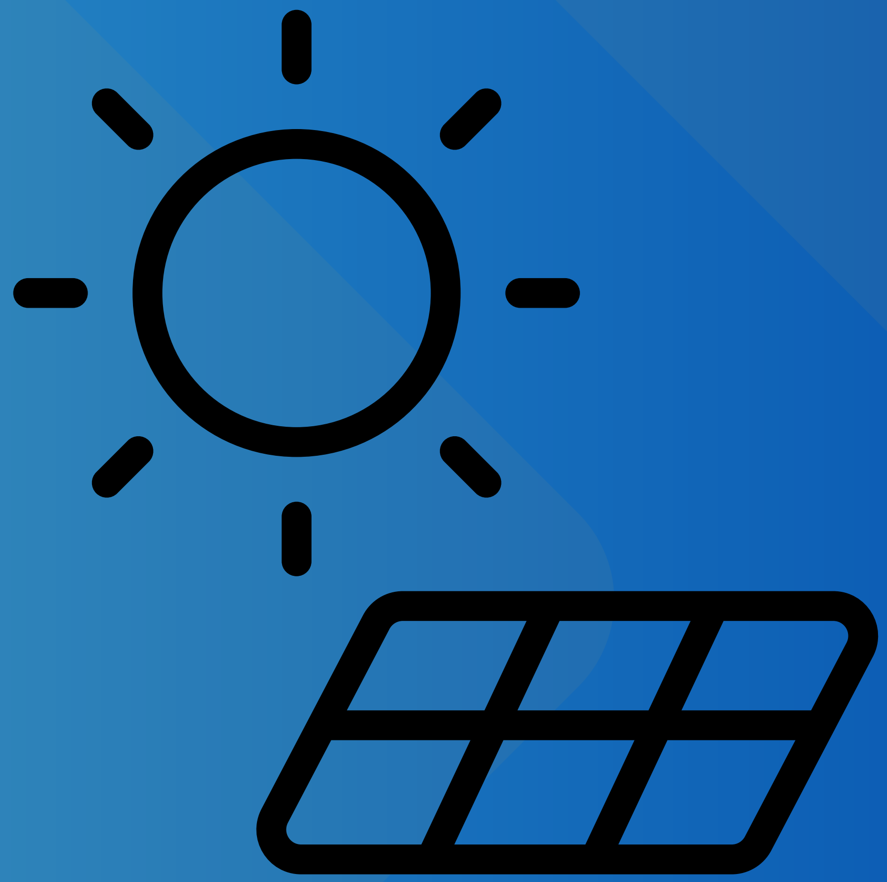
COMPEA

Cognitive Power Metering and Prediction using Edge AI

Final Defence



PRESENTED BY	Nazeefa Muzammil Saad Zafar Khan Usama Qadoos
COMMITTEE	Mansoor Asif S.M. Hasan Zaidi (former) Salman Abdul Ghafoor (co-advisor)

Our Team

Usama Qadoos

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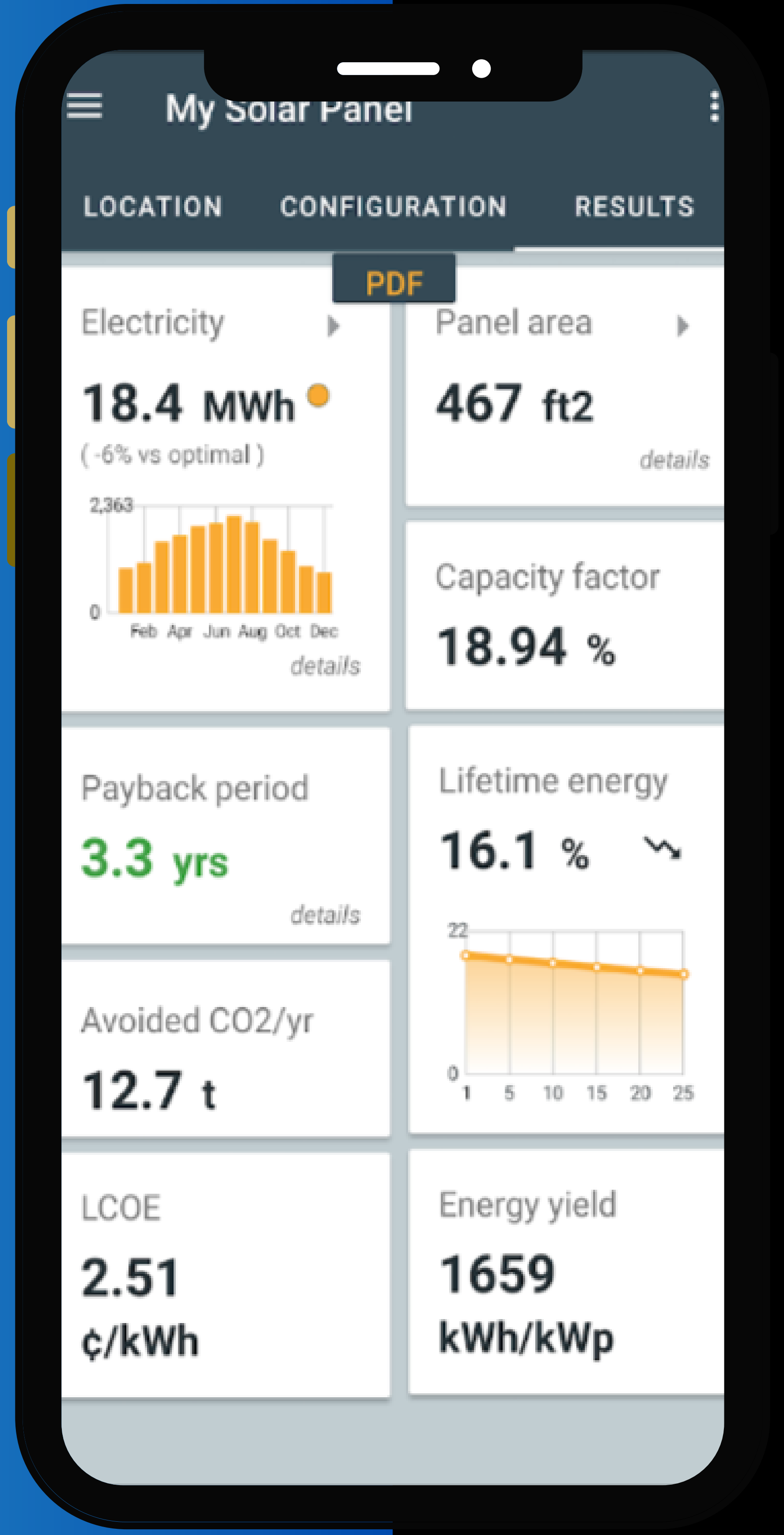
Saad Zafar Khan

Agenda

Problem Statement



To develop a smart and efficient home solar system through IoT and Machine Learning to improve the existing conventional solar system solutions.

Literature Review

Optimizing Stand-Alone Photovoltaic-Battery (SAPVB) systems for residential buildings

- Developed rule-guided load management system
- Segregated loads into Critical Loads (CLs) and Uncritical Loads (ULs)
- Rescheduled ULs to maximize energy capture
- Prioritized CLs for consistent operation

Results:

1. PV system met 49.8% CLs and 23.7% ULs
2. Scenario 2: 93.8% CLs, 74.2% ULs
3. Scenario 3: 90.9% CLs, 70.1% ULs
4. Scenario 4: 87.2% CLs, 65.4% ULs

Literature Review contd.

- **Challenge:** Erratic fluctuations due to climate and geography
- **Issues caused:** Voltage surges, system instability, inefficient planning, financial losses
- Reviewing and evaluating contemporary forecasting techniques
- **Factors to consider in forecasting models:**
    - Time stamp, forecast horizon, input correlation analysis, data pre-processing
    - Weather classification, cloud motion study, network optimization
    - Uncertainty quantification, performance evaluations
- **Findings:**
    - Solar irradiance highly correlates with PV output
    - Ensembles of artificial neural networks best for short-term forecasting
    - Online sequential extreme learning machines excel in adaptive networks
    - Bootstrap technique optimal for uncertainty estimation
    - Convolutional neural networks reveal deep non-linear relationships in models

Objectives

1. To develop a smart and efficient home solar system through IoT and Machine Learning to improve the existing conventional solar system solutions.

2. To design a load shedding algorithm using relay system and provide an interactive recommendation system for the user for efficient energy consumption

3. To develop a dashboard for data analytics and control

Devised Solution

Collection of dataset by recording and examining the effect of different weather parameters on the power generated by the solar panels

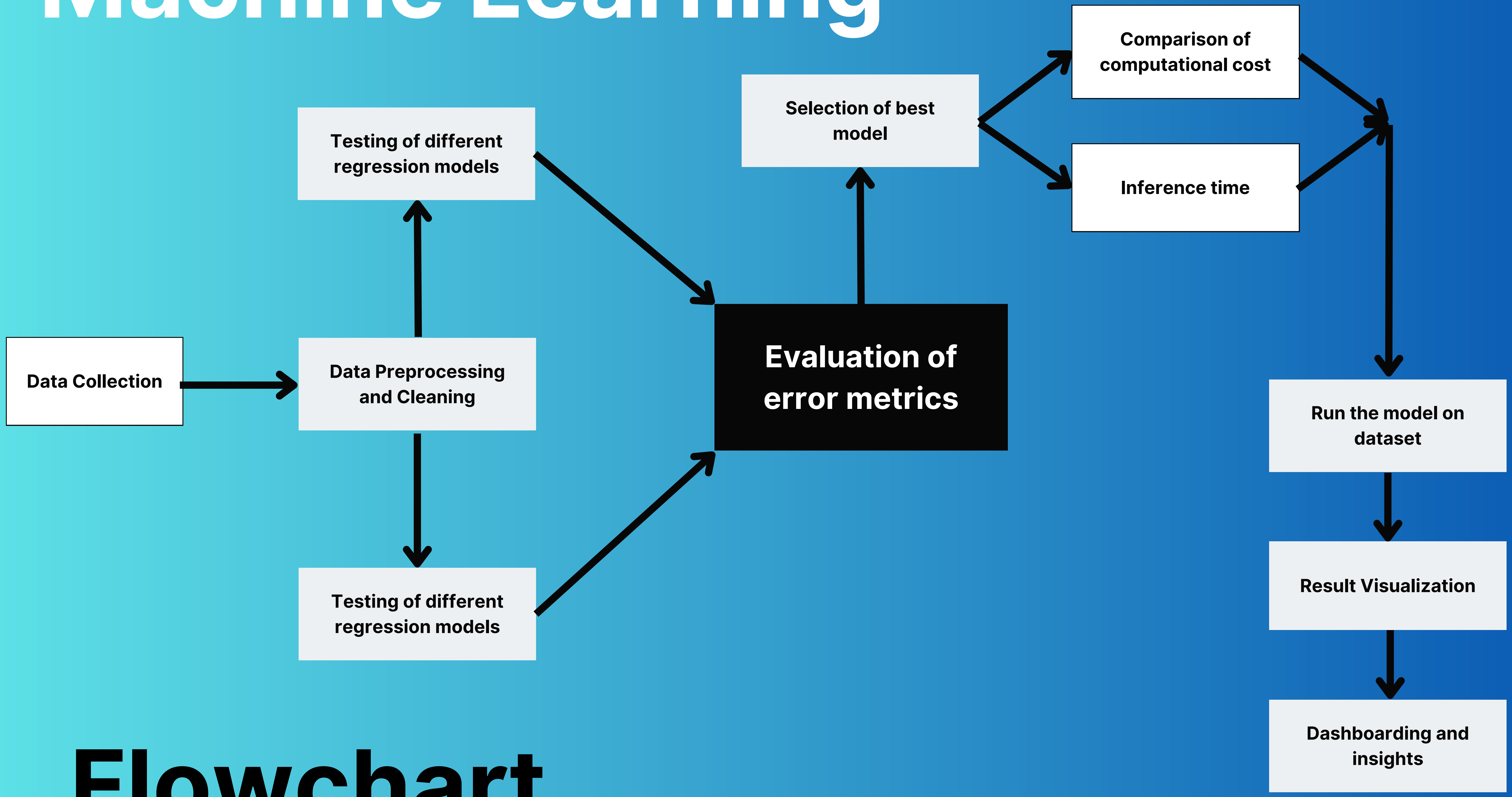
The recorded parameters are transferred to Firebase for data analytics and prediction

LSTM and ARIMA used for time series forecasting to predict the future power consumption and power generation

An optimal demand side management to be set up to allow efficient load scheduling

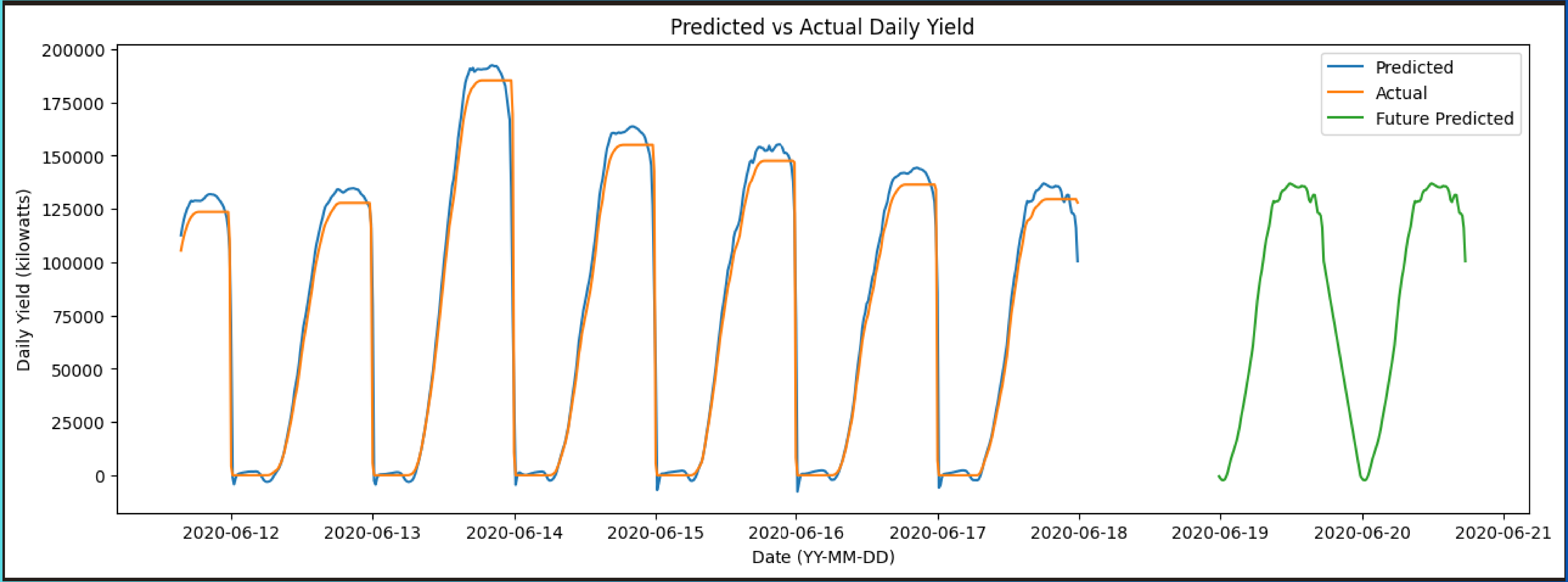
An interactive dashboard is developed to allow users to track, control, and monitor the panels remotely and to optimize the production, storage, and usage of electricity.

Machine Learning

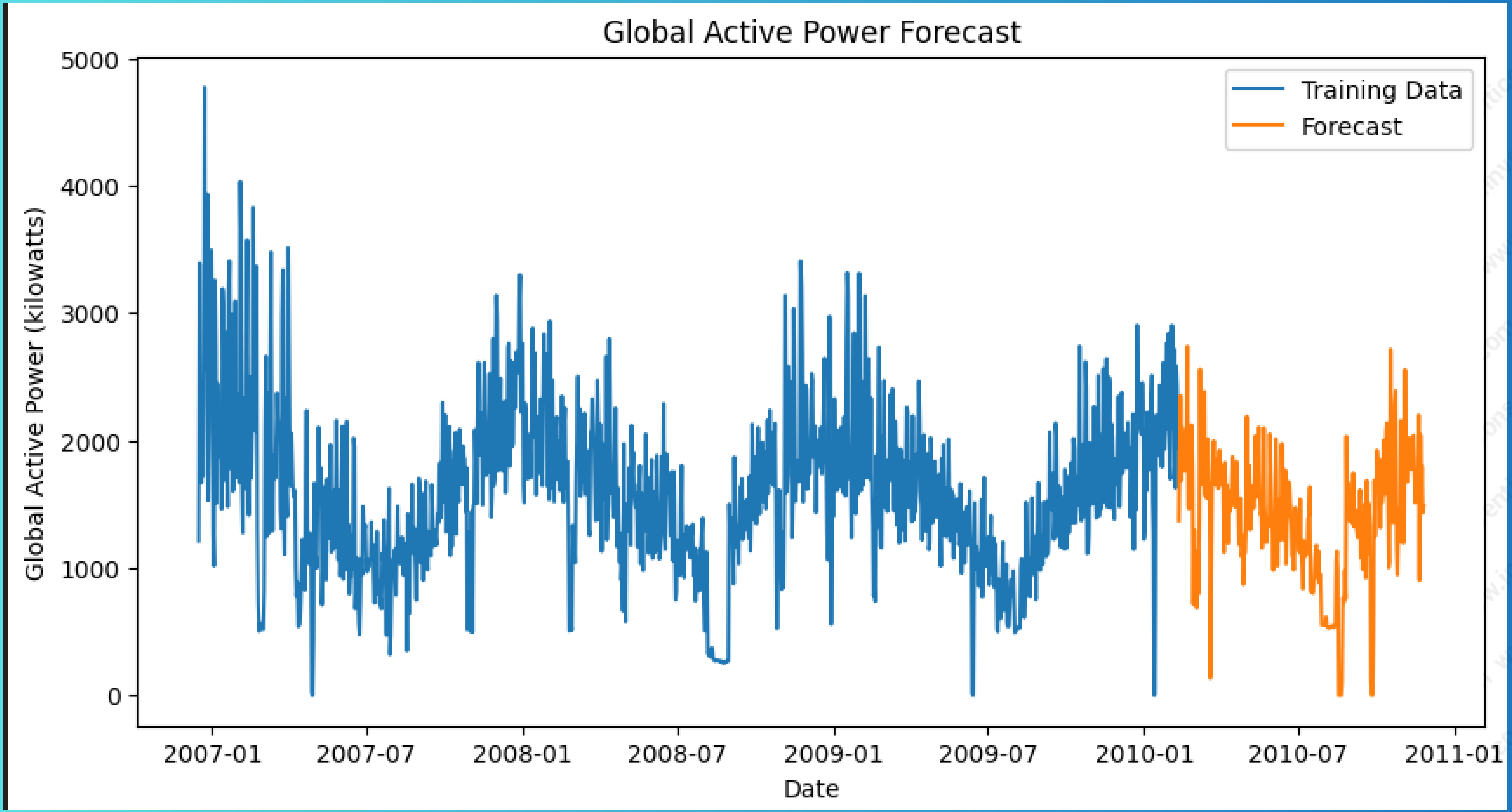


Flowchart

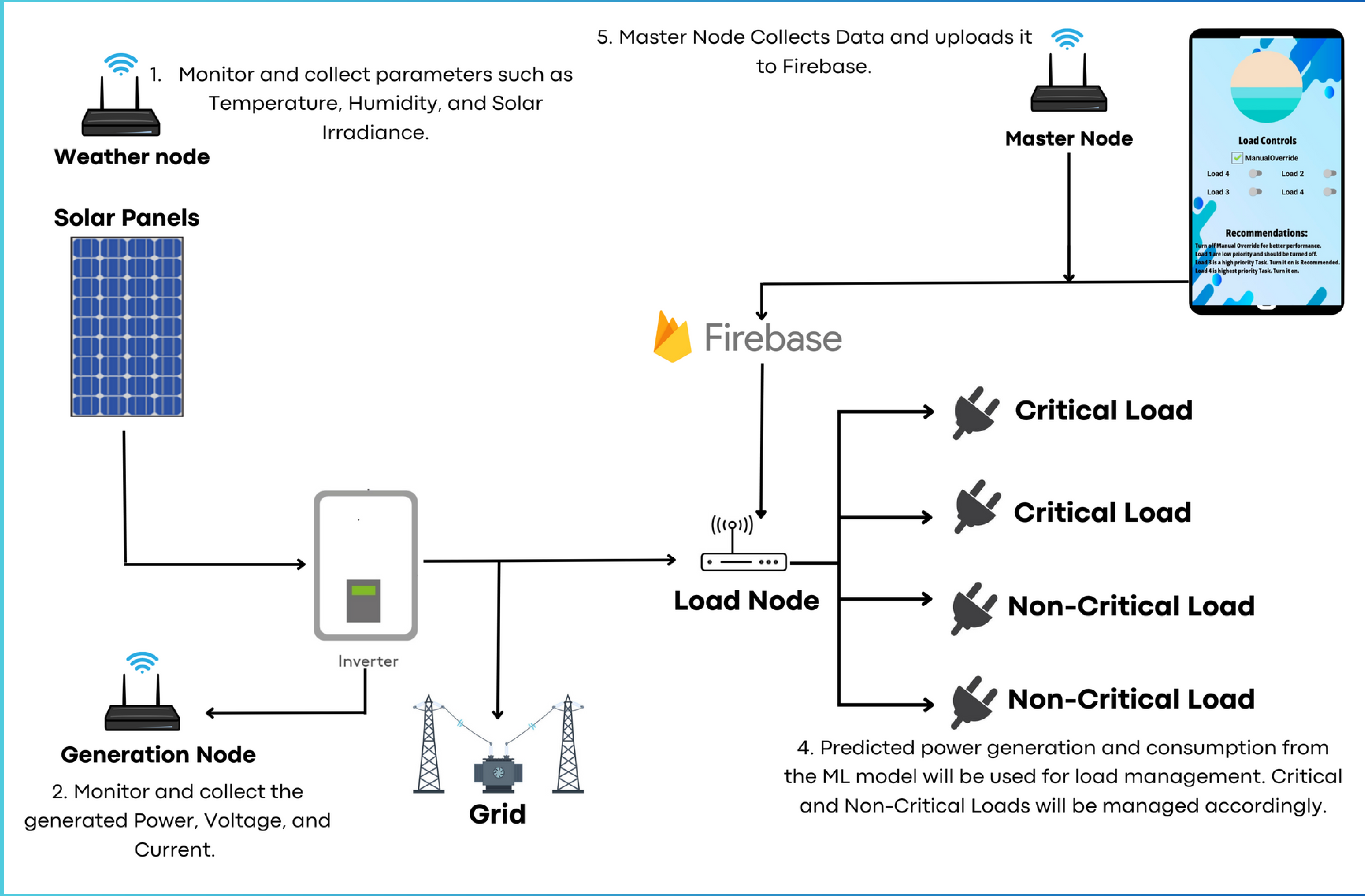
Generation Side Forecasting



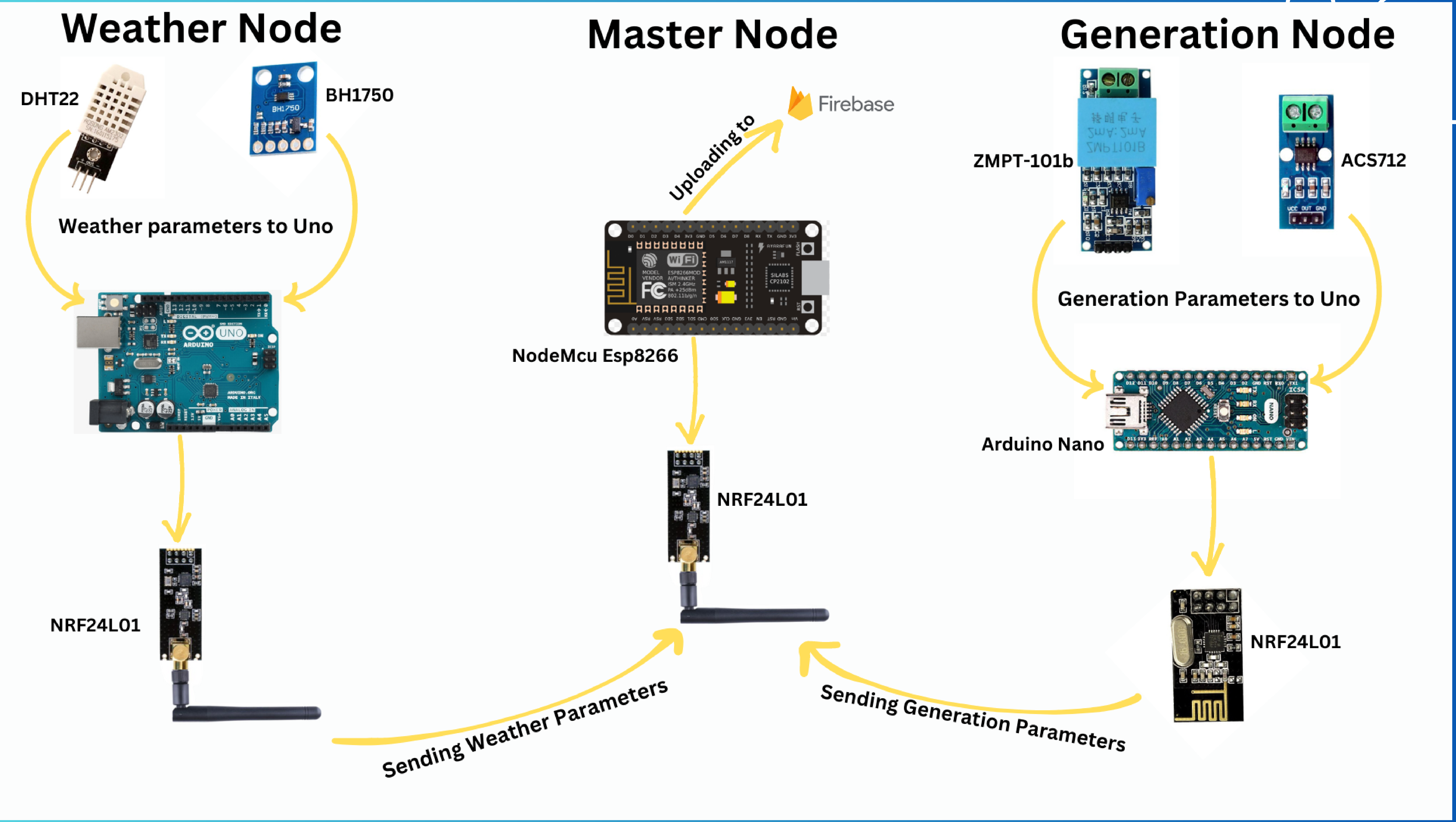
Consumption Side Forecasting



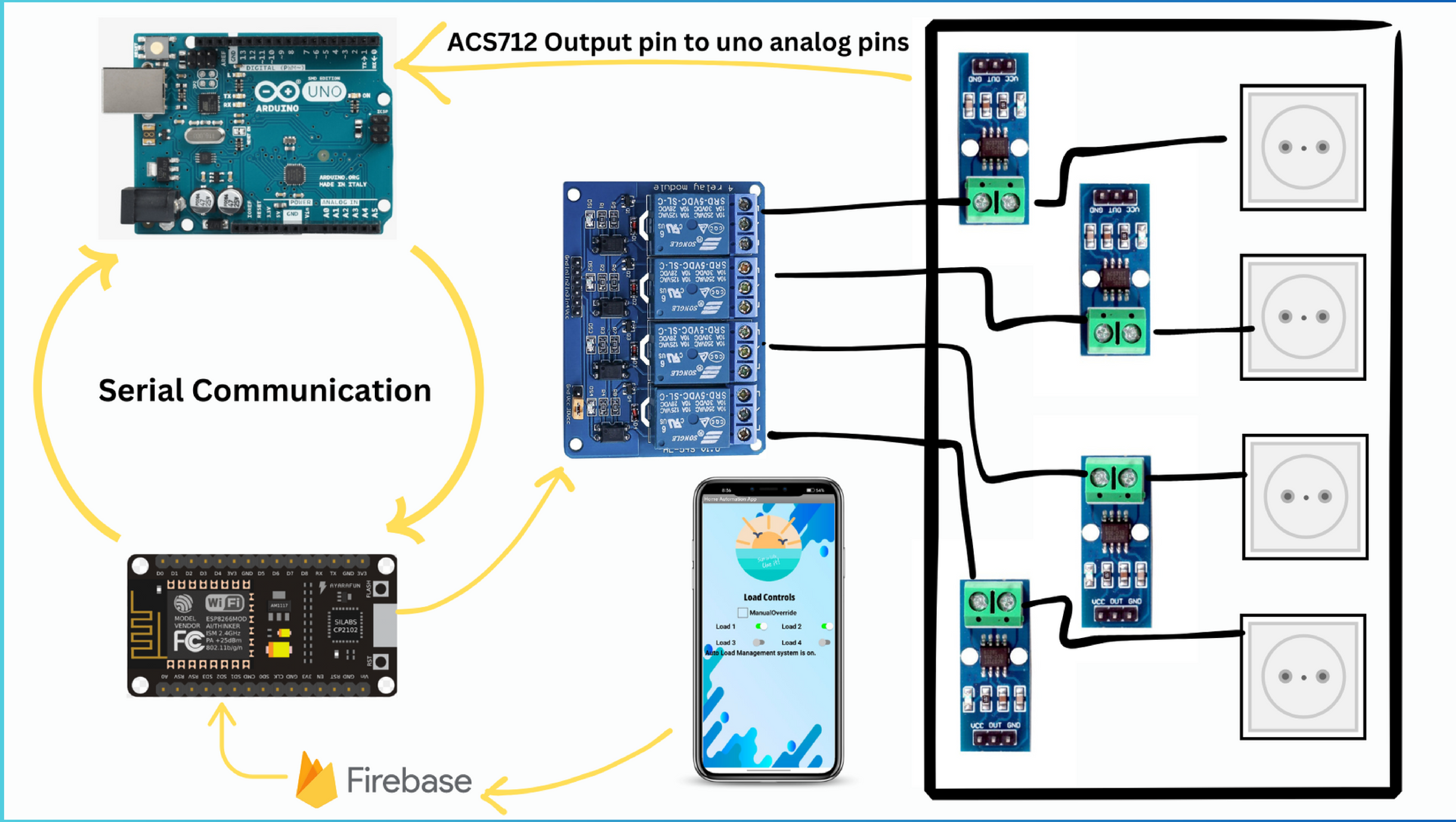
Block Diagram



Node Designs

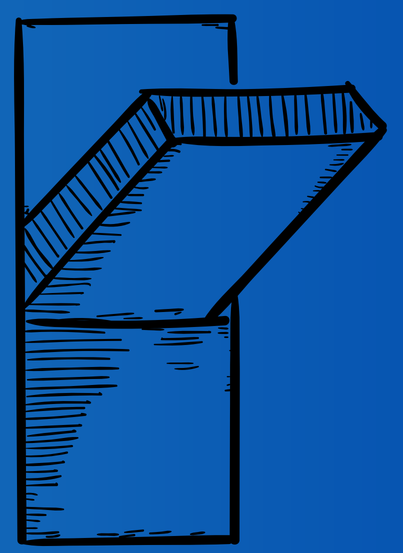


Load Management

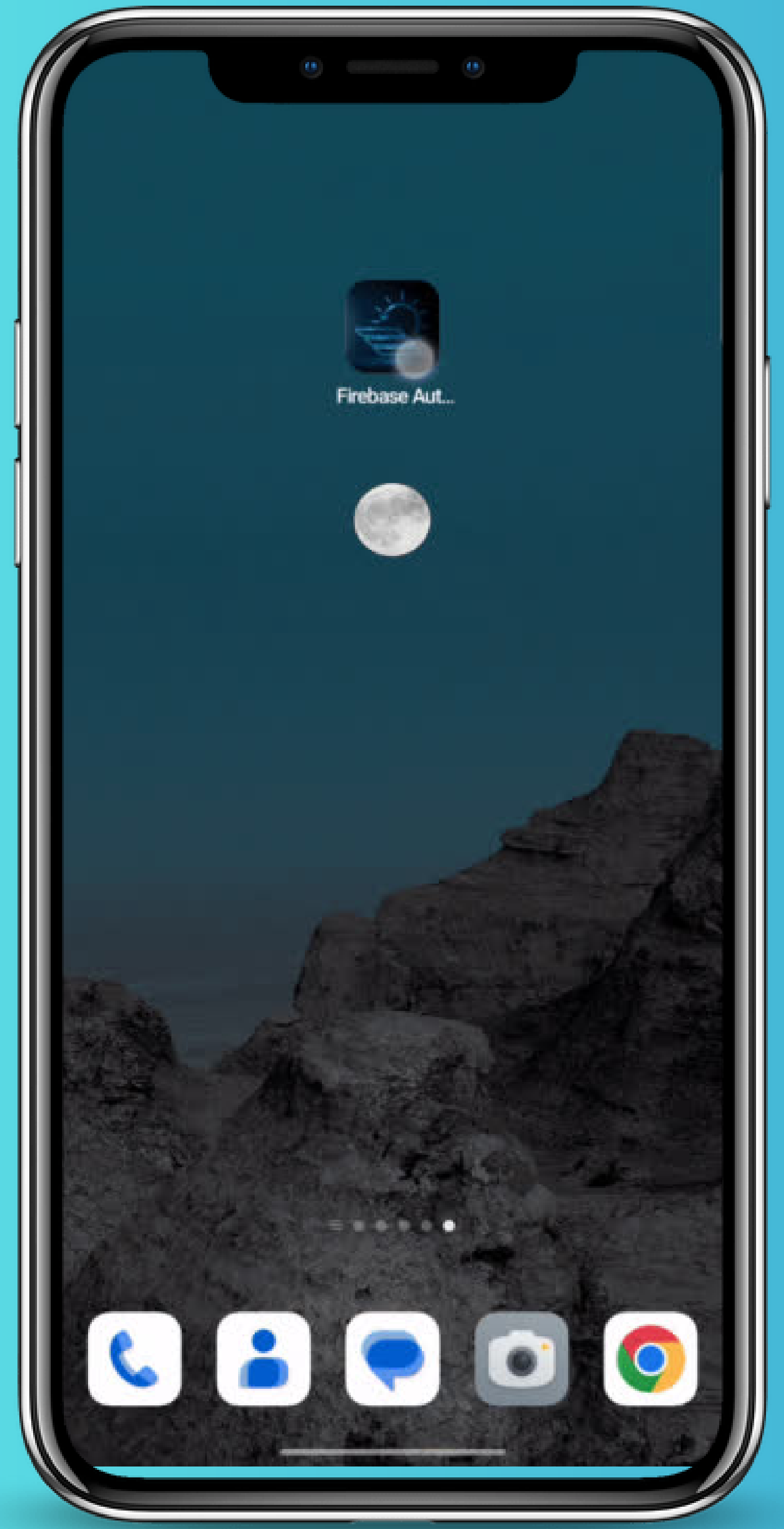


Load **Management**

- Assign priority numbers (1, 2, 3, 4) to each load.
- If energy difference < -Threshold (=>Threshold = 100W)
- Disable the lowest priority load.
- Re-evaluate energy difference.
- Repeat Step 2 until the energy difference ≥ -Threshold
- If energy difference > Threshold:
- Enable the highest priority load.
- Re-evaluate energy difference.
- Repeat Step 4 until energy difference ≤ Threshold

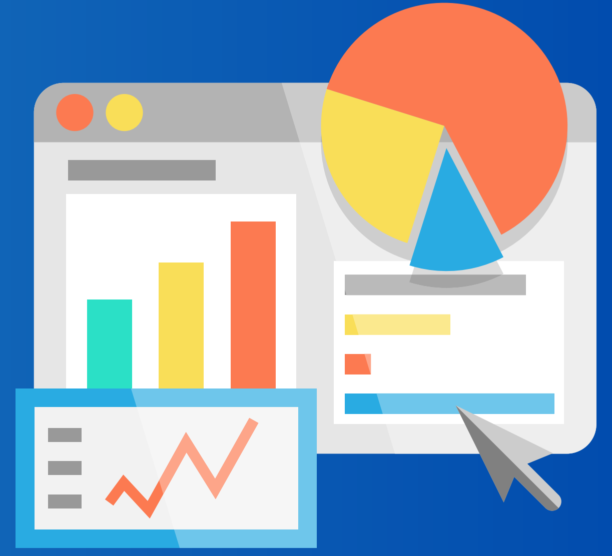


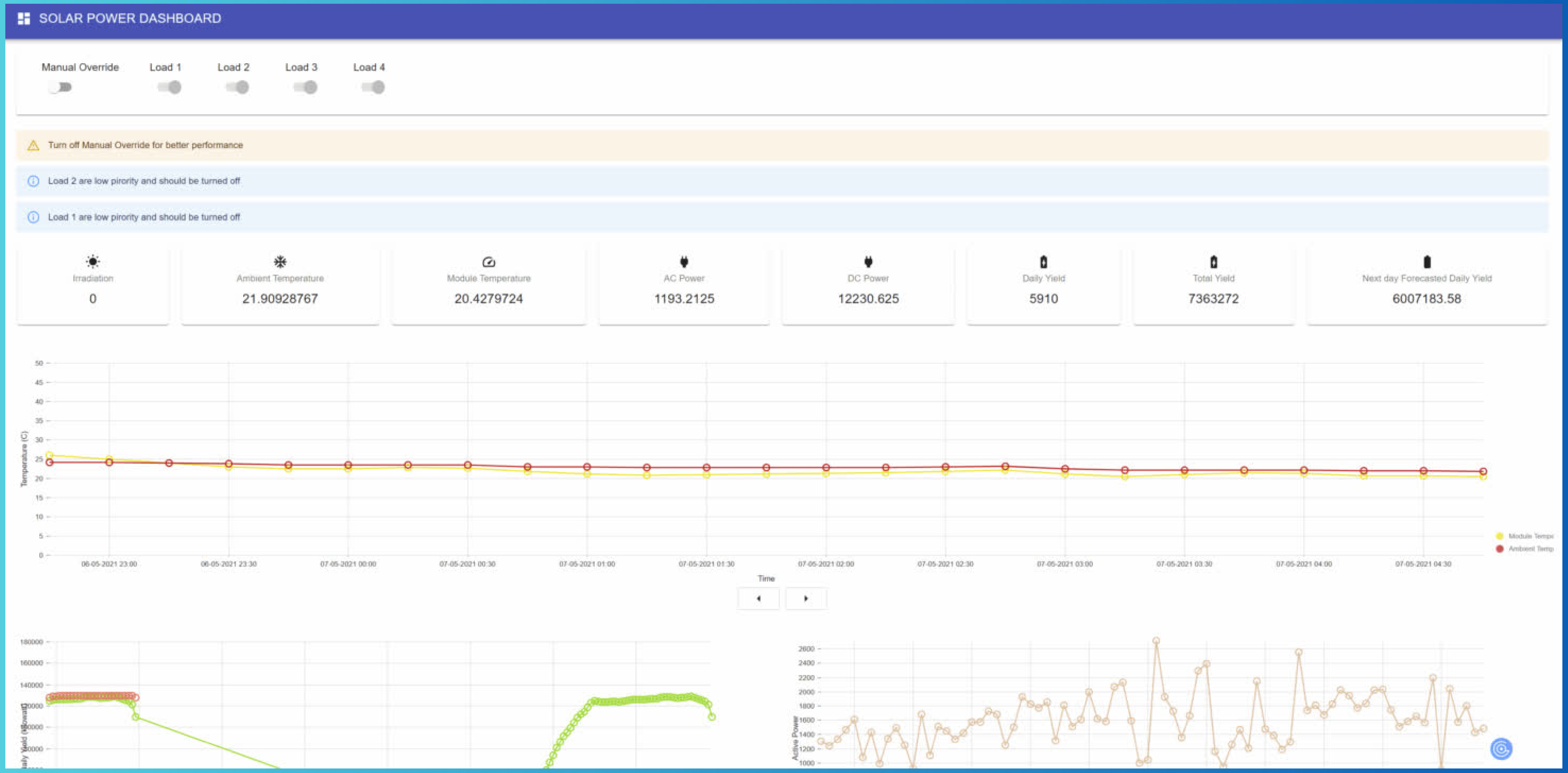
Application and Recommendations

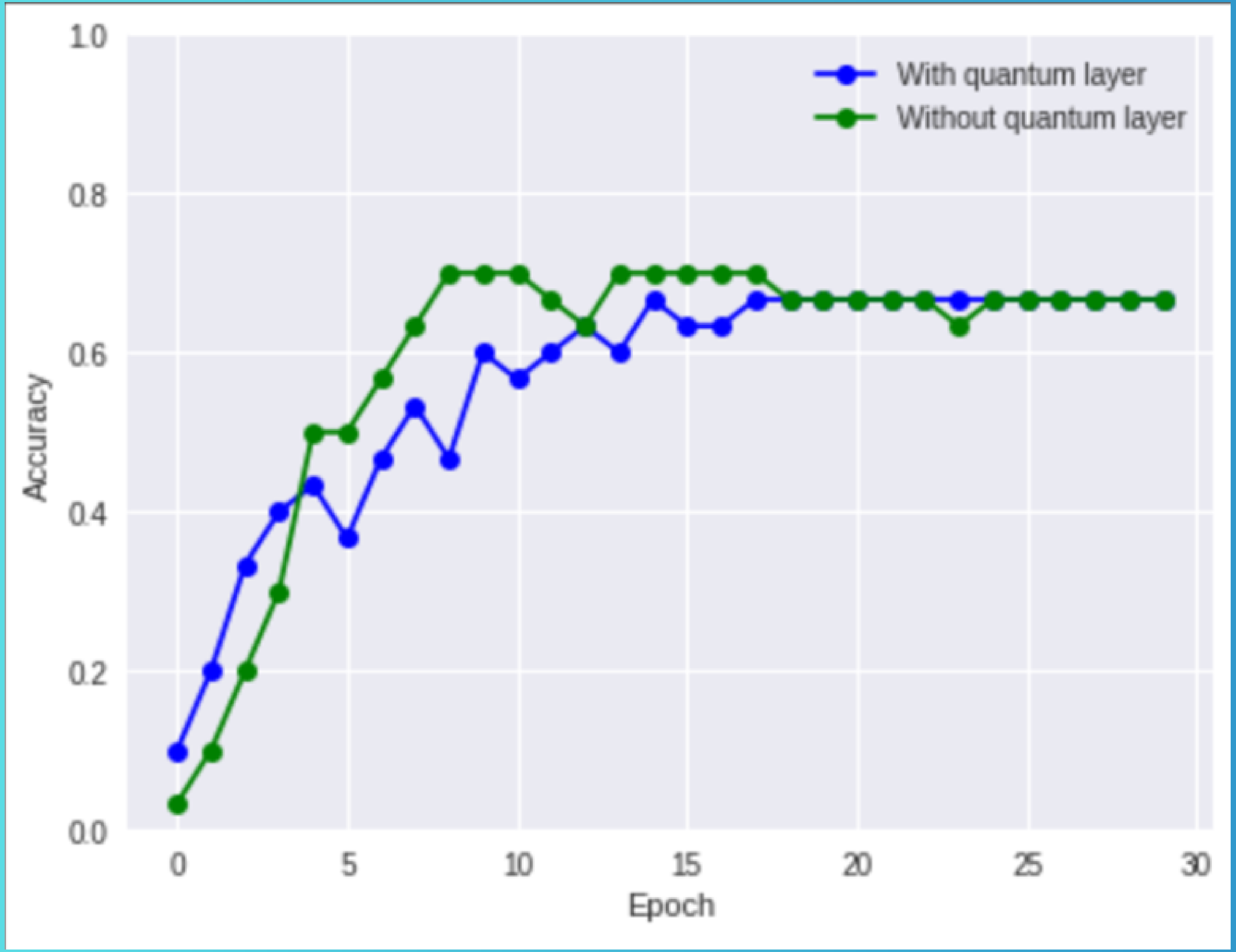


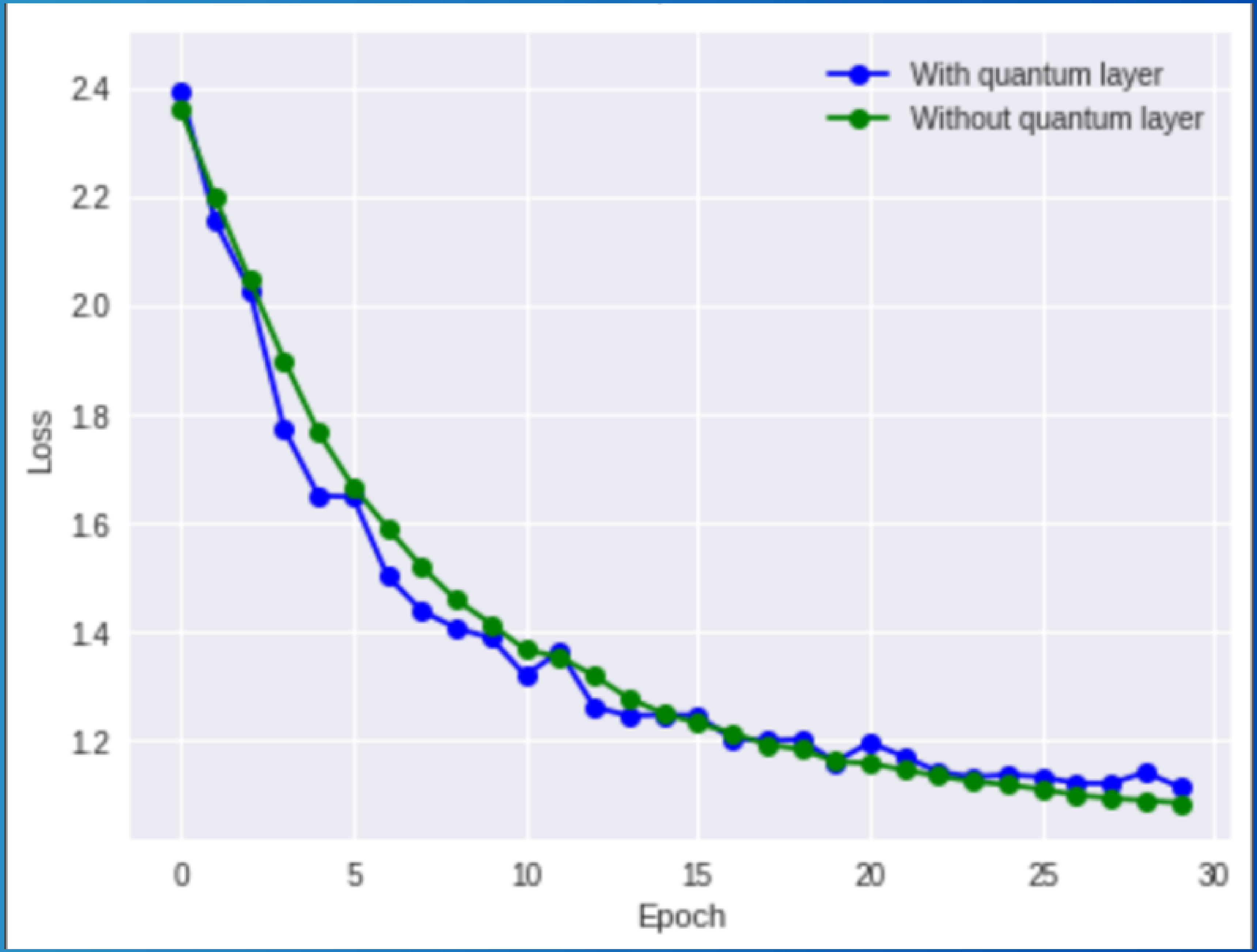
- **Mobile App Connectivity:**
  Connects to Firebase for remote load control
  Allows users to activate/deactivate loads from anywhere
- **Manual Override Option:**
  Provide full control over load activation/deactivation
  Bypasses load management algorithm
- **Load Management Recommendations:**
  Provides suggestions for load activation/deactivation
  Helps optimize energy consumption
- **Automatic Load Management:**
  The algorithm takes over when manual override is disabled
  Balances energy by calculating energy difference
  Users authorize algorithm-based load control

Data Analytics Dashboard









Quantum CNN

The Quantum CNN has achieved the similar accuracy to the classical model, by using very less amount of data i.e., 50 training images instead of 60,000 training images

Benefits of the proposed solution

High return on investment keeping in mind the inflation currently (payback period of 3-4 years)

The proposed solution requires minimal human intervention, making it easy for the user

The proposed solution provides the user with accurate predictions for power consumption and power generation

This solution will ultimately lead to efficient load management.

Conclusion

- Developed a 2kVA testbed
- Gathered data from surroundings using sensors
- Logged the data in real-time using Firebase
- Used the data for future predictions of power generated
- Used datasets for future predictions of power consumed
- Used LSTM and ARIMA for forecasting
- Implemented a load shedding algorithm for energy optimization
- Provide recommendations to the user for efficient usage
- Developed a frontend for a dashboard for data analytics

Project Timeline

1

Idea Selection and PMS enrolment (5th April 2022)

2

Proposal Defence (7th October 2022)

3

Design Expo (21st October 2022)

4

Mid Defence (1st March 2023)

5

Final Defence (10th May 2023)

6

Open House (24th May 2023)

FYP Deliverable Status

Sr.	FYP Deliverable	Status
1	Final Report	✓
2	Final Presentation Slides	✓
3	Poster A1 Size	✓
4	Plagiarism Report	✓
5	Demo Video	✓

References

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Thank You