DESIGN AND ANALYSIS OF A SOLAR WATER PUMPING FOR A FISH FARM IN PAKISTAN

Presented by:
- Adnan Sarwar
  Memorial University of Newfoundland

Supervised by:
- Dr. Tariq Iqbal
  Memorial University of Newfoundland

CONTENT

INTRODUCTION

OVERVIEW OF FISH FARMING

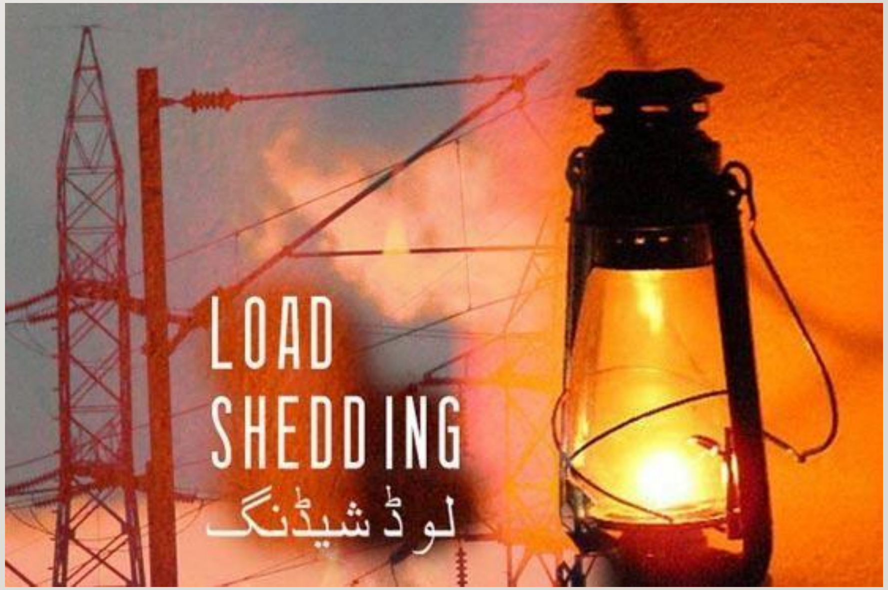
- 18 million people are connected in fish farming in Asia pacific region, and 90% are categorized as small-scale fish farming Stated to the Food and Agriculture Organization of the United Nations (FAO)
- Overfishing has made wild capture fisheries increasingly unsustainable over the last few decades.
- Efforts are being made to reduce harvesting from the ocean to maintain the ecosystem of the marine environment.
- As a result, aquaculture is growing, particularly in developing countries.
- A typical fish farm needs a water pump to operate for many hours a day, thus putting a significant strain on power consumption.

OVERVIEW OF WATER RESOURCES OF PAKISTAN

- Water availability was around 5000m^3 per capita in the 1950s
- It has shrunk to around 1000m^3 per capita currently
- By 2025, the water shortfall is expected to reach 150.8 Million acre-feet

ELECTRICITY SCENARIO OF PAKISTAN

- The country's scenario is not ideal as a shortfall of 5,000MW is faced by the country
- Tilt is towards fossil fuels for powering water pumping systems



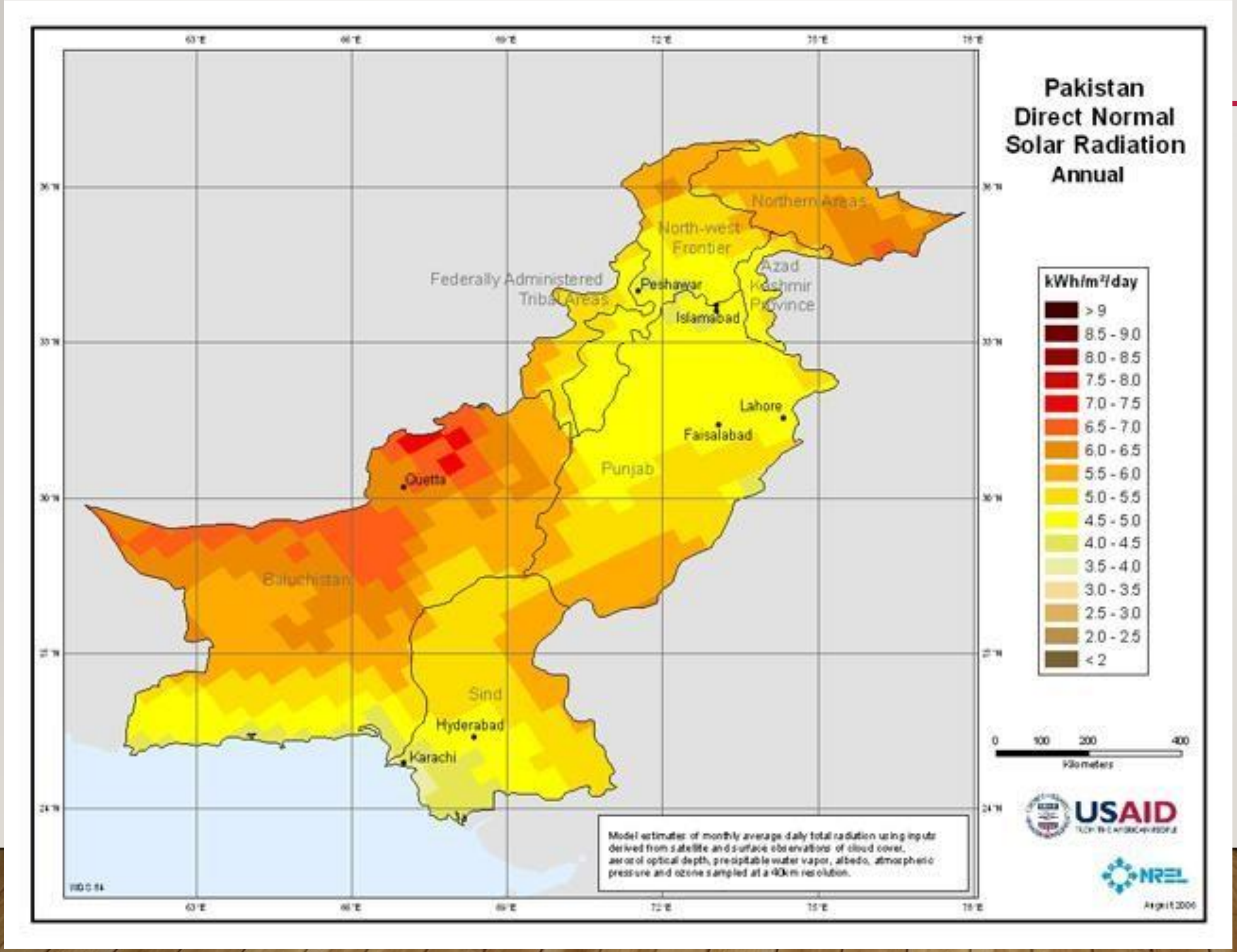
FOSSIL FUELS DEPENDENCE AND PAKISTAN

- Pakistan is not rich in fossil fuels and is primarily not an oil-producing country
- It imports 346,400 barrels of oil on a daily basis, which costs a staggering 10.7 billion US dollars to the economy
- Its increased dependence on imported fossil fuel for electricity production has increased the circular debt to 1.2 trillion Pakistani rupees during the period of last five years

SOLAR POTENTIAL OF PAKISTAN

- There is a massive potential for renewable energy in Pakistan, which is around 167.7 GW
- Among renewable energies, the potential for photovoltaics, in particular, is immense in the country
- Pakistan is one of the wealthiest countries in terms of its solar potential, which is up to 100,000MW
- The average solar insolation for the country is about 5.5kWh/m^2/day

SOLAR POTENTIAL OF PAKISTAN



LITERATURE REVIEW

LITERATURE REVIEW

Literature Surveyed Regarding Solar power System design and economic analysis

Paper Reviewed	Comments
P. Chaudhary	Discussed different components, parameters and control methodologies related to a solar water pumping system
A. Allouhi	Discussed sizing and economics of a solar water pumping system
R. Sharma	Discussed optimized design of a solar water pumping system
M. T. Chaichan	Discussed four different designs of solar water pumping system and found PV based solar water pumping system to be the most feasible solution
H. A. Kazem	Discussed designing of a solar water pumping system in Oman
S. Biswas	Discussed a solar water pumping design in HOMER for Bangladeshi conditions
F. Alkarrami	Designed solar water pumping systems using HOMER Pro, HOMER Beta, and iHOGA software and found HOMER Pro as the best option

LITERATURE REVIEW

Literature Review regarding water pumping system automation and control

Paper Reviewed	Comments
Biswas	ESP32 microcontroller was used for water pumping automation for an irrigation system. The programmable sensors used to detect temperature, humidity, and soil moisture levels
Reza	PIC1650 microcontroller used with water level sensor for a water management system for home to reduce water consumption.
G anesh and S. Girishi	GSM module and a PIC16F877A microcontroller are used to automate the water pump for irrigation purposes. The system operates through the mobile phone to start or stop the water pump
Cahyono and Dwi	An automation system for fishpond water circulation designed using Arduino UNO. The system consisted of a ph sensor, water level sensor, and water pump.
Snehal R and R S Khamitkar	ATMEGA 3 GSM microcontroller is used to automate farmers' 3-phase water pump control. Automation of the water pump monitored the electricity supply, water flow rate, and water level in the reservoir

LITERATURE REVIEW

Literature Review regarding IoT-based real-time health monitoring system for fish farming

Paper Reviewed	Comments
K. Preetham and K. Umesha	Raspberry Pi-3 is used with turbidity, pH, temperature, and water level sensors. Time series charts display the system quality metrics using the Wi-Fi module
R. K. Kodali and A. C. Sabu	ESP32 microcontroller and DHT11 were used to monitor the temperature, water level sensor, and fish feeder for the fish farm. Data can be accessed anywhere using the Amazon web services dashboard
C.S. Goud and S. Das	A wireless sensor network model for shrimp culture monitoring using open source IoT. Arduino microcontroller used with pH, dissolved oxygen, and temperature sensors.

RESEARCH OBJECTIVE

- Design and optimization of a solar PV system for an off-grid fish farm in Pakistan using homer pro, which can provide uninterrupted electric power to a fish farm.
- Solar-powered water pumping system automation and control for fish farm, which can reduce the fish farm operating cost and save electricity
- IoT- based real-time fish farm health monitoring system, aquafarmers can increase fish production and growth using a monitoring system.

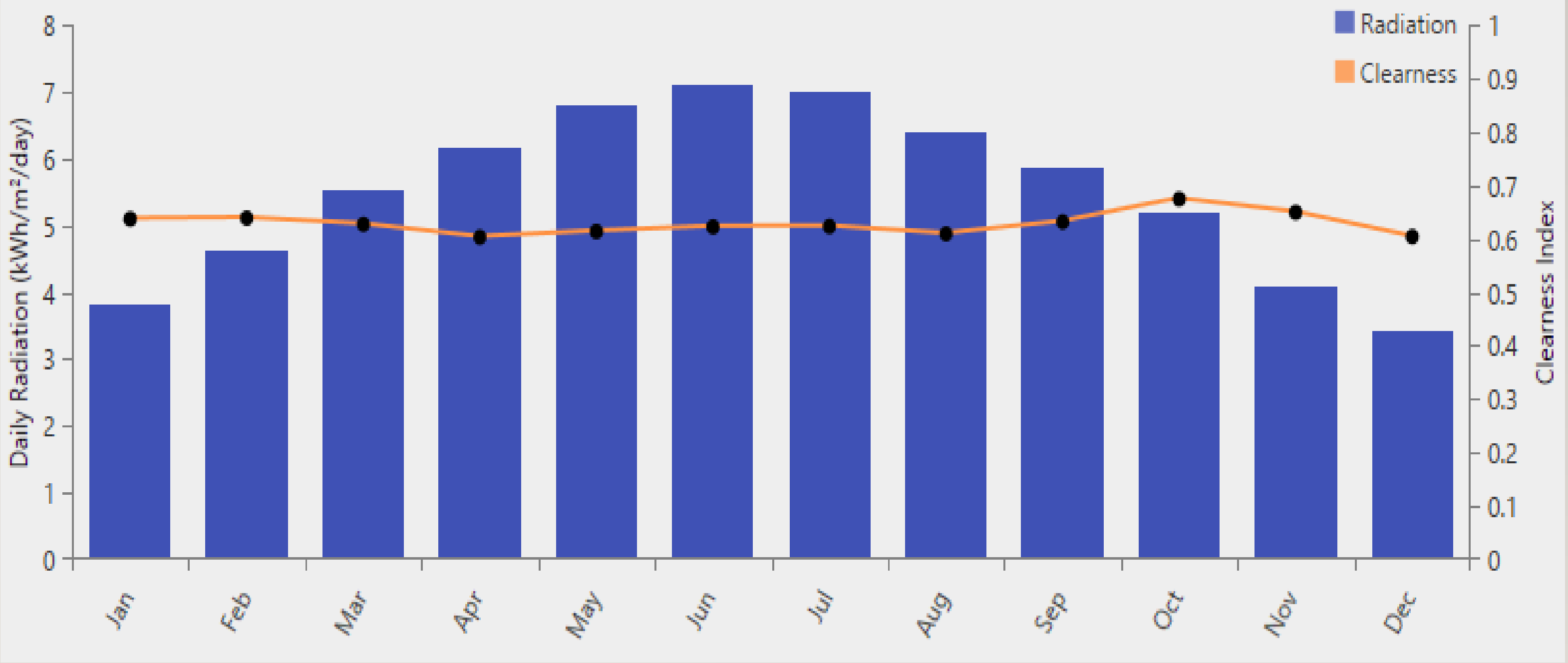
DESIGN AND OPTIMIZATION OF A SOLAR PV SYSTEM FOR A FISH FARM IN PAKISTAN

SITE SELECTION

- A site location is “Saif Khosa Fish Farm” located near the bank of river Indus near Wasti Mahermani, Kot Haibat, District Dera Ghazi Khan, Punjab, Pakistan. Location coordinates are 30° 6' 40.88753" E, 70° 38' 56.34821"N

SOLAR RADIATION

- The solar radiation and the clearness index data for the chosen location Dera Ghazi Khan, Pakistan, is retrieved from the National Renewable Energy Laboratory (NREL) global database.

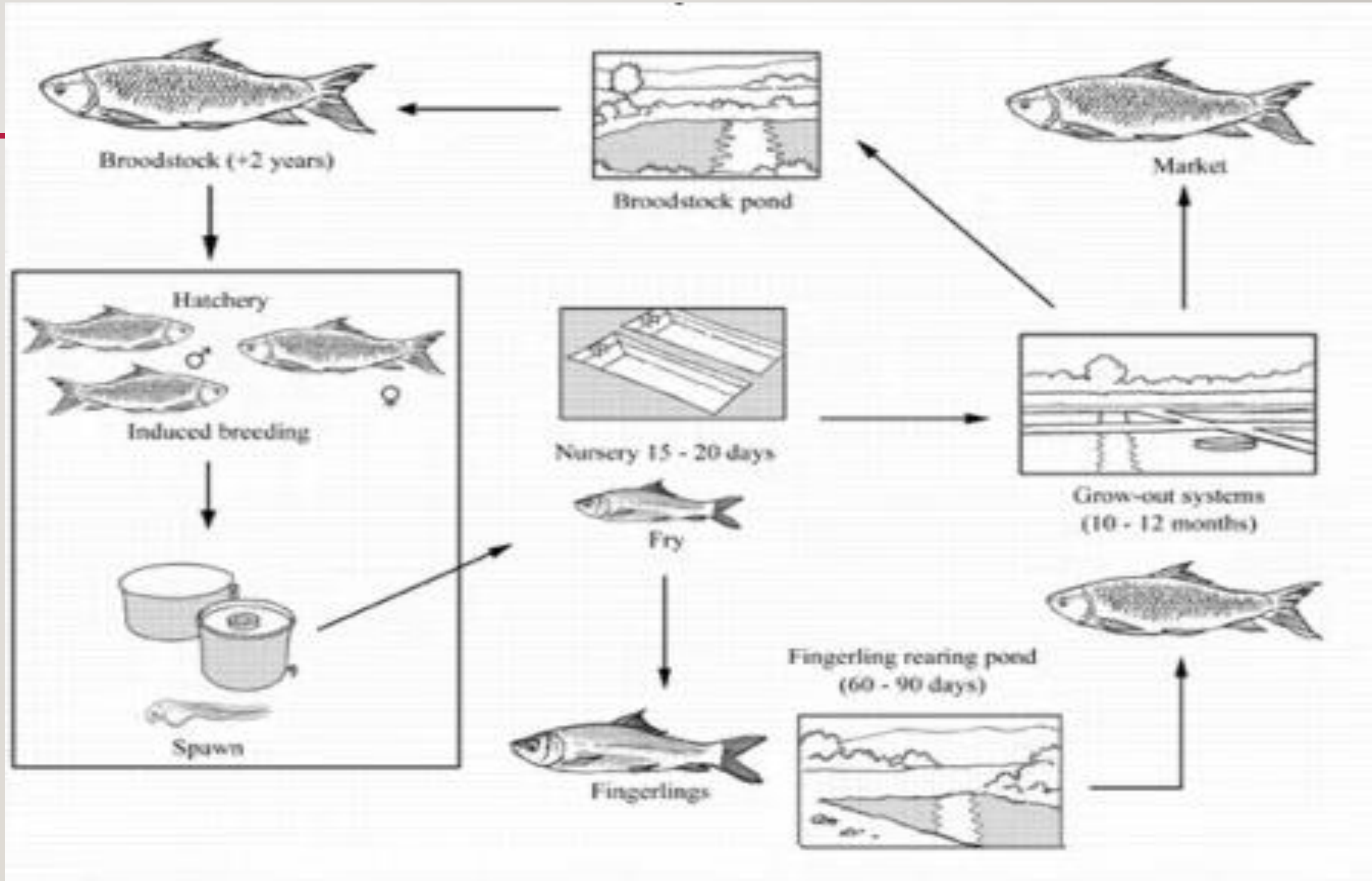


CHOICE OF SYSTEM SIZING TOOL: HOMER

- HOMER stands for Hybrid Optimization of Multiple Energy Resources. It is a software application used to design and analyze a power system's technical and financial aspects for stand-alone, remote, and distributed generation applications.

HOMER Pro
STANDALONE MICROGRIDS

FISH FARM OPERATION



CALCULATION OF WATER PUMP LOAD

- According to the table required water volume, 230 m^3/hour water flow is suitable for the fish farm. Based on the selected flow rate, 156 hours are required to fill the water into the ponds as needed.
- **Water level = 15ft**
- **Dynamic head = 25ft**
- **Pipe diameter= 6 inch**
- **Water flow requirement = 230 m^3/h**

Ponds	Surface area (m^2)	Average water depth (m)	Water volume (m^3)
1	10052.84	1.5	15079.26
2	6045.34	1.5	9068.02
3	2841.63	1.5	4262.44
4	5366.36	1.2	6439.63
5	1003.84	1	1003.84

PROPOSED WATER PUMP

- The proposed WILO pump, model is Atmos GIGA-B 150/180-7, 5/4 Single-Stage centrifugal pump.

Motor data

Motor efficiency class: IE3
Mains connection: 3~400V/50 Hz
Voltage tolerance: +-10 %
Rated power: 7,5 kW
Rated speed: 1450 1/min
Rated current: 14,9 A
Power factor: 0,81
Motor efficiency: 87,4 %
Motor efficiency: 89,3 %
Motor efficiency: 89,8 %
Insulation class: F
Protection class: IP55
Motor protection: PTC integrated

LOAD PROFILE OF THE FISH FARM

Water Pump

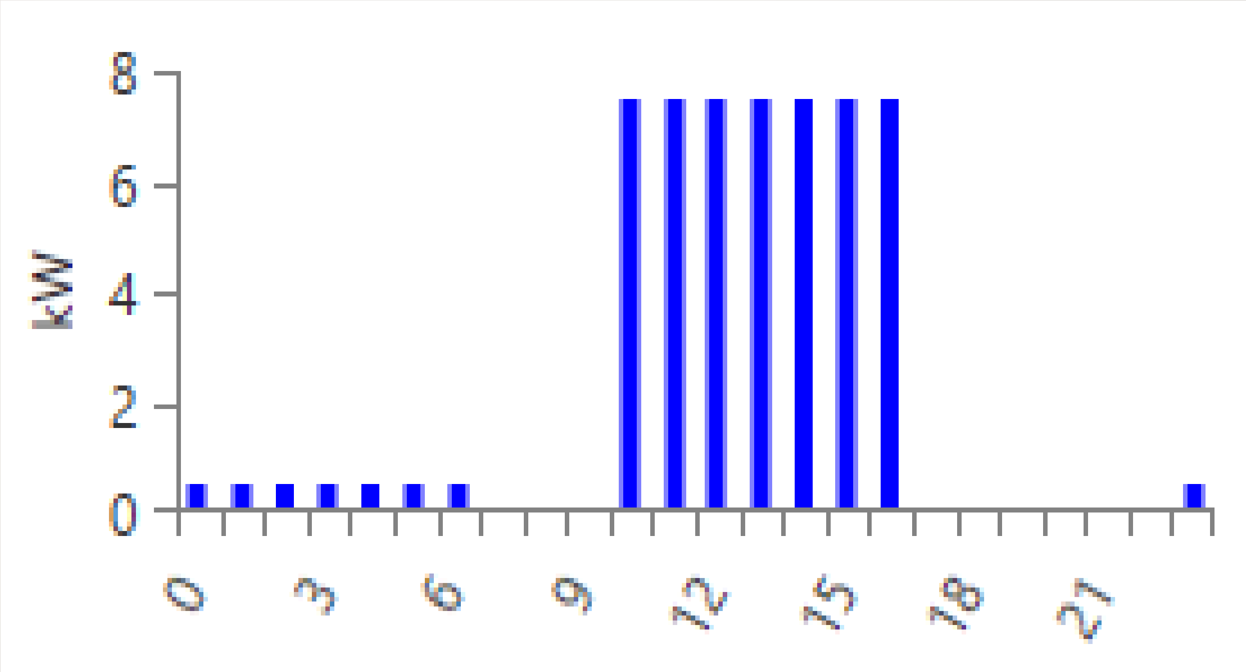
Schedule	Months	Time	Daily Hours
1	November to May	09:00-16:00	7
2	June to July	06:00-18:00	12
3	August to October	08:00- 16:00	8

Aeration System & Lights

QTY	Component Load	Time	Daily Hours
1	Aeration System 0.5 hp	22:00-6:00	8
1	Indoor Light 23W	18:00-22:00	5
4	Outdoor Light 23W	18:00-06:00	12

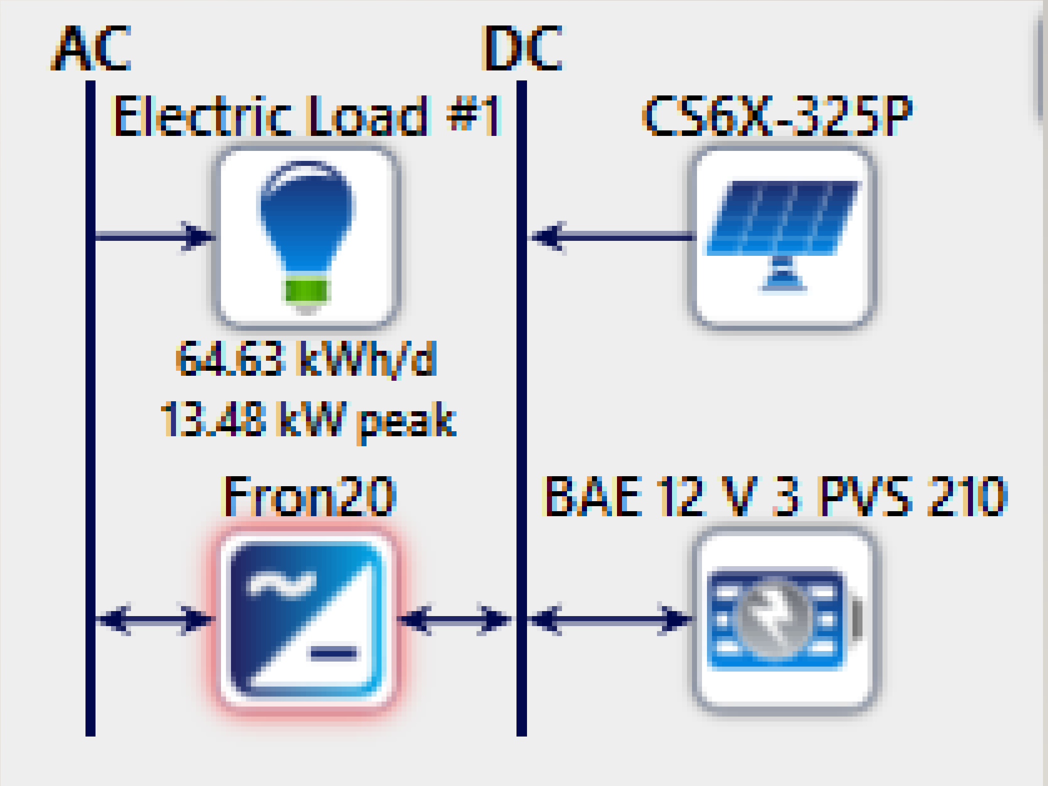
DAILY LOAD PROFILE

- Load profile observed maximum during the day at 64.63kW.

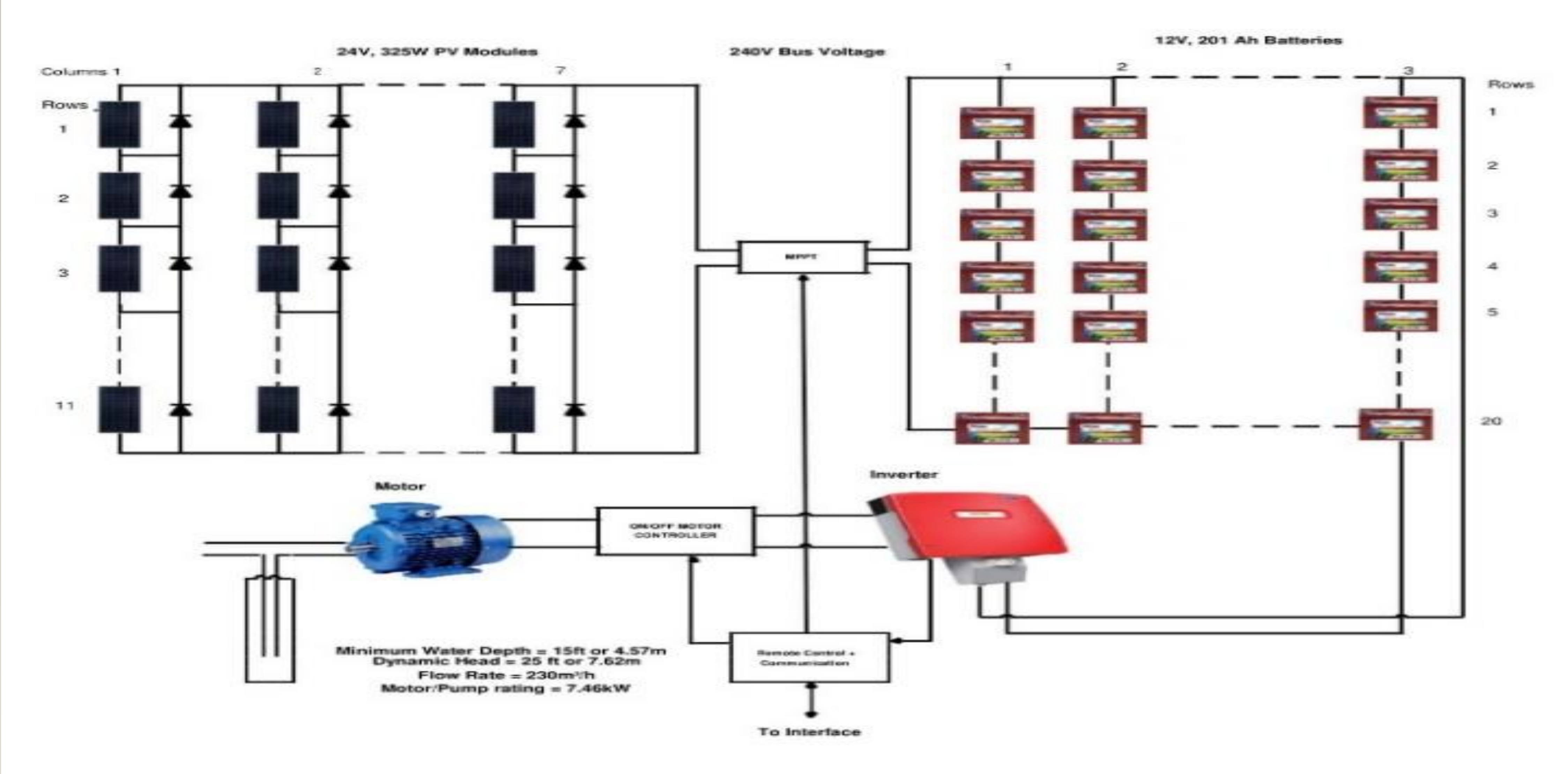


SYSTEM DESIGN

- 64.63 kW/h per day
- Peak load 13.48 kW

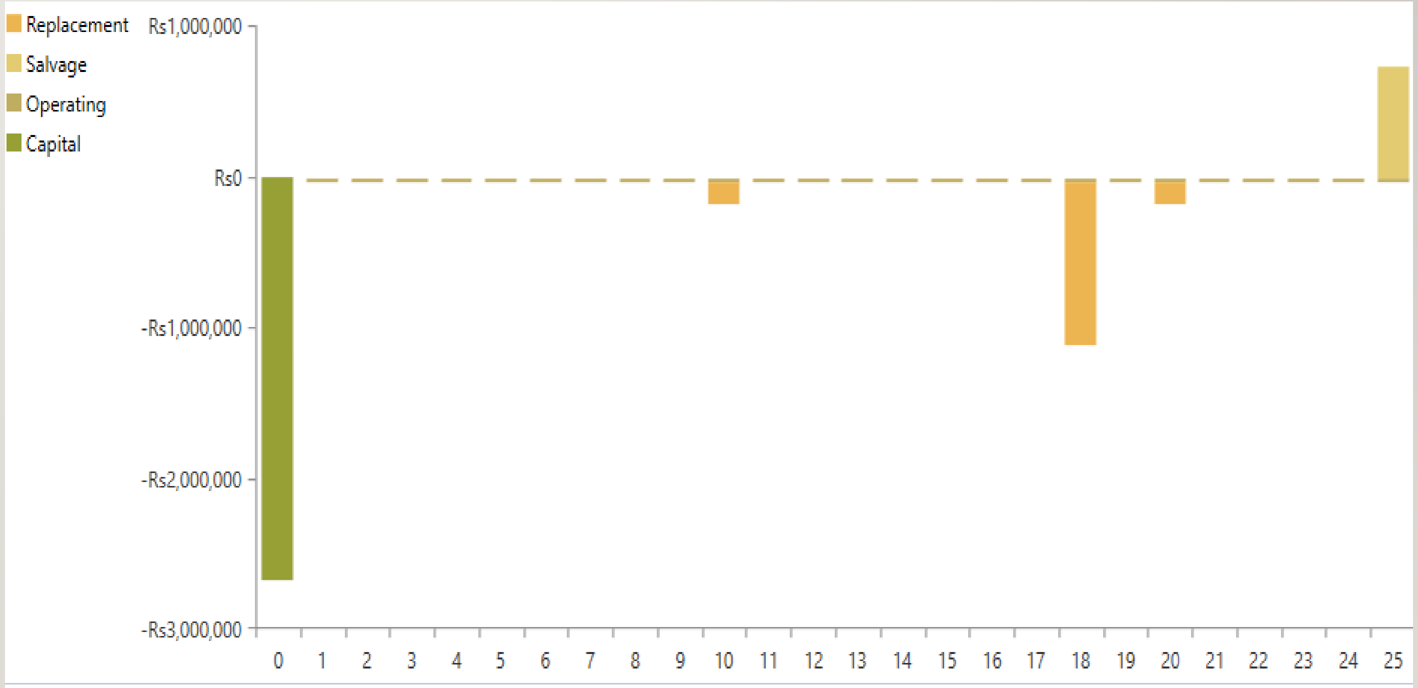


PROPOSED SYSTEM LAYOUT



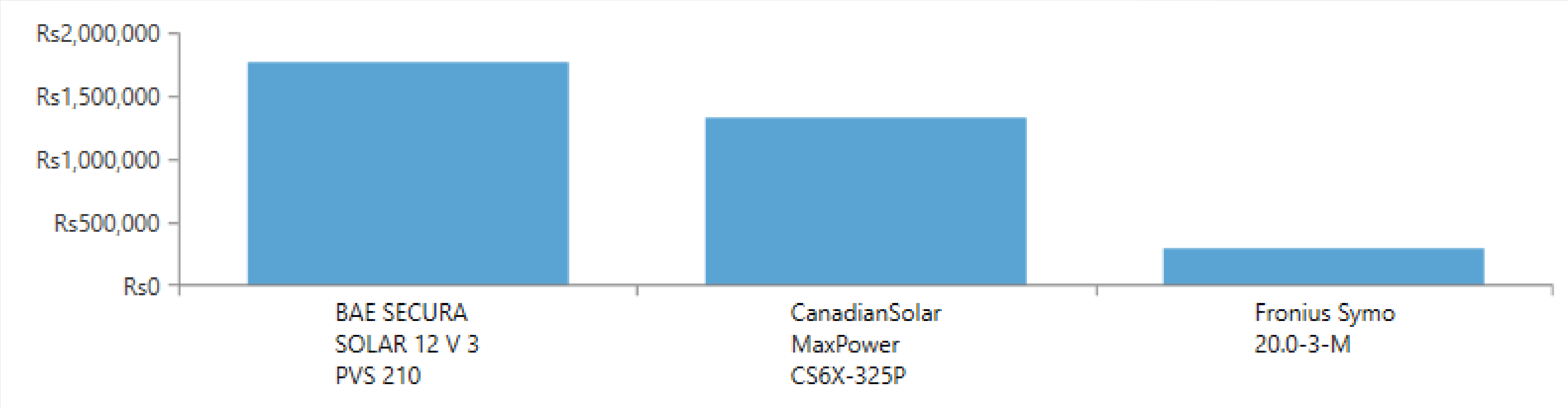
COST SUMMARY OF THE SYSTEM

- The cost of the summary of the system is shown. The system's total net present (NPC) is 3,395,740 Pakistani Rupees (PKR). The system's Levelized cost is 11.14 PKR, and the operating cost is 55,193.50 PKR per year.



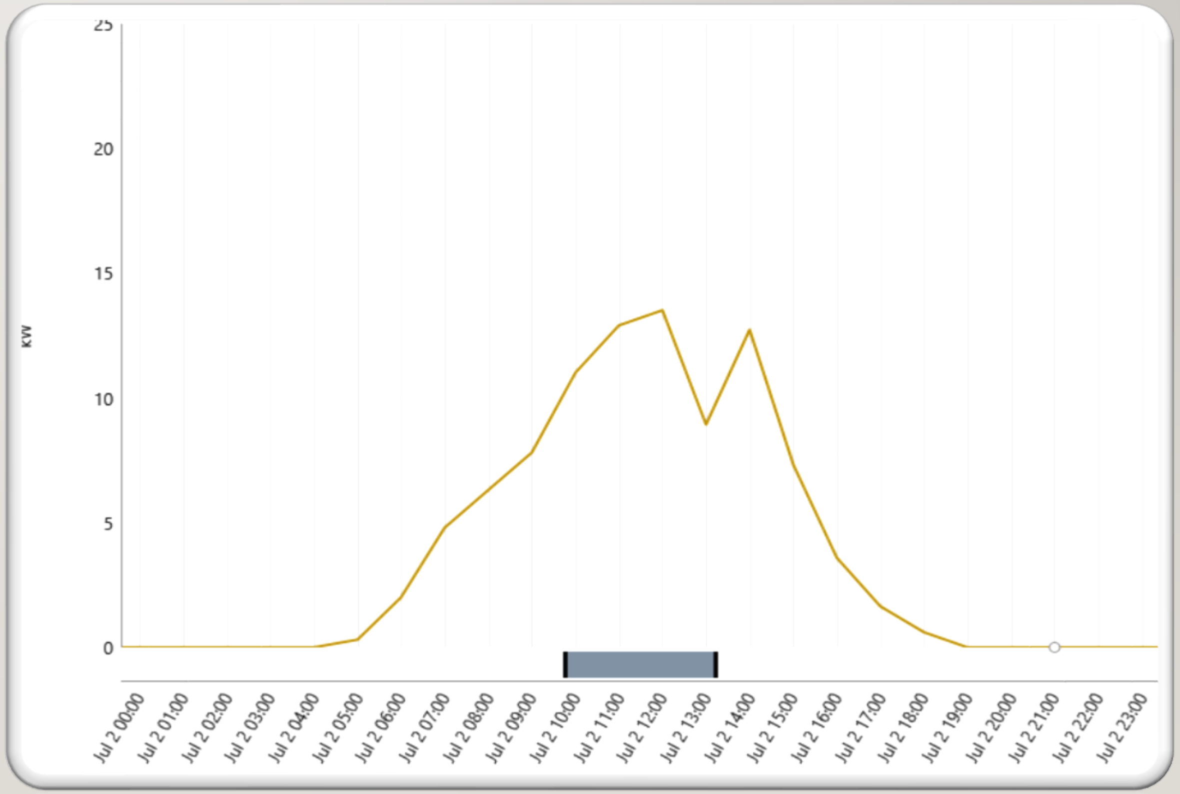
COMPONENT COST

- PV panels Cost 1,235,507.86 PKR
- Batteries Cost 1,302,600.00 PKR
- Inverter Cost 144,117.29 PKR

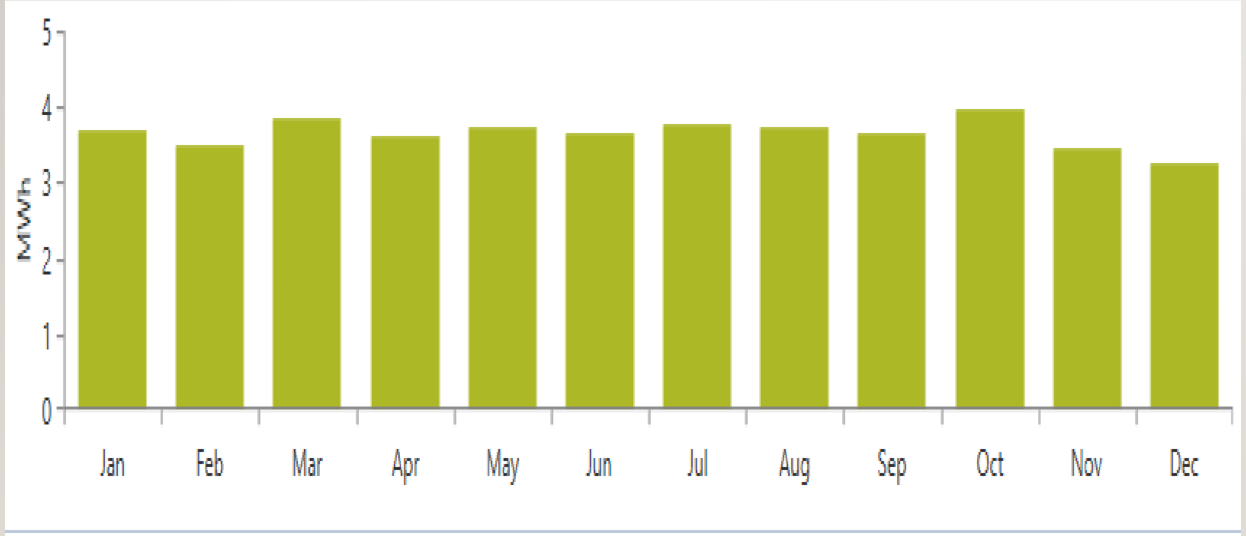


ELECTRIC POWER PRODUCTION

Daily Power Output by Solar Panels

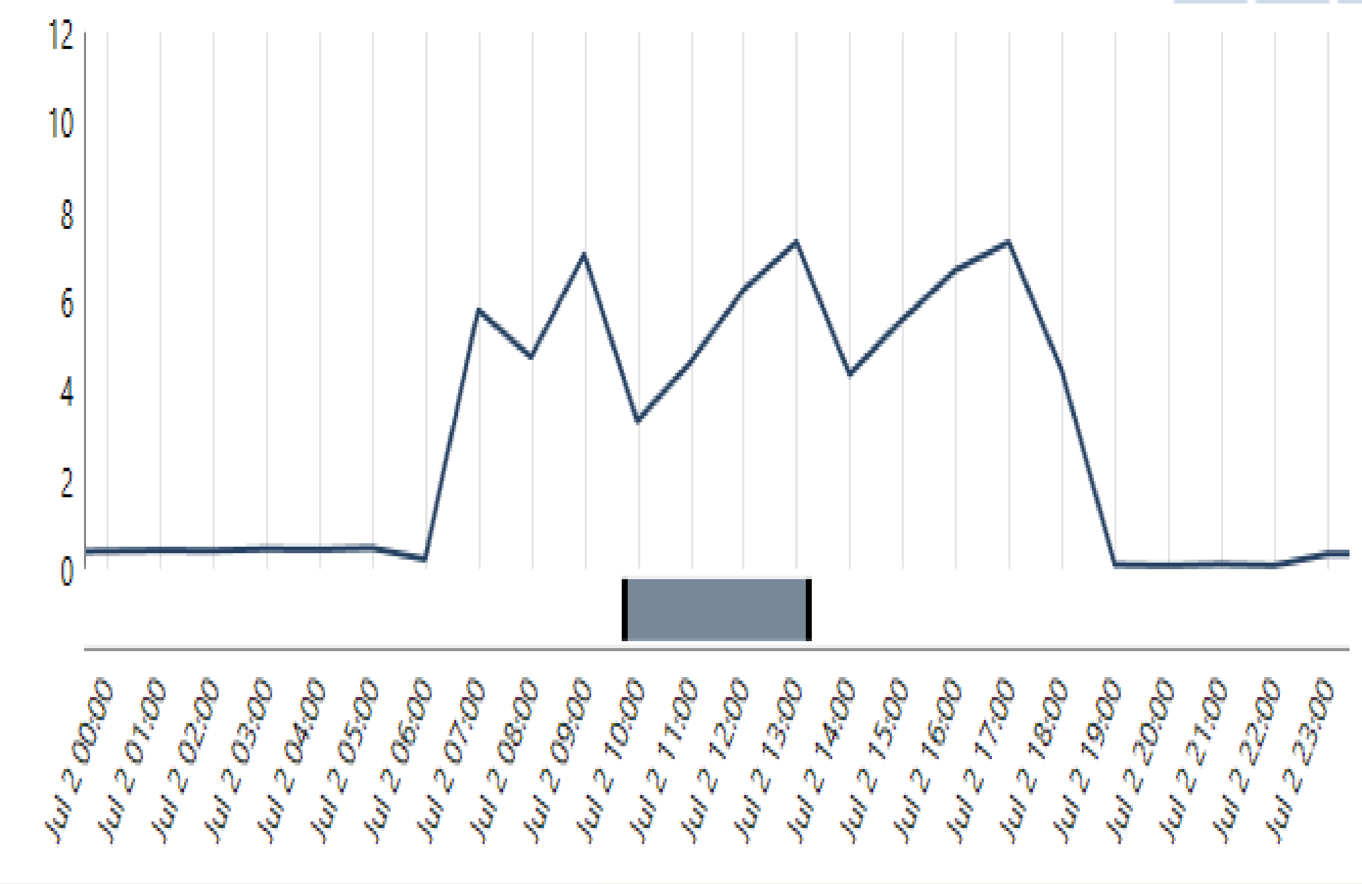


Monthly Electric Power Production by Solar Panels



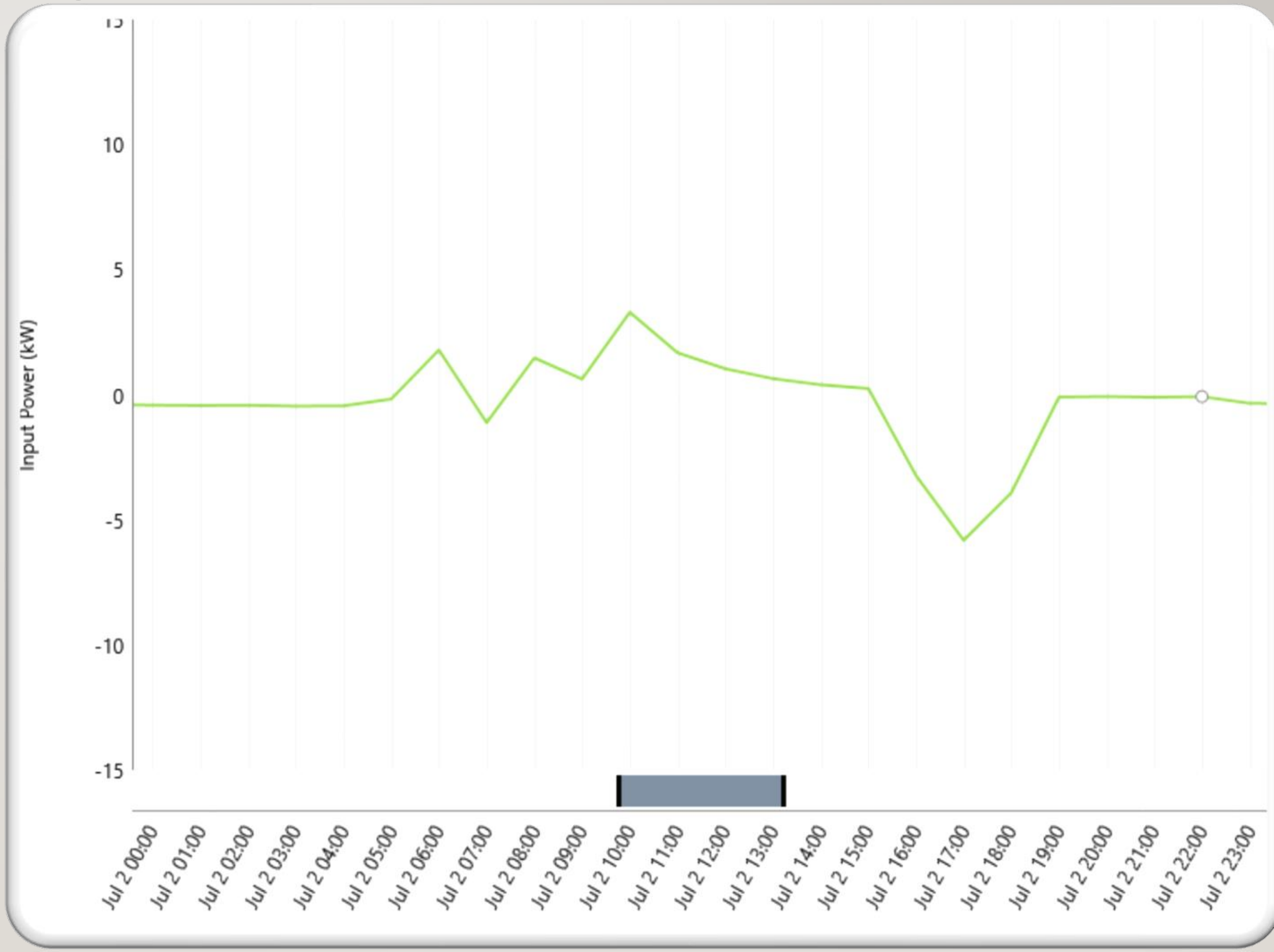
ELECTRIC LOAD SERVED

- The maximum load served in the daytime is 7.31 kW, and the minimum load is served at 3.31 kW during the day.



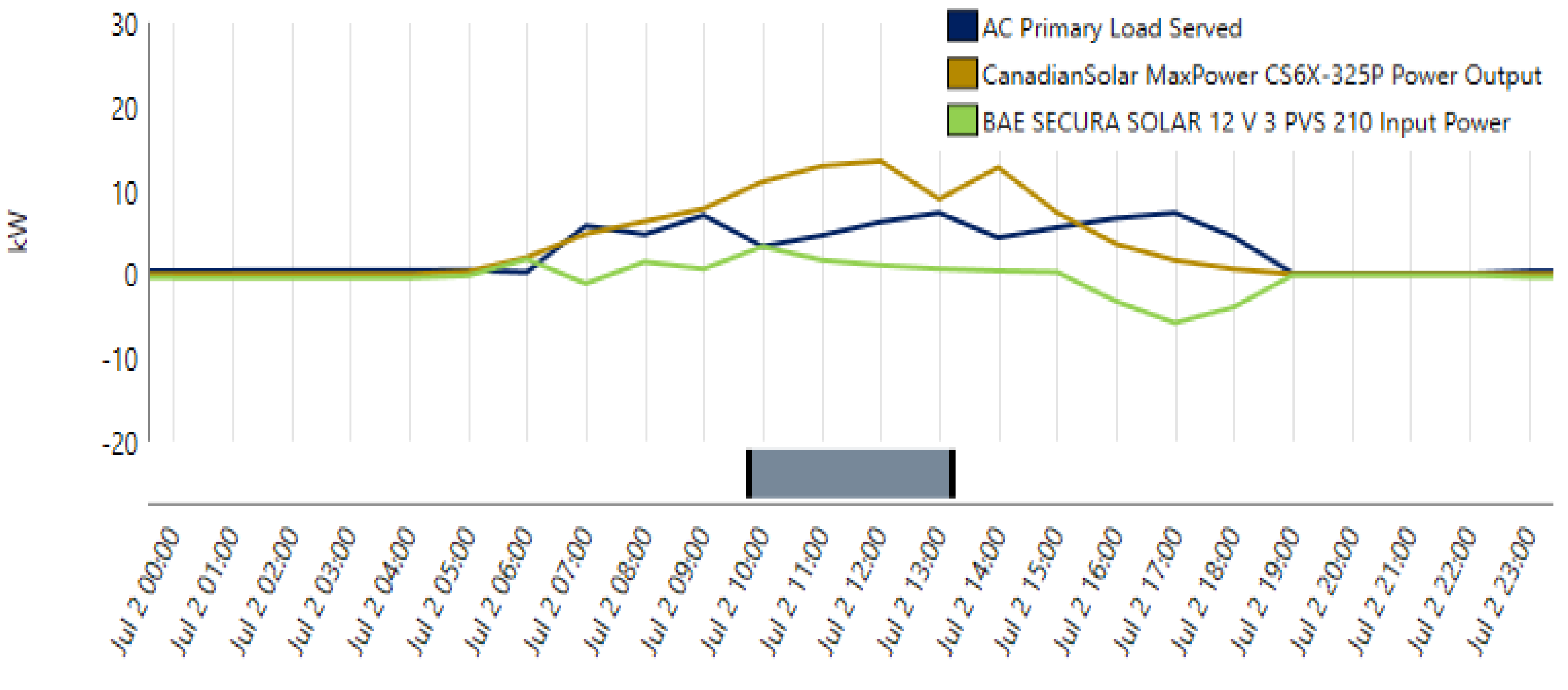
BATTERY INPUT TO THE SYSTEM

- Batteries served load at maximum -5.82 kW in the evening



POWER SOURCES COMPARISON

- Early morning batteries served -0.99kW, power production was 4.80 kW, and system load required 5.79 kW.
- Electric power production during the day was 13.52kW, required power 6.23kW, and batteries were on charging at 1.04kW.
- Batteries providing -5.82kW, when load required 7.31kW and production was 1.65kW



SOLAR POWERED WATER PUMPING SYSTEM AUTOMATION AND CONTROL

ON SITE FISH FARM

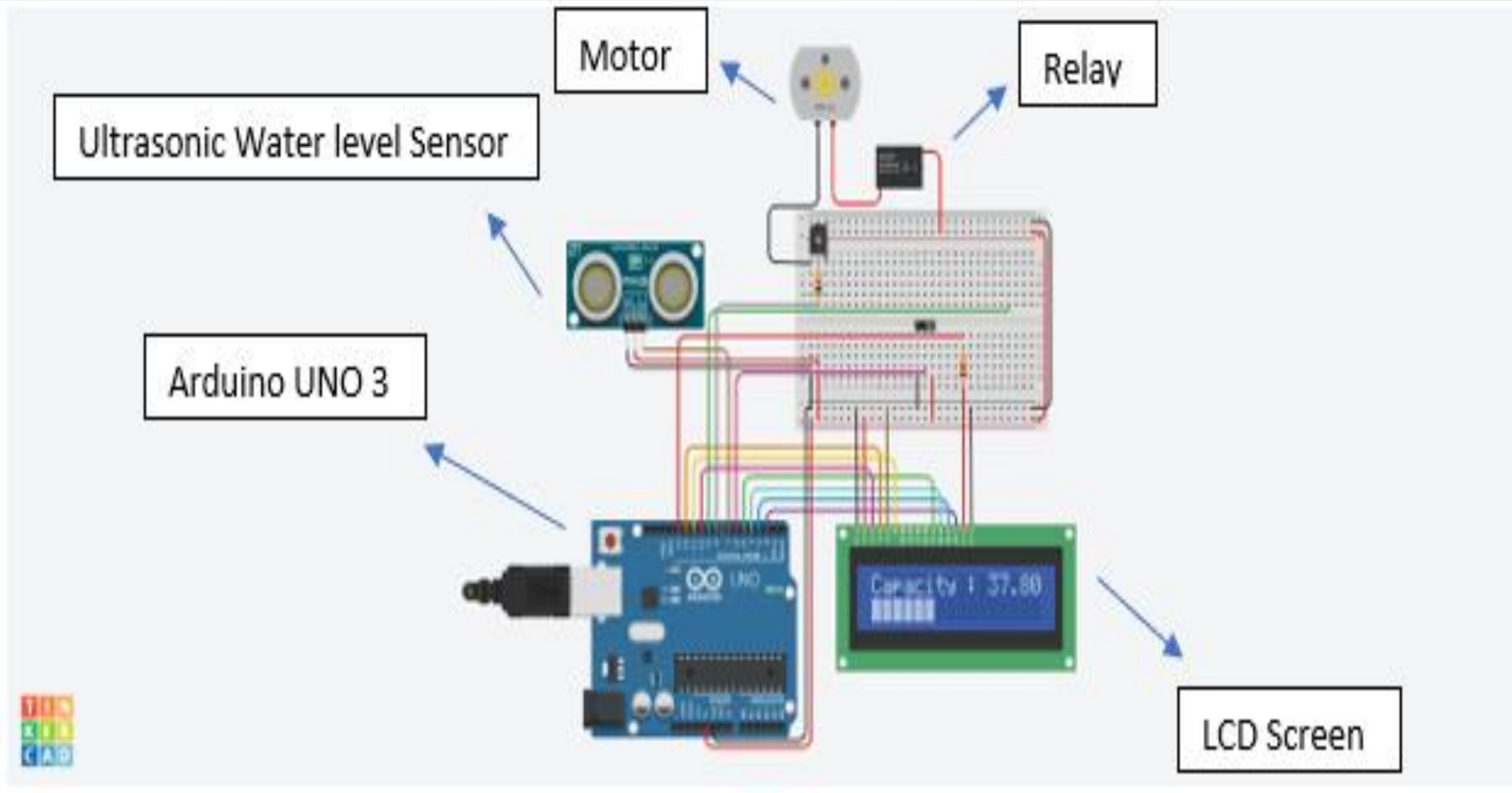
- Site survey was conducted for data collection
- Refilling water after annual cleaning of the fishpond.

ON SITE WATER PUMPING SYSTEM

- Labor operated
- Using a simple ON/OFF switch
- Depended on visual observation for maintaining the water level in ponds.
- High operation and labor cost

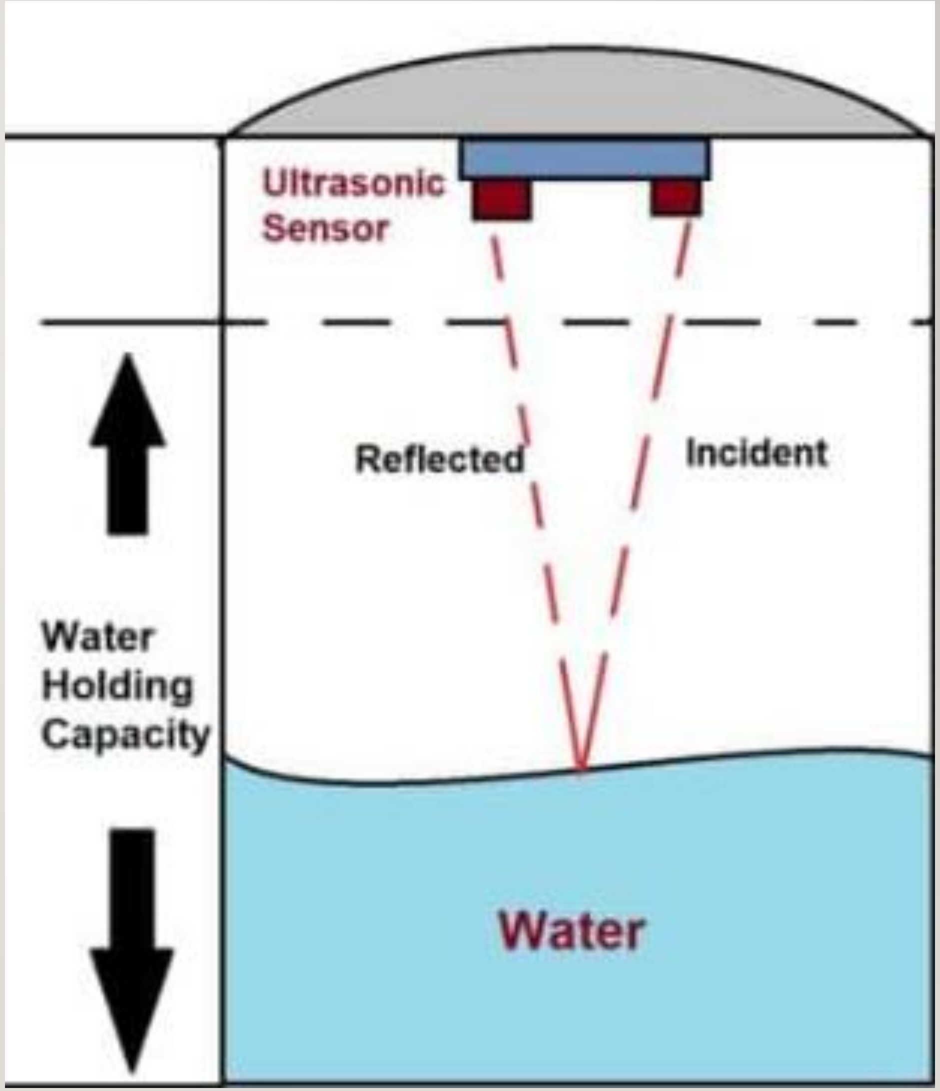
PROPOSED SYSTEM SIMULATION

- Designed Water pumping system automation and control using TinkerCAD.
- Water pumping system is Turned ON when the water level is under the threshold level



ULTRASONIC SENSOR WORKING

- Transmitter
- Receiver

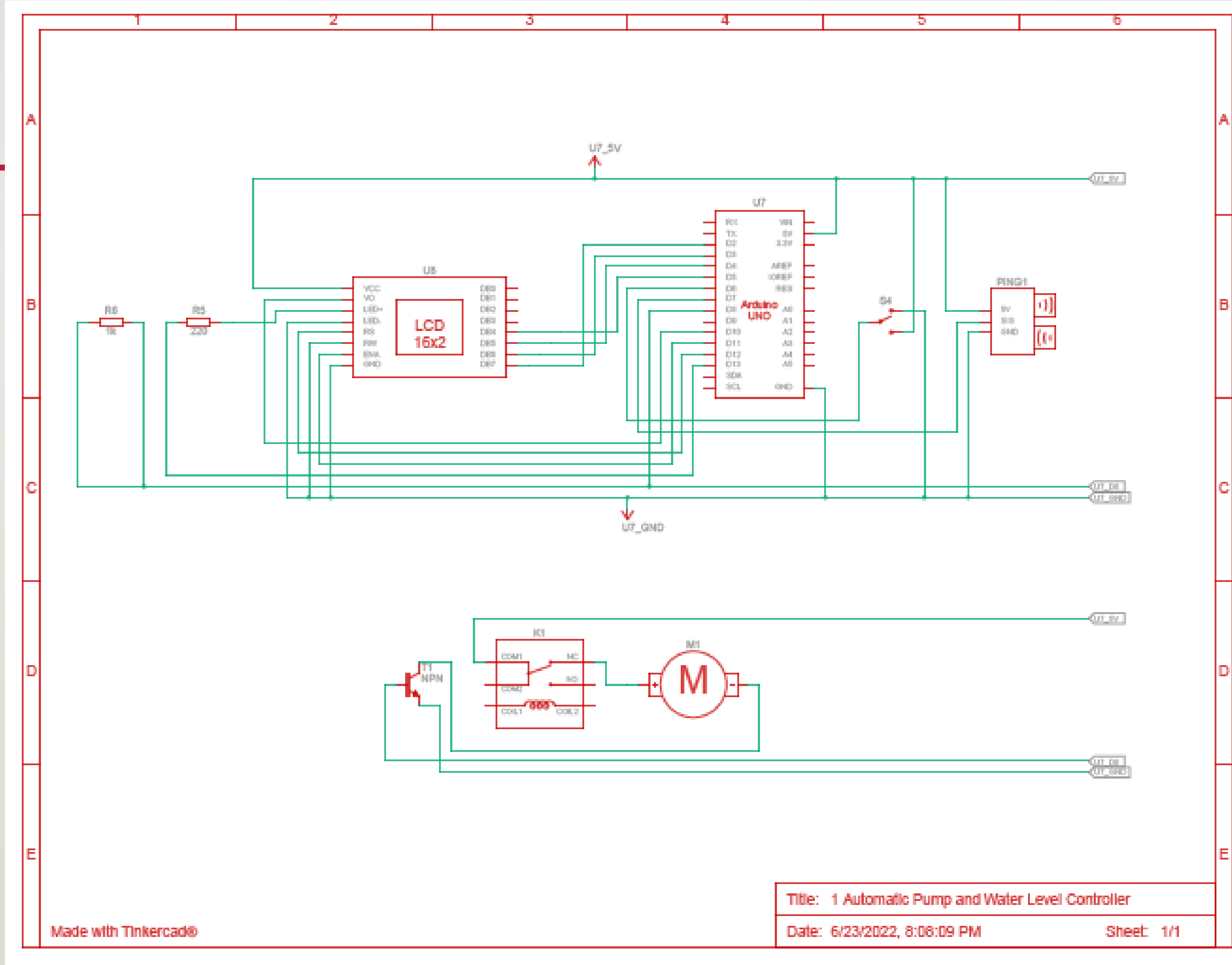


PROPOSED SYSTEM OBSERVATION TABLE

Sr.No	Observation	Motor Status	Pond Level
1	Water level under the threshold	ON	Empty
2	Filling the Ponds	ON	1m
3	After reaching the level Motor Switch	OFF	1.5m

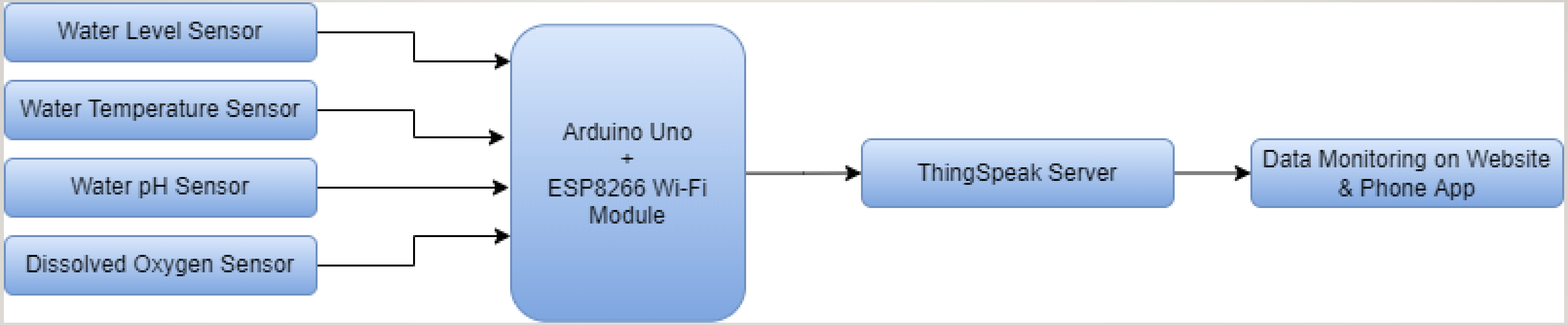
CIRCUIT DIAGRAM

- Established connections between components
- Green color represented the wires
- Red color represented the components



IOT-BASED REAL-TIME AQUACULTURE HEALTH MONITORING SYSTEM

PROPOSED SYSTEM BLOCK DIAGRAM

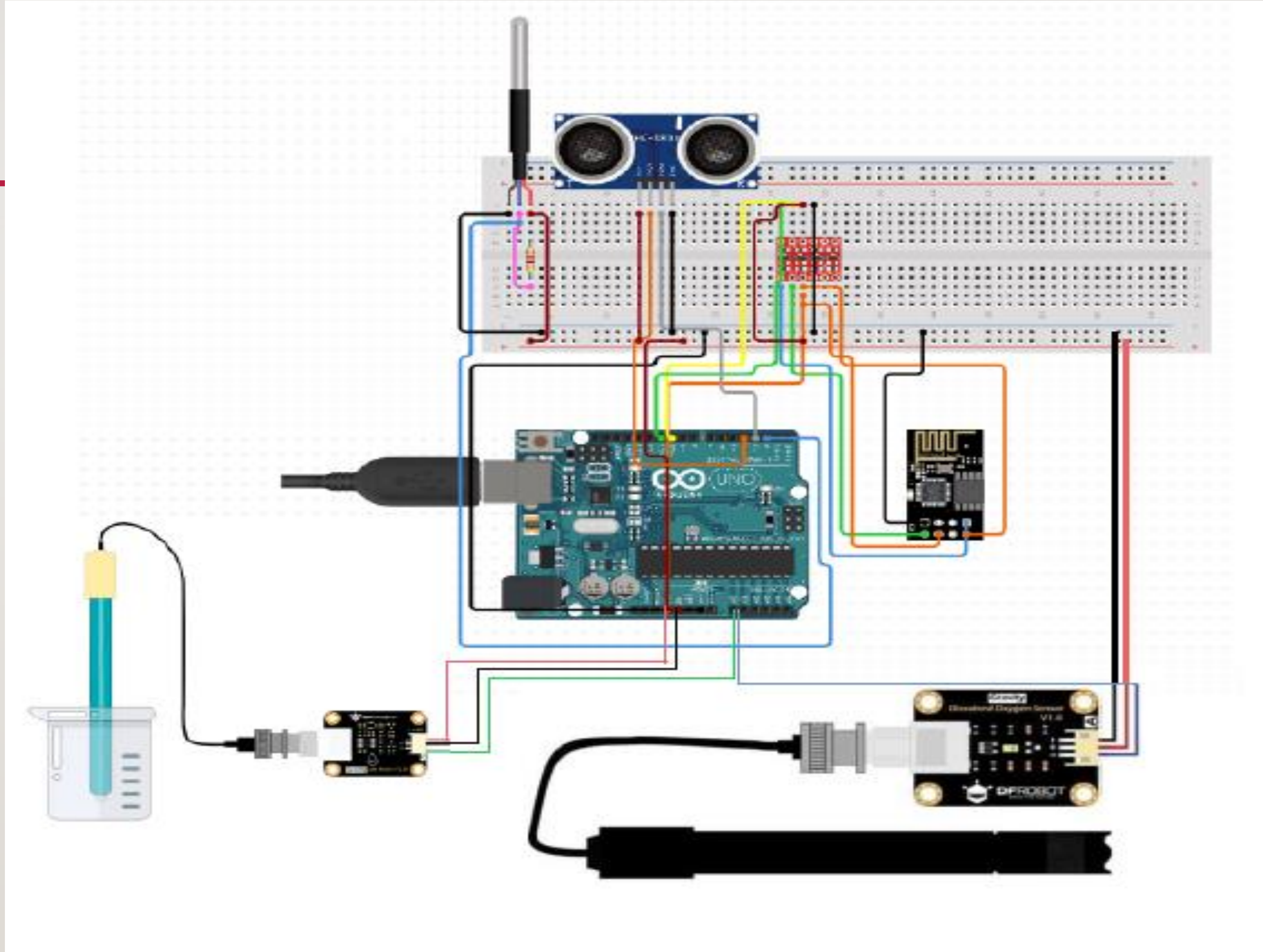


HARDWARE COMPONENT LIST FOR MONITORING SYSTEM

Serial Number	Component Name	Description
1	Arduino UNO R 3	It acts as a hub for sensors, which takes the data from sensors and push it forward to iCloud
2	ESP8266	Wi-Fi Modular which is used to transmit data from Arduino to the iCloud platform
3	Ultrasonic Sensor	Used to measure the water level
4	Temperature Sensor	Used to sense the water temperature
5	pH Sensor	Used to sense the water pH level
6	Dissolved oxygen sensor	Used to sense dissolved-oxygen level in water

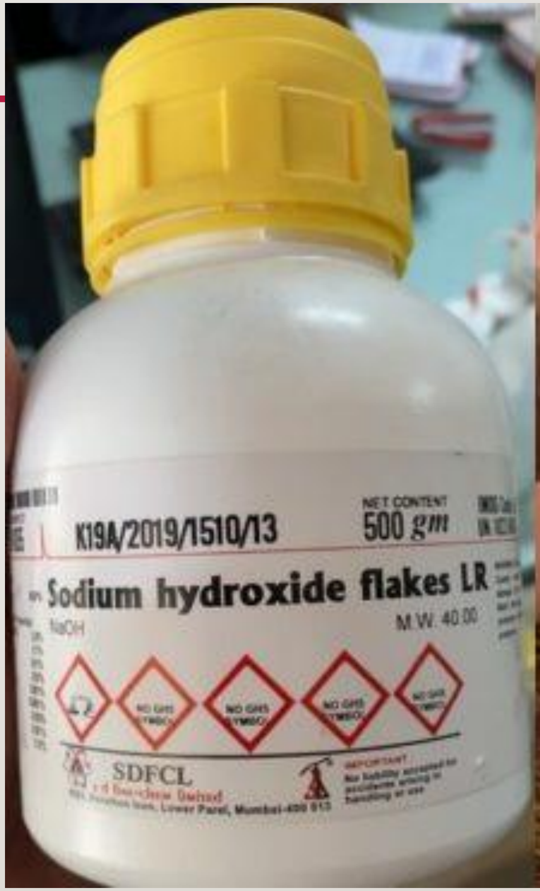
DIAGRAM OF THE CIRCUIT

- Arduino UNO
- ESP8266 Wi-Fi module
- Ultrasonic sensor
- pH sensor
- Temperature sensor
- D.O sensor



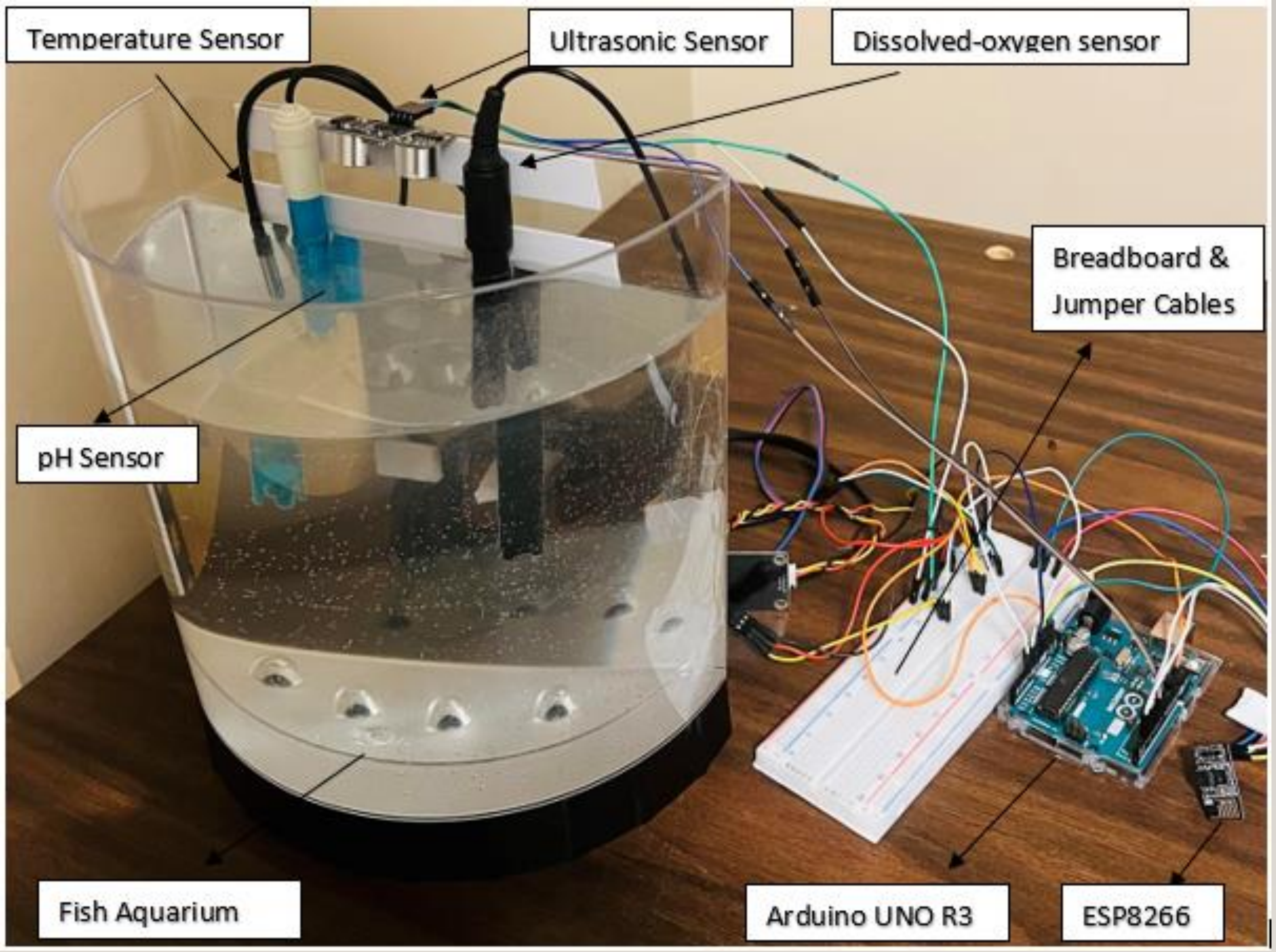
SENSOR CALIBRATIONS

- pH sensor calibration
- Dissolved-oxygen sensor calibration
- 0.5m NaOH used in sensor
- Write down reading



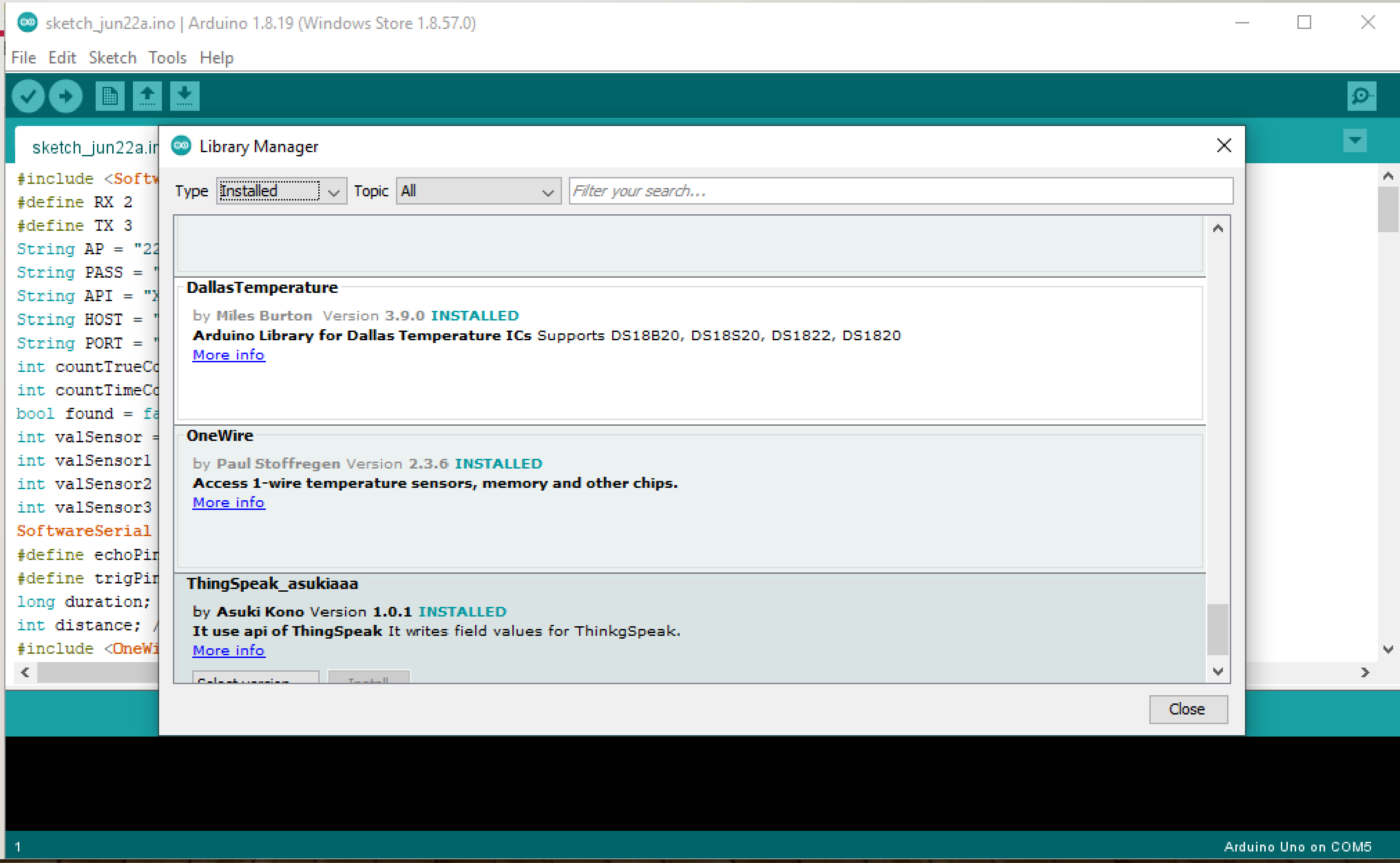
PROTOTYPE OF PROPOSED SYSTEM

- Arduino UNO R3
- ESP8266
- Breadboard
- Fish Aquarium
- Sensors



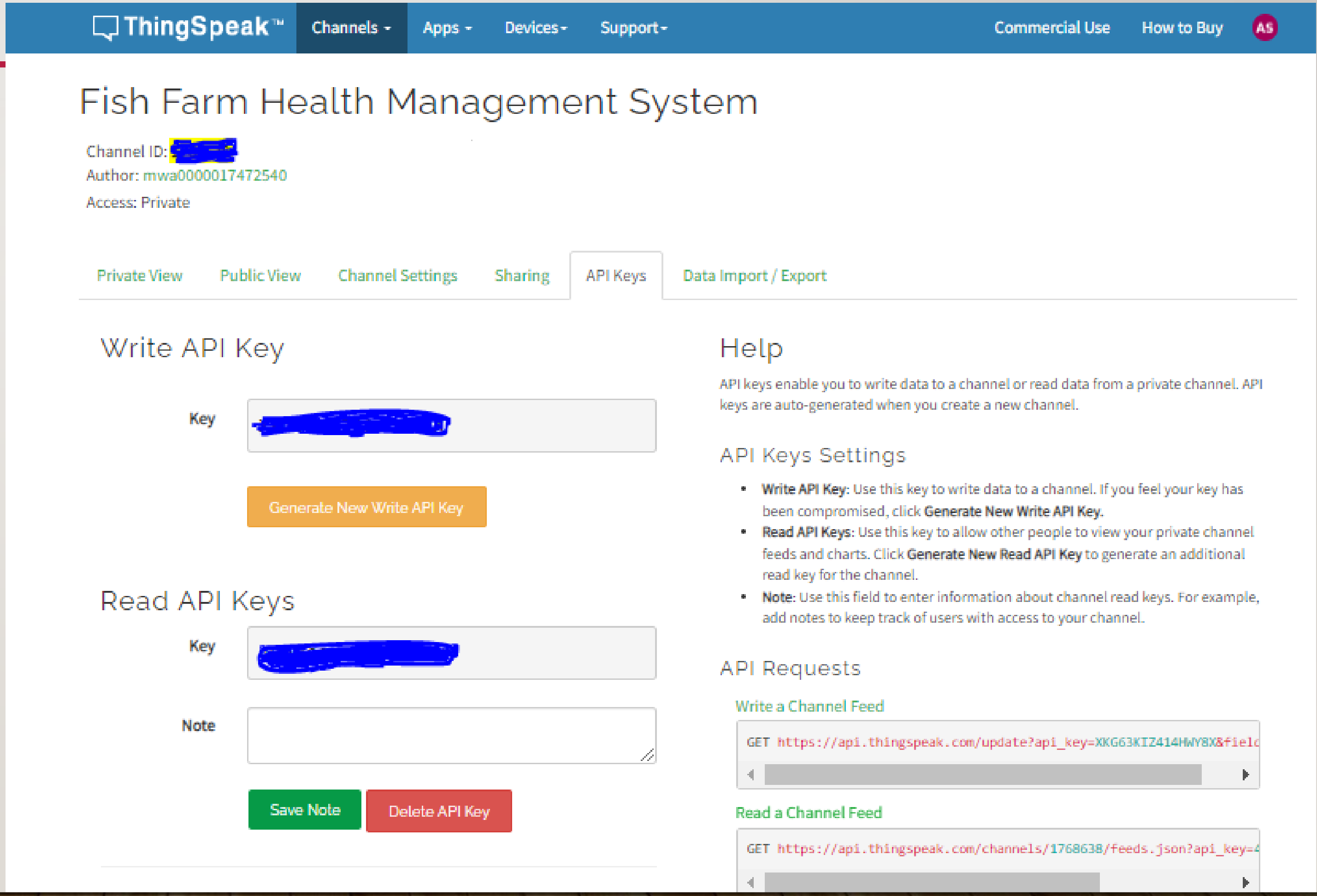
SOFTWARE IMPLEMENTATION

- IDE used for Arduino programing
- Configuration sensors using IDE library
- Testing using the serial monitor



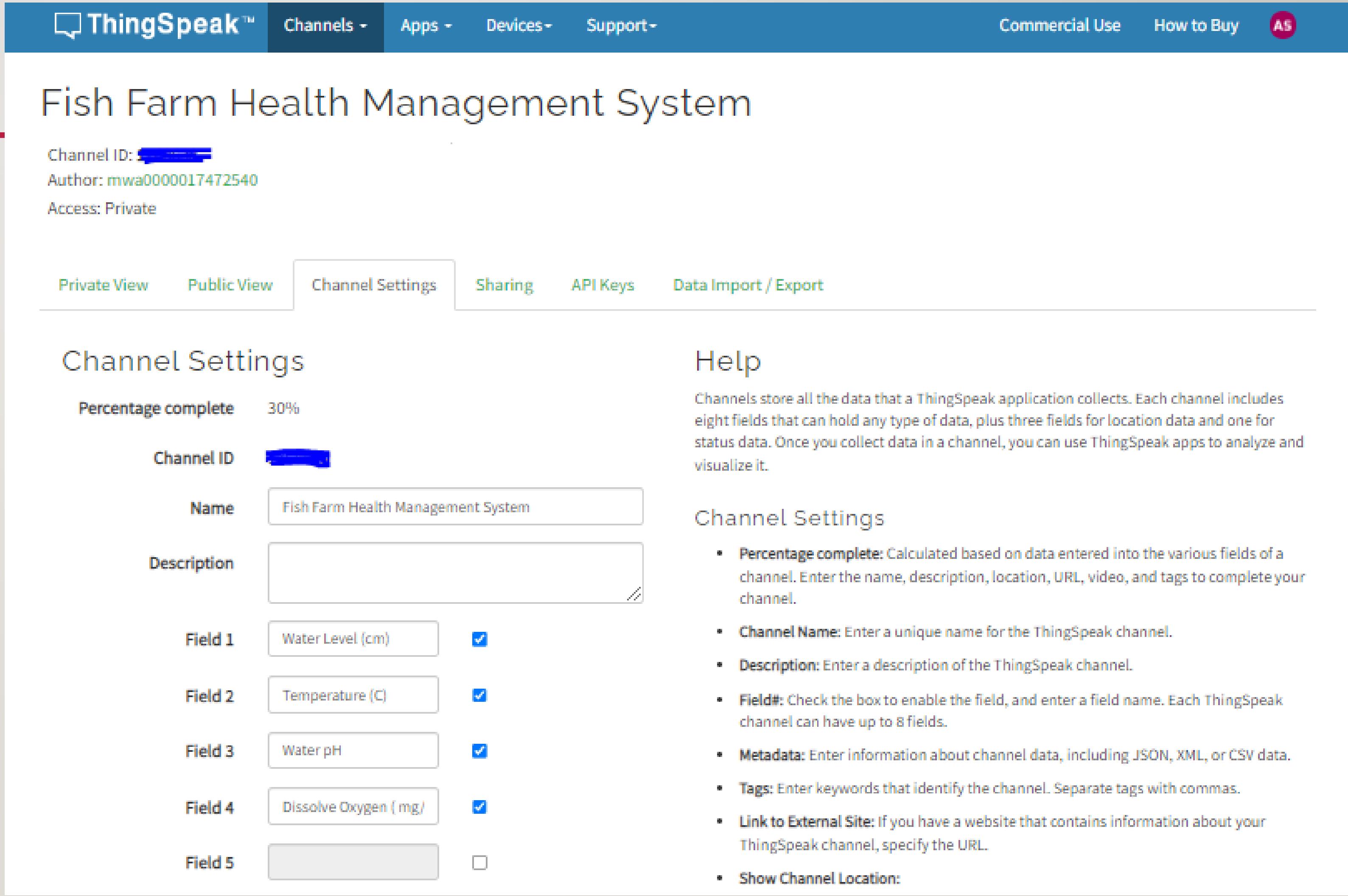
THINGSPEAK SET UP

- ThingSpeak web interface used
- Create an account
- Used write and read API keys
- Configuration API Keys in Arduino



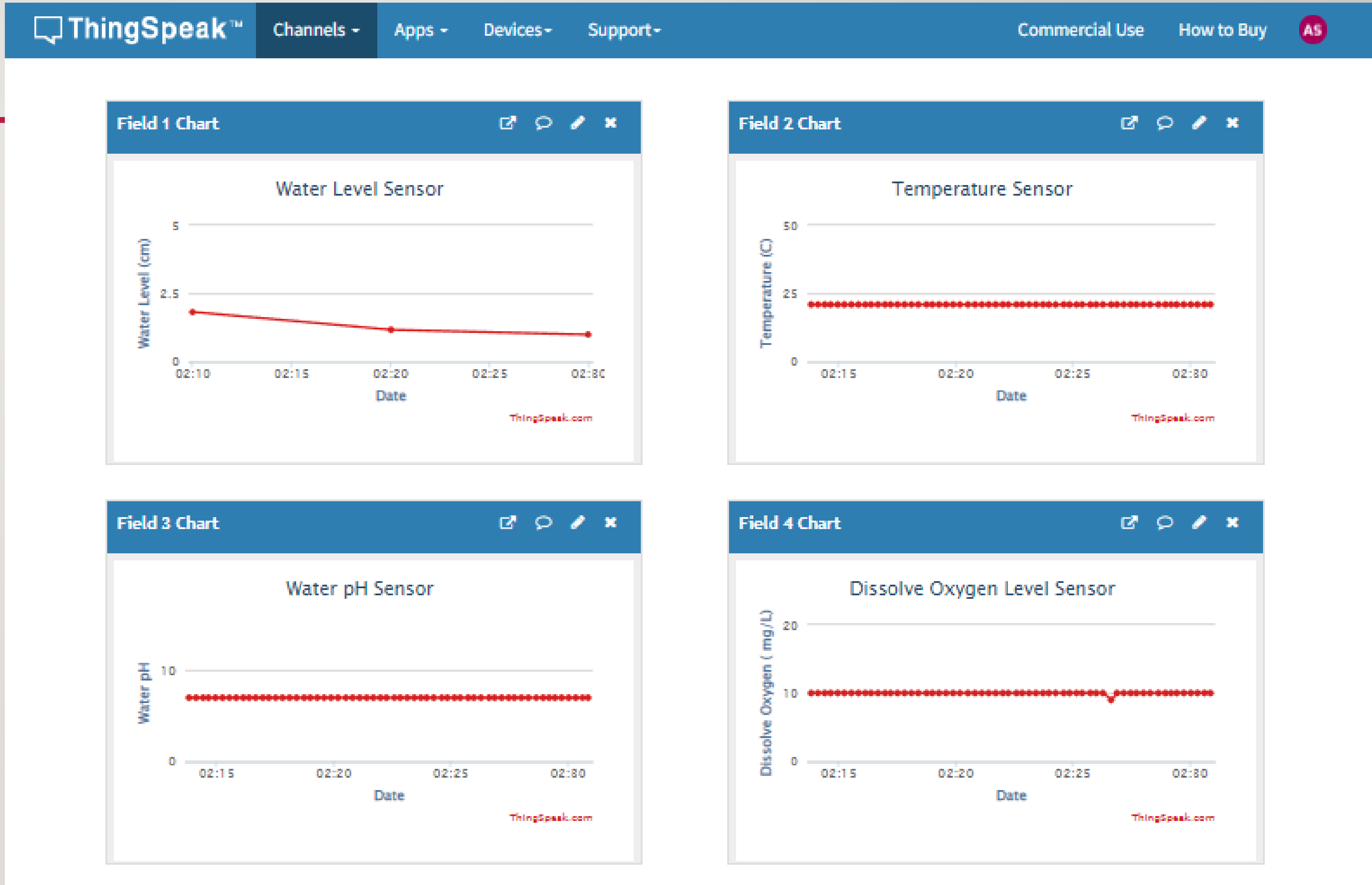
CHANNEL SET UP

- Created 4 channels
- Parameter ranges set up
- Time chart display name set up



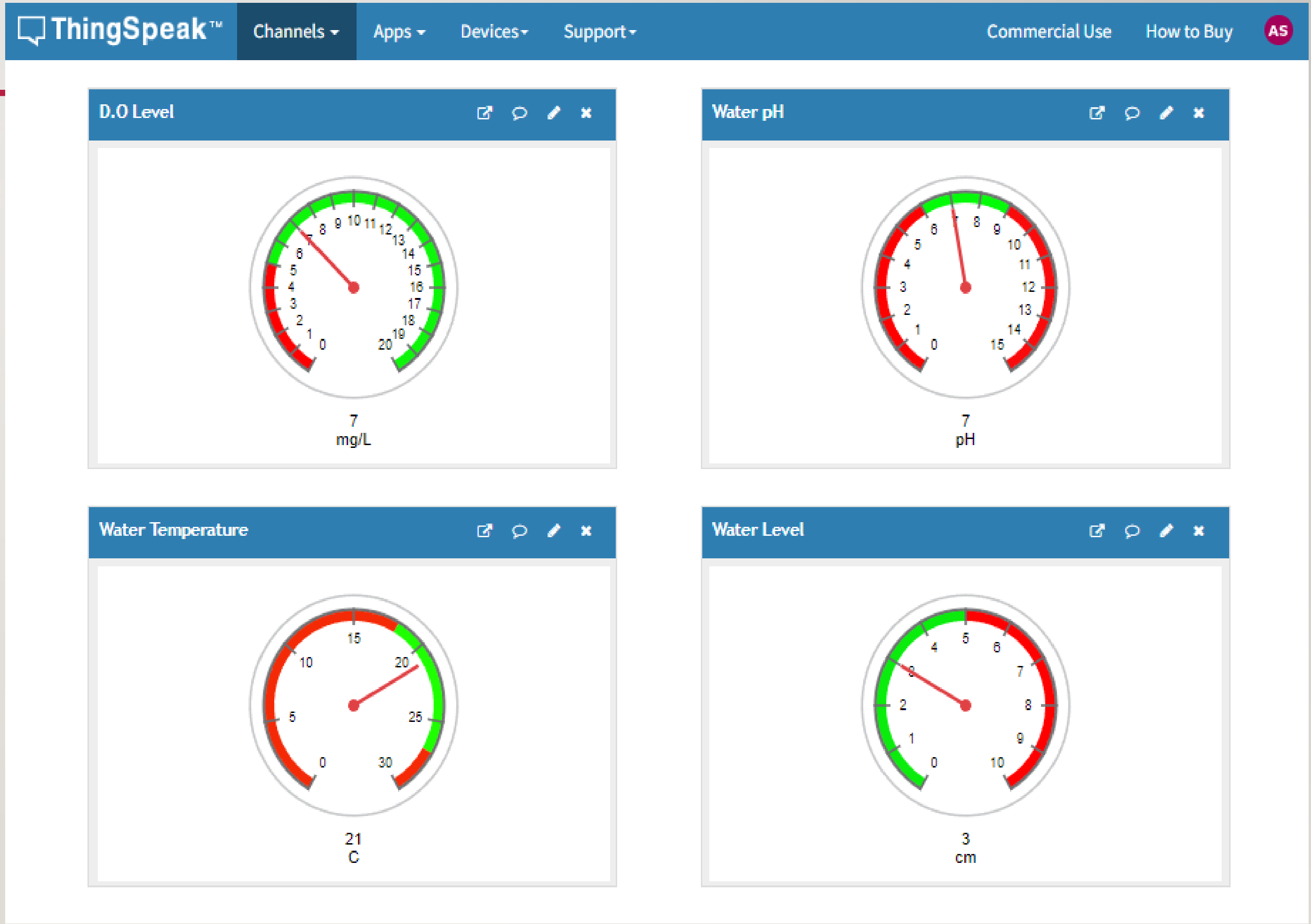
DASHBOARD DISPLAY

- Water level measurement
- Temperature level
- Water pH level
- Dissolved-oxygen level in the water



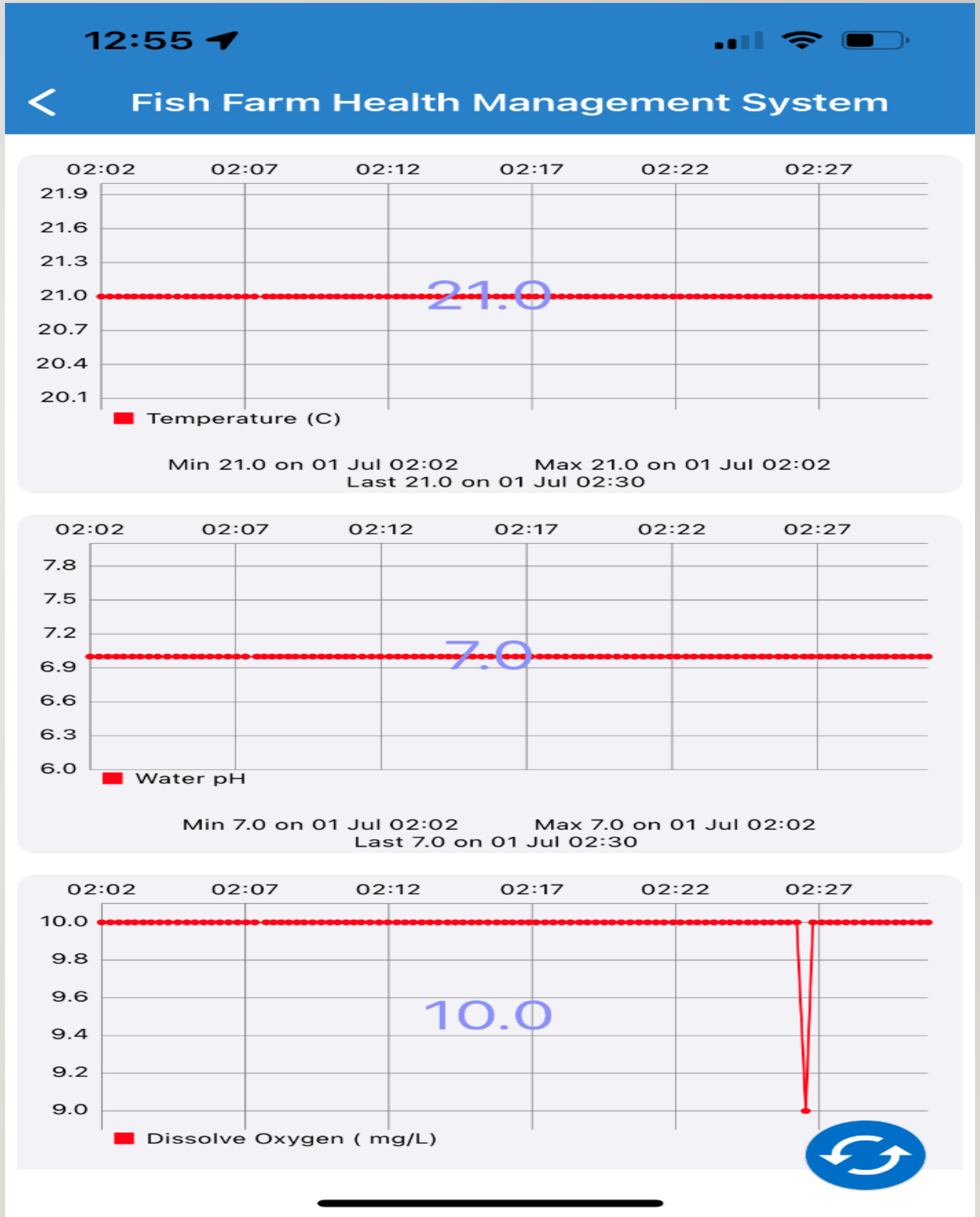
GAUGE DASHBOARD DISPLAY

- Gauge Display set up on ThingSpeak channel
- Red indicated under threshold levels
- Green values indicated an acceptable range of parameters



WIRELESS & REMOTE DISPLAY

- Phone App Dashboard display
- Water metrics displayed



CONCLUSIONS

A detailed design and cost analysis for a solar PV power system for a fish farm was performed in HOMER Pro.

The HOMER simulation summary for the system is as follows

- The PV panel network was 64.63 kW
- The inverter rating came as 13.48 kW
- The battery requirement came out to be 60
- The net present cost for the overall system came out to be 3,395,740 PKR
- The Levelized cost of energy came out as 11.14 PKR
- The operating cost for the system came out to be 55,193.50 PKR

CONCLUSIONS

Water pumping system automation and control were proposed and achieved following observations.

- water pumping system turn on when the water level is low
- water pumping system turned OFF when the level is full
- Could save labor cost
- reduce electricity consumption
- Could reduce water wastage

CONCLUSIONS

- IoT-based read-time aquaculture health monitoring system was implemented to monitor four different categories of parameters
  - Water pH parameters
  - Hydro parameters
  - Temperature parameters
  - Dissolved- oxygen in the water
- The data obtained was reflected on three different custom-made dashboards
  - Time chart Dashboard
  - Real-time Gauge Dashboard
  - Phone App Dashboard

RESEARCH CONTRIBUTIONS

- A comprehensive design and cost analysis for a battery-based solar water a pumping system for a fish farm, selected site in Pakistan was performed in HOMER
- Solar-powered water pumping system automation and control proposed, which can help to reduce the labor cost and encourage the automation and technology use in aquaculture.
- An open-source IoT-based real-time aquaculture health monitoring system

FUTURE WORK

- Dynamic analysis of a solar PV power system for a fish farm MATLAB/Simulink can be performed for the already designed system in HOMER
- Using cloud technology to track the data make monitoring and controlling the system more accessible. To increase data storage other sources can be used SQL, AWS, and Azure.
- A notification alert system can be incorporated into the already developed

  system using Swift-mailer

PUBLICATIONS

- Adnan Sarwar, M. Tariq Iqbal, Design and Optimization of Solar PV system for a Fish farm in Pakistan, presented at IEEE Annual Computing and Communication Workshop and Conference (CCWC) 2022.
- Adnan Sarwar, M.Tariq Iqbal, Solar Powered Water Pumping System Automation and Control Using a Microcontroller for Aquaculture, Accepted for publication in European Journal of Electrical Engineering and Computer Science
- Adnan Sarwar, M.Tariq Iqbal, IoT-based Real-time Aquaculture Health Monitoring System, Submitted for publication in European Journal of Electrical Engineering and Computer Science

REFERENCES

- [1] Canada, Natural Resources. "About-Renewable-Energy." Natural Resources Canada, January 27, 2009.
- [2] D. Manolakos, G. Papadakis, D. Papantonis, S. Kyritsis, "Astand-alone photovoltaic power system for remote villages using pumped water energy storage", *Energy*, v. 29, no.1, pp. 57-69, 2004.
- [3] Leung, T. L., and Bates, A. E., 2013. "More rapid and severe disease outbreaks for aquaculture at the tropics: implications for food security". Journal of applied ecology, 50(1), pp. 215–222.
- [4] Belton, B., Karim, M., Thilsted, S., Collis,W., Phillips, M., et al., 2011. "Review of aquaculture and fish consumption in bangladesh".
- [5] Food and Agriculture Organization of the United Nations. Fisheries Dept, A. O., 2014. The state of world fisheries and aquaculture, 2014. Food & Agriculture Org.
- [6] B´en´e, C., Macfadyen, G., and Allison, E. H., 2007. Increasing the contribution of small-scale fisheries to poverty alleviation and food security. No. 481. Food & Agriculture Org.
- [7] A. Khan and N. Awan, "Inter-Provincial Water Conflicts in Pakistan: A Critical Analysis," *J. South Asian Middle East. Stud.*, vol. 43, no. 2, pp 42–53, 2020, doi:10.33428/jsoutasiamiddeas.43.2.0042.
- [8] B. Ahmad, "Water Management: A Solution to Water Scarcity in Pakistan," *J. Indep. Stud. Res.-Manag. Soc. Sci. Econ.*, vol. 9, pp. 111 –125, Dec. 2011, doi: 10.31384/jisrmsse/2011.09.2.9.
- [9] M. M. Rafique and S. Rehman, "National energy scenario of Pakistan Current status, future alternatives, and institutional infrastructure: An overview," *Renew. Sustain. Energy Rev.*, vol. 69, pp. 156–167, Mar. 2017, doi: 10.1016/j.rser.2016.11.057.
- [10] M. Ali, R. Sultana, S. Tahir, I. A. Watson, and M. Saleem, "Prospects of microalgal biodiesel production in Pakistan – A review," *Renew. Sustain. Energy Rev.*, vol. 80, pp. 1588–1596, Dec. 2017,doi:10.1016/j.rser.2017.08.062.
- [11] F. Muhammad, M. Waleed Raza, S. Khan, and F. Khan, "Different Solar Potential Co-Ordinates of Pakistan," *Innov. Energy Res.*, vol. 06, no 02,2017, doi: 10.4172/2576-1463.1000173.

Thank You for your attention,
Any Question?