the excel spreadsheet from the Arduino for the practical demonstration.

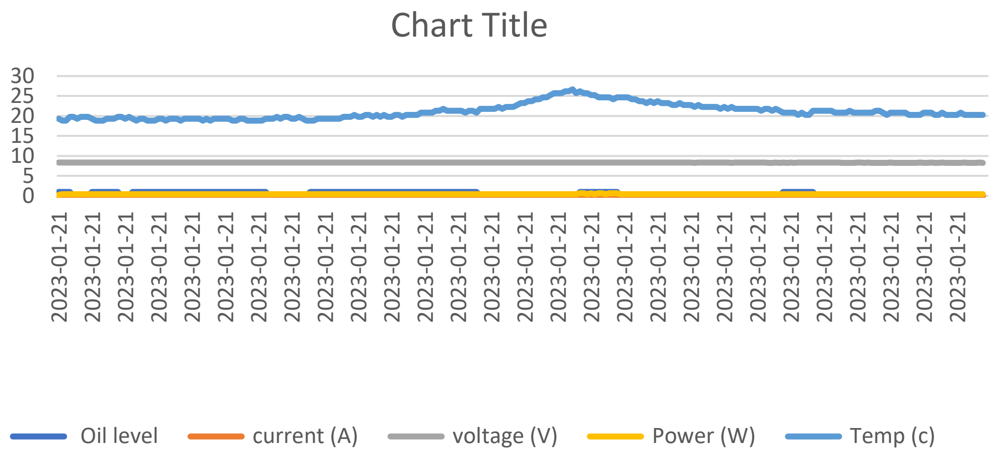


Figure 23 : Overall data plot in Excel.

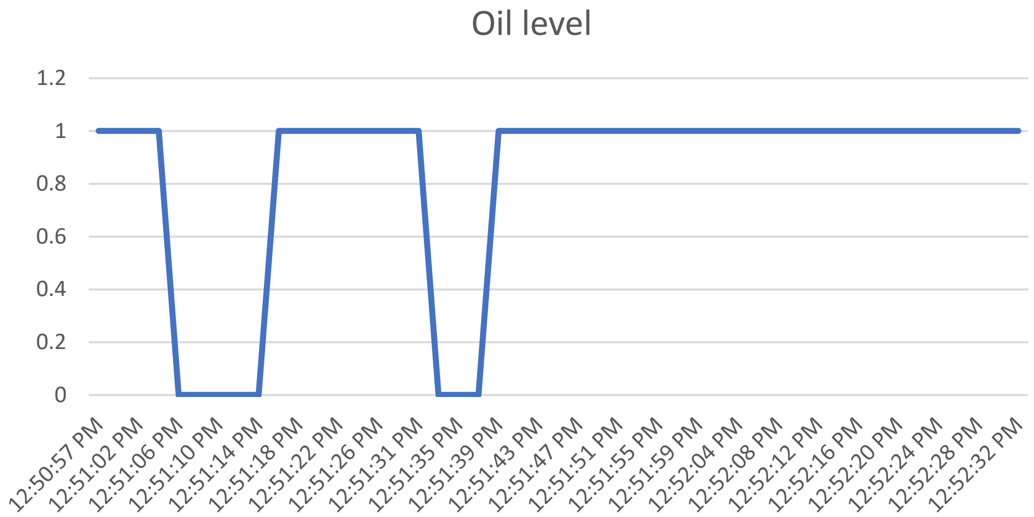


Figure 24 : Oil level float switch status

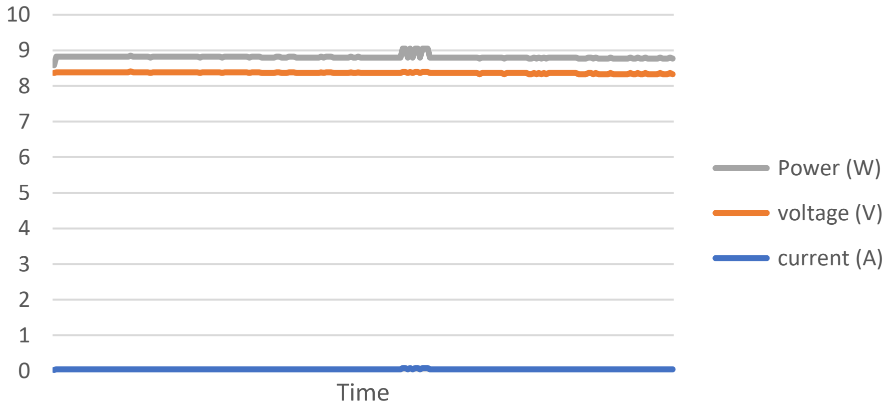


Figure 25 : Voltage, Current and Power data from a lab test setup

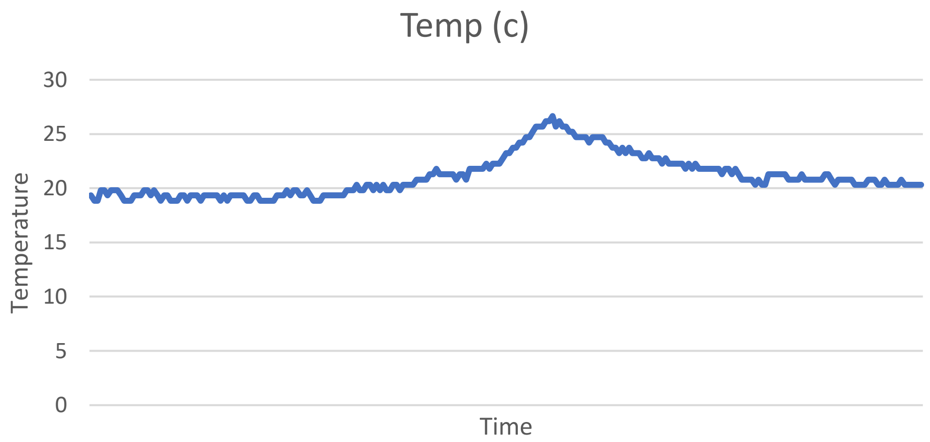


Figure 26 : Temperature Data Chart

Real-time Monitoring And Data Acquisition Using LoRa For a Remote Solar Powered Oil Well.

- This study proposes a wireless communication-based approach that allows for data acquisition and system monitoring of the entire solar system of a remote oil well in regions with no internet network.
- A wireless communication tool for a long-range transmission called **LoRa** is used, ***TTGO LoRa32 SX1276 OLED as the sender node and Heltec LoRa esp 32 as the transmitter node.***
- This process involves utilizing a LoRa module transmitter to receive sensor data . Subsequently, the data is transmitted from the LoRa sender node to a receiver node.

Lora Sender

- The flowchart shown in below illustrates the systematic process of a Sender Node
- initialize the setup,
- Read sensor information
- transmit the data as packets to the receiver node.

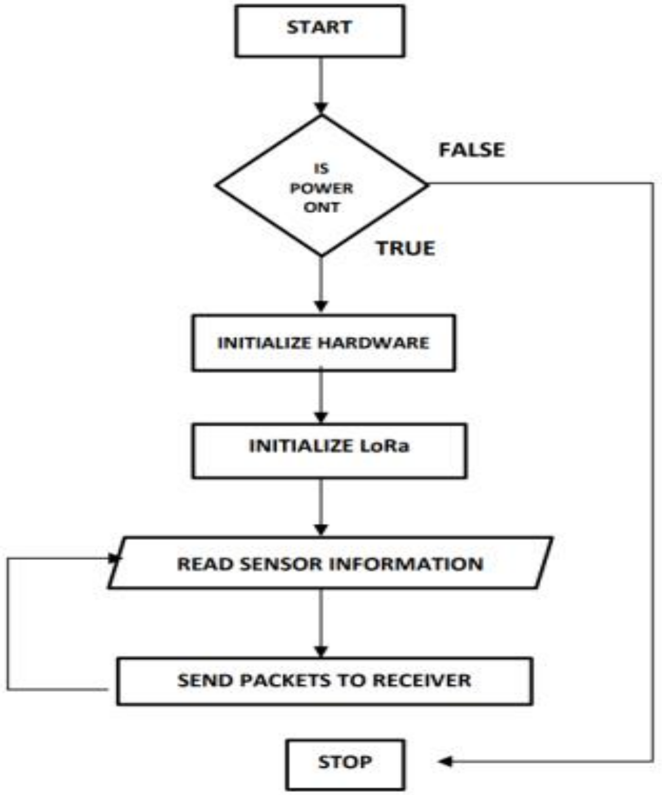


Figure 27: LoRa Sender Node FlowChart

- **Lora Receiver**

- The following flowchart presents the system of methods employed in the receiver node.
- initialize the setup,
- Receive the Packet from the sender
- Updates Data in the open source

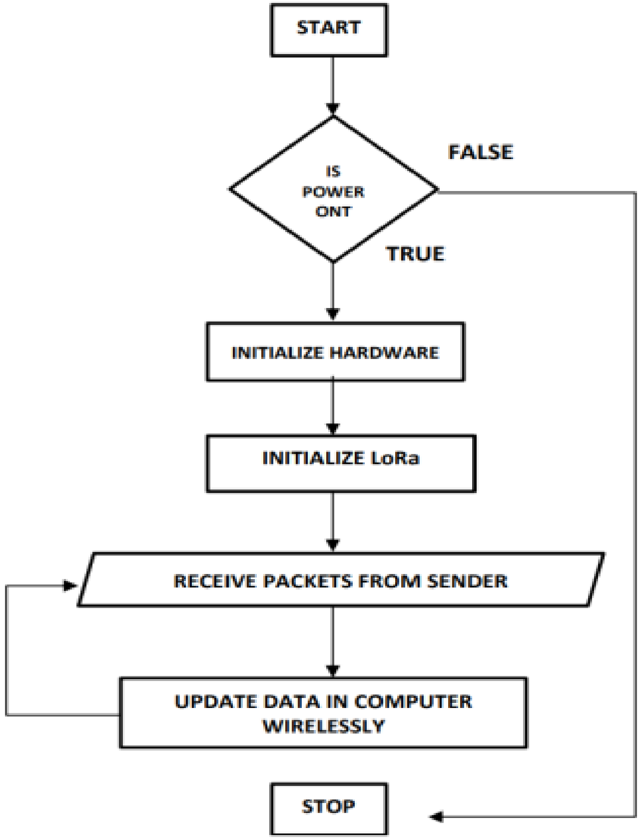


Figure 28: Lora Receiver Node Flowchart

Other Wireless Communications

- **ZigBee mesh :** reliable performance over **short to medium distances**.
- Bluetooth **transmission rates are moderate**, but the **range is severely restricted.**
- The **IEEE802.11 Wireless Local Area Network:** high transmission rate and bandwidth capabilities but limited transmission range and high battery consumption.
- **Wi-Fi** : short battery life and must be close to the Wi-Fi access point . with operating frequencies of 2.4 and 5 GHz of Wi-Fi signals which make them **less effective at passing through obstacles.**
- LoRa technology is a promising solution for IoT-driven applications.

LoRa technology

- Low Power consumption
- easy install, cost-effective
- Data transmission is secured and can be encrypted.
- High transmission rate
- Up to 30km of transmission range
- Independent on the network connection

Methodology

- To transmit the data wirelessly using LoRa by using Heltec LoRa 32 device and TTGO LoRa32.

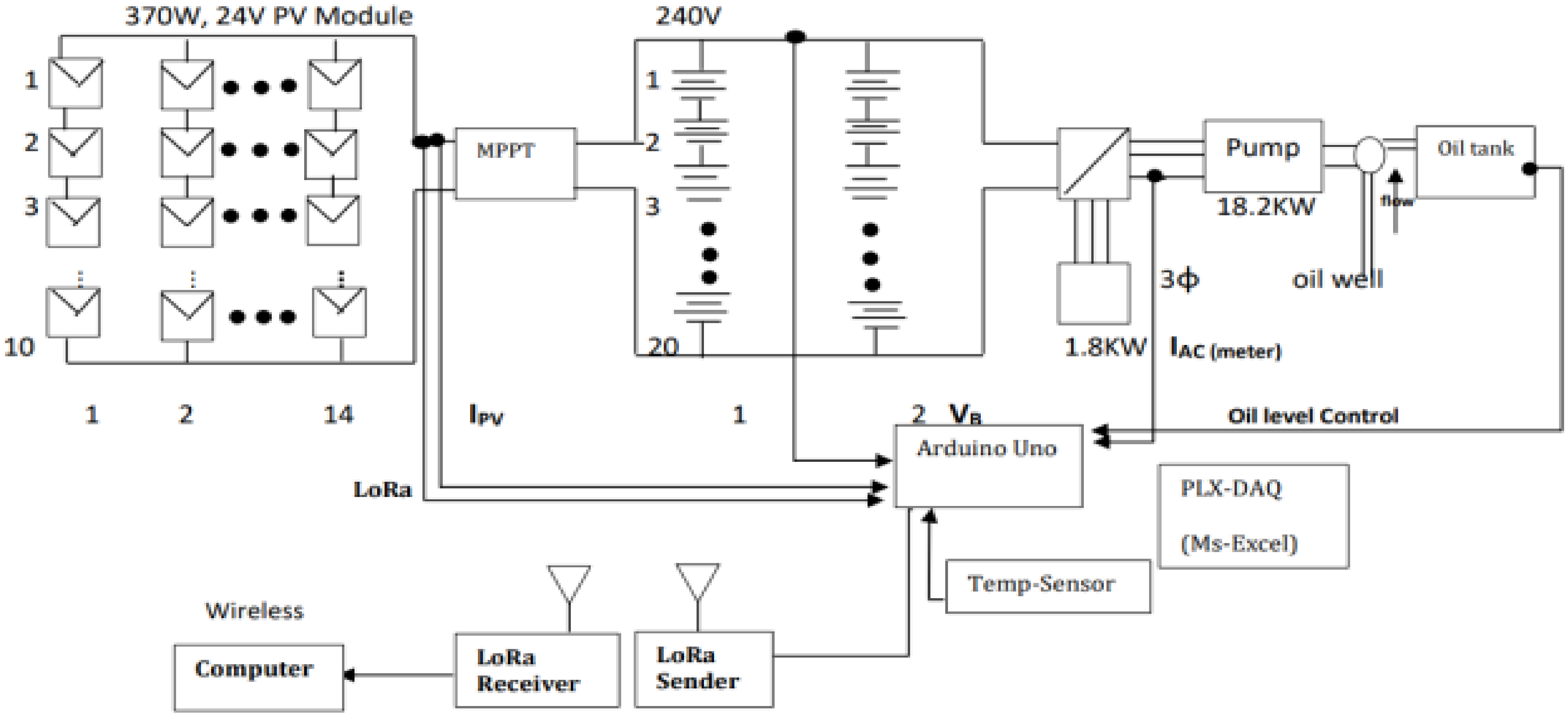


Figure 29: Instrumentation Block Diagram of the Entire Monitoring System

LoRa Sender/ Receiver Syntax

- During the configuration of LoRa, **including the library that facilitates the communication between the esp. 32 and the LoRa module.**
- Within the **setup() function**, it becomes essential to carry out **software reset of the OLED by utilizing the RST pin.**
- In order to identify and establish the necessary connections for the LoRa chip, the LoRa module utilizes **the SPI pins and must be defined.**
- Subsequently, initialize the LoRa module by **begin() function** and **specifying the desired frequency** BAND 915E6 is for North America.
- In the loop() function, the transmission of packets will occur.
- The **int packetSize = LoRa.parsePacket();** is to receive a packet from the sender module, while the while **(LoRa.available()) {** is to read the packet.

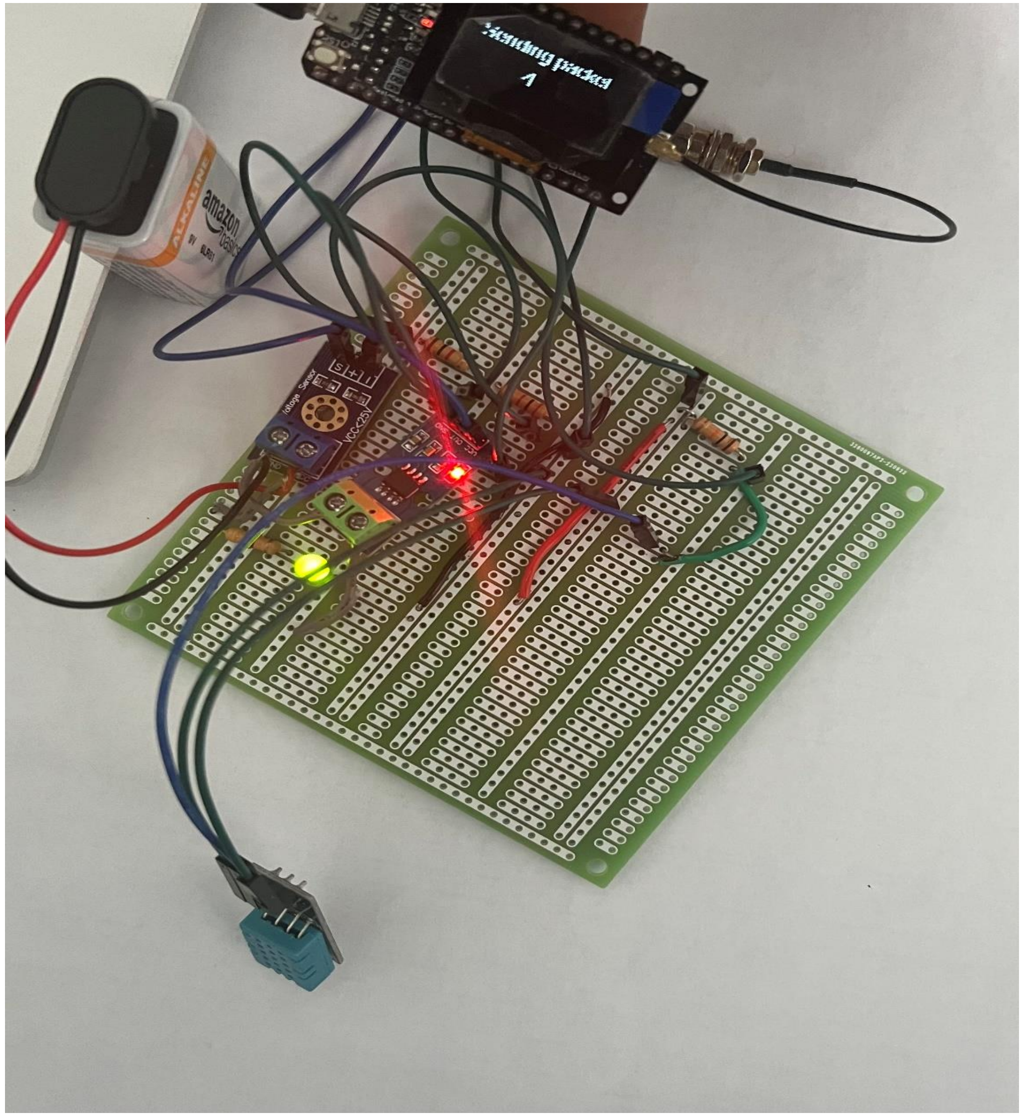


Figure 30: Implemented Circuit with Sender Node

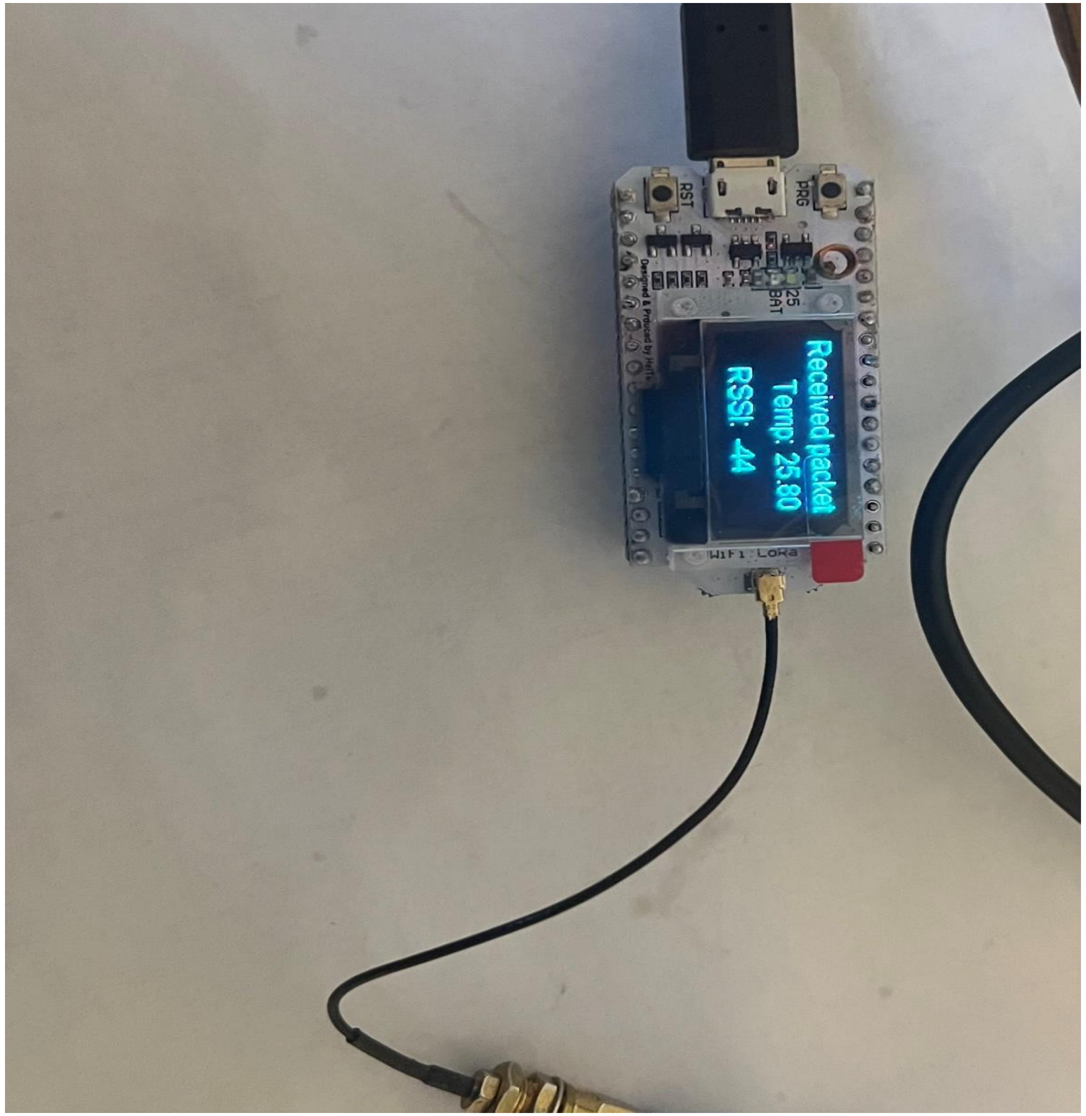


Figure 31: Receiver Node

```
PuTTY (inactive)
ets Jun  8 2016 00:22:57

rst:0x1 (POWERON_RESET),boot:0x17 (SPI_FAST_FLASH_BOOT)
configsip: 0, SPIWP:0xee
clk_drv:0x00,q_drv:0x00,d_drv:0x00,cs0_drv:0x00,hd_drv:0x00,wp_drv:0x00
mode:DIO, clock div:1
load:0x3fff0018,len:4
load:0x3fff001c,len:1044
load:0x40078000,len:10124
load:0x40080400,len:5856
entry 0x400806a8
LoRa Receiver
LoRa Initial OK!
Received packet. Temp:26.70
Voltage (V):7.85
current(A):0.45
Power(W):3.55
OilLevel:0
Counter:36
 with RSSI -34
Received packet. Temp:26.70
Voltage (V):7.83
current(A):0.45
Power(W):3.55
OilLevel:0
Counter:37
 with RSSI -33
Received packet. Temp:26.70
Voltage (V):7.81
current(A):0.45
```

Figure 32: Data Transmitted wirelessly to PuTTY

```
Received packet. Temp:26.70
Voltage (V):7.80
current(A):0.45
Power(W):3.52
OilLevel:0
Counter:70
 with RSSI -33
Received packet. Temp:26.70
Voltage (V):7.81
current(A):0.46
Power(W):3.57
OilLevel:1
Counter:71
 with RSSI -32
Received packet. Temp:26.70
Voltage (V):7.79
current(A):0.45
Power(W):3.52
OilLevel:1
Counter:72
 with RSSI -31
Received packet. Temp:26.70
Voltage (V):7.80
current(A):0.46
Power(W):3.55
OilLevel:1
Counter:73
 with RSSI -30
Received packet. Temp:26.70
Voltage (V):7.78
current(A):0.46
Power(W):3.56
OilLevel:0
Counter:74
 with RSSI -42
Received packet. Temp:26.70
Voltage (V):7.80
current(A):0.46
Power(W):3.58
```

Figure 33: Data indicating that the Oil Level is high

Conclusion and Future Work

➢ Conclusion

- The impact of an abandoned well with a low production rate on the environment is severe.
- To mitigate this issue, a cost-effective alternative technology, namely the solar-powered pump, presents an effective solution for oil companies, considering the expensive nature of minimizing the impact caused by pumping the remaining oil.
- In this context, a comprehensive system sizing approach was proposed for Olobiri oil well 17.
- The software's performance was evaluated by simulating the oil depth to align with the site's specifications. The results showed that for a 5-hour running time, the system efficiency was 11.4%, and the pump efficiency was 37.9%
- A real time and remote system monitoring was implemented irrespective of Internet connection

➢ Future Work

- In the scope of future work, the system modeling should be comprehensively performed using MATLAB, encompassing all the electrical devices' specifications.
- The model must accurately depict the electrical response under two distinct working conditions: when operating for 5 hours and when running non-stop.
- It is crucial to integrate the optimized system details from HOMERpro into the model to assess its compatibility with the intended operations.

Publications

- **Articles in Refereed Publications**

- O. Chidolue and M. Tariq Iqbal, “Design and Performance Analysis of an Oil Pump Powered by Solar for a Remote Site in Nigeria,” *European Journal of Electrical Engineering and Computer Science*, vol. 7, no. 1, pp. 62–69, Feb. 2023, doi: https://doi.org/10.24018/ejece.2023.7.1.496.
- O. Chidolue and T. Iqbal, “Real-time Monitoring and Data Acquisition using LoRa for a Remote Solar Powered Oil well “ has been accepted for publication under the *International Journal of Applied Power Engineering (IJAPE)*

- **Refereed Conference Publications**

- O. Chidolue and T. Iqbal, "System Monitoring and Data logging using PLX-DAQ for Solar-Powered Oil Well Pumping," 2023 IEEE 13th Annual Computing and Communication Workshop and Conference (CCWC), Las Vegas, NV, USA, 2023, pp. 0690-0694, doi: 10.1109/CCWC57344.2023.10099099.
- S. U. Uddin, O. Chidolue, A. Azeez and T. Iqbal, "Design and Analysis of a Solar Powered Water Filtration System for a Community in Black Tickle-Domino," 2022 IEEE International IOT, Electronics and Mechatronics Conference (IEMTRONICS), Toronto, ON, Canada, 2022, pp. 1-6, doi: 10.1109/IEMTRONICS55184.2022.9795758.

- **Regional Conference Publications**

- O.Chidolue and M. Tariq Iqbal, “Design of a Solar Powered Pump for oil well in Nigeria presented at the 32nd Annual IEEE NECEC conference St. John’s, 2022

THANK YOU