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KU Smart Meter Monitoring and Analytics System

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Presentation Outlines

1. Introduction
2. Problem Statement
3. Methodology
4. Results and Discussions
5. Conclusion and Future Works
6. References

1. Introduction

- *Modern energy systems require real-time monitoring for efficiency and reliability.*
- *Traditional analog meters only provide cumulative readings.*
- *Smart meters provide high-resolution data including*

    Energy consumption

    Voltage levels

    Load variations

    Outage events

- *This project develops a real-time smart meter analytics platform for Kathmandu University.*

1. Introduction

- *Objectives*

  Develop a scalable web-based smart meter monitoring platform.

  Integrate secure API-based real-time data acquisition.

  Provide interactive dashboards for visualization and analysis.

  Implement AI-based forecasting for energy prediction.

  Design a modular and scalable system architecture..

2. Problem Statement

- *Kathmandu University operates multiple facilities with significant energy demand.*
- *Challenges:*

  No centralized real-time monitoring

  Limited visibility into voltage instability and outages

  No predictive insights for peak load management

  Difficulty in data-driven energy planning
- *Research Gap:*

  Existing IoT platforms are generic and not tailored for smart meter analytics in academic environments.
- *Need:*

  A domain-specific, customizable, and scalable smart meter monitoring and analytics system.

3. Methodology

- *System Architecture*

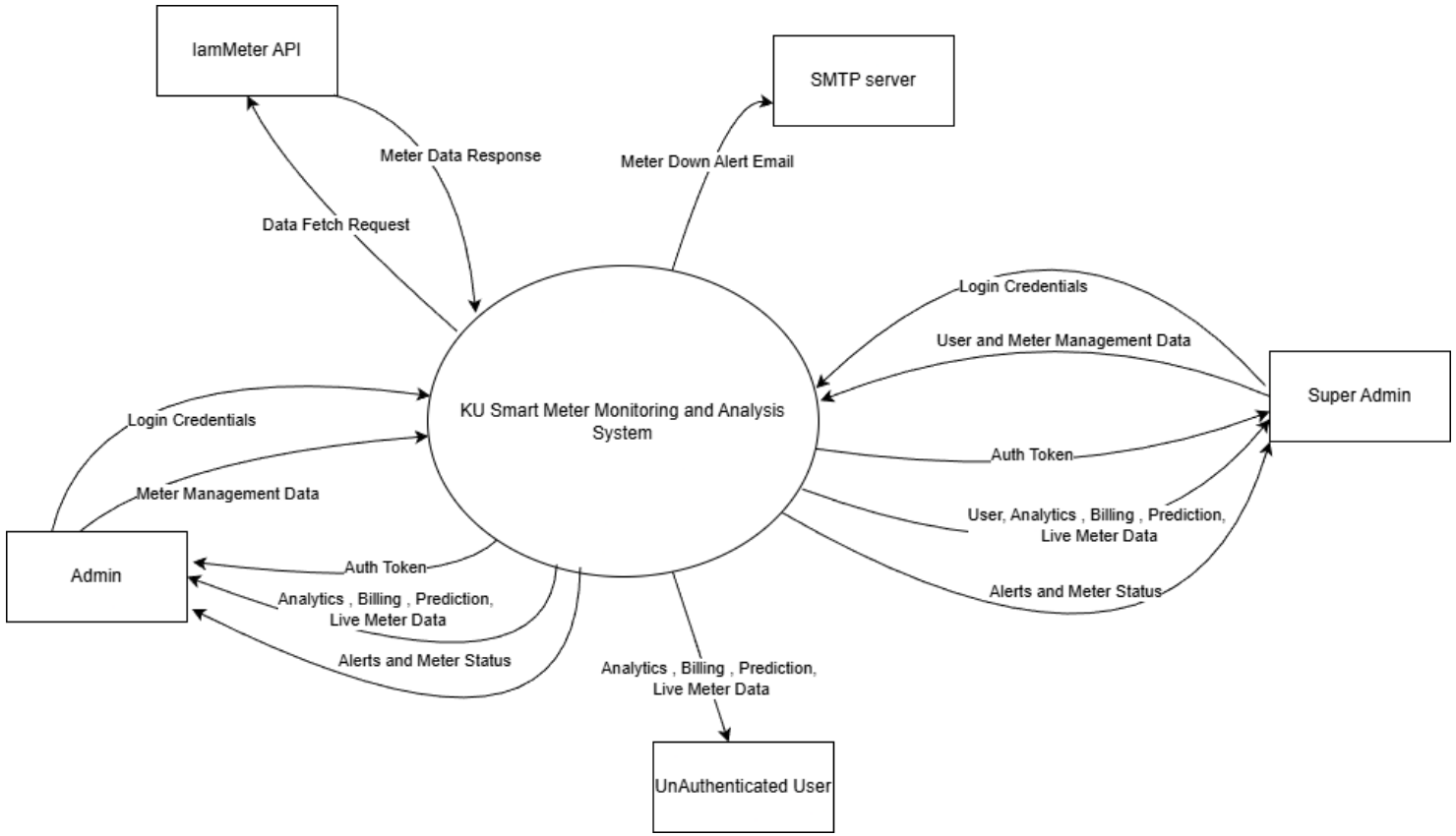

Figure 1- Context Diagram

3. Methodology

- *Development Approach*

  Agile development methodology adopted.

  Phases:

  Planning and requirement analysis

  Research on smart meter APIs and forecasting models

  Frontend development using React

  Backend development using FastAPI

  Database design using PostgreSQL

  Model training using Random Forest regression

  System testing and validation

3. Methodology

- *Machine Learning Model*

  Model Used: Random Forest Regression

  Features:

    Hour of day

    Day of week

    Month

    Historical lag values

  Total Dataset Size: 8355 samples

  Training Samples: 6684

  Testing Samples: 167

  Evaluation Metrics:

    Mean Absolute Error (MAE): 13.26 kW

    Root Mean Squared Error (RMSE): 19.65 kW

    Coefficient of Determination (R2 Score): 0.6777

4. Results and Discussions

- *System Features and Implementation*
    - *Real-time smart meter data acquisition*
    - *Interactive dashboard with graphs and trends*
    - *Voltage and current analysis*
    - *Billing and cost analysis*
    - *Geographical meter mapping*
    - *Role-based access control*
    - *ML-based 24-hour forecasting*

System successfully integrates IoT, web technologies, database systems, and ML models.

4. Results and Discussions

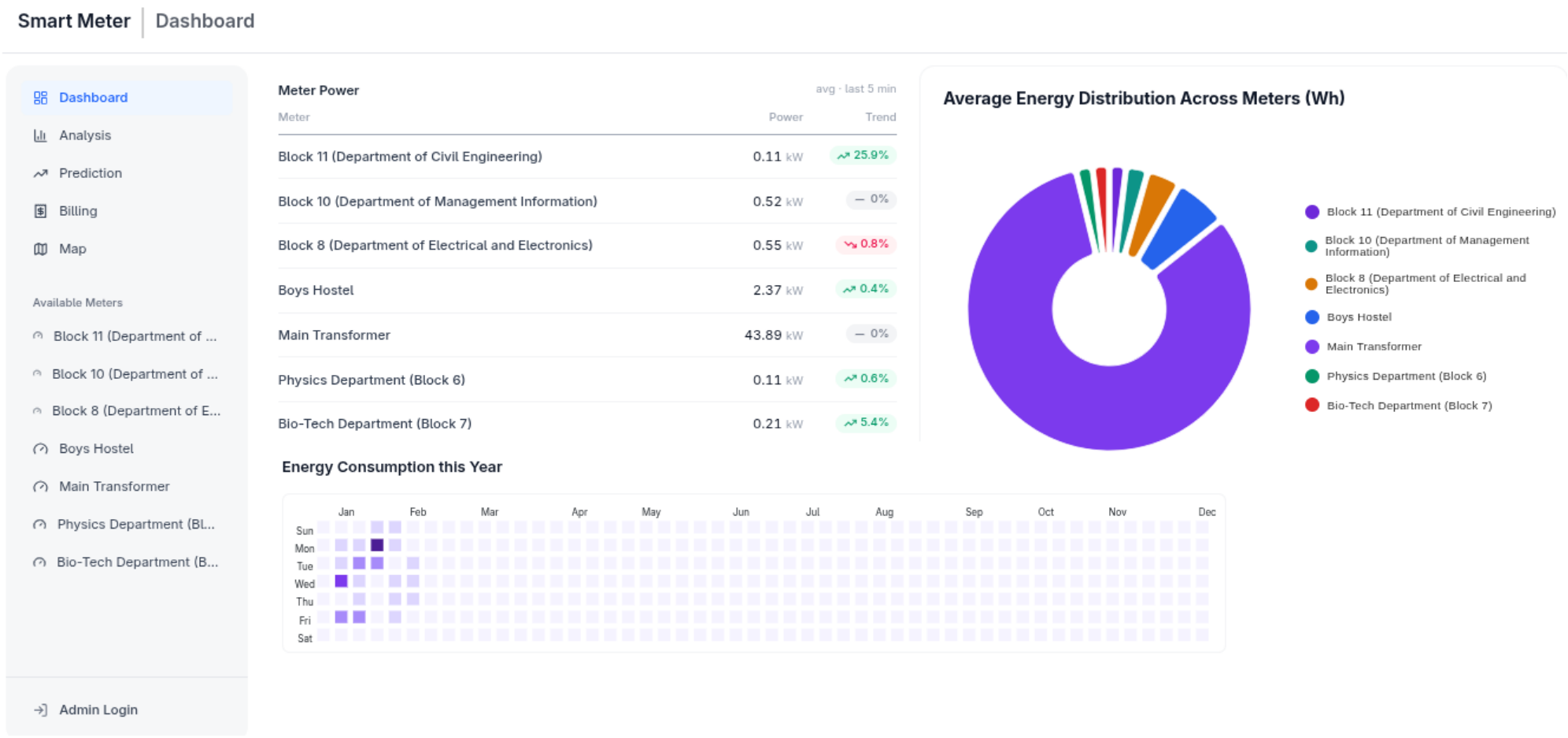

Figure 2- Main Dashboard

4. Results and Discussions

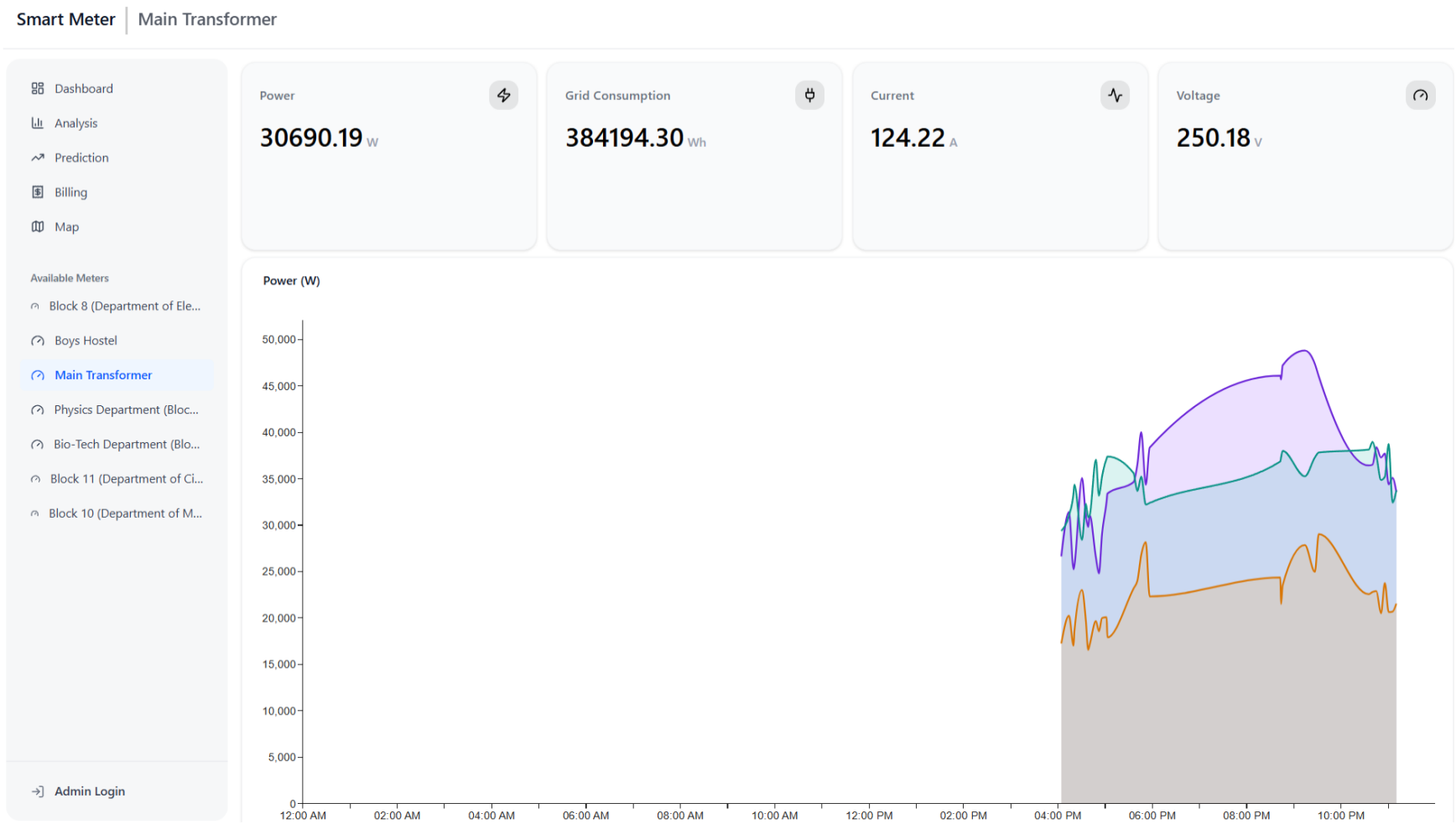

Figure 3.1.- Individual Meter Page

4. Results and Discussions

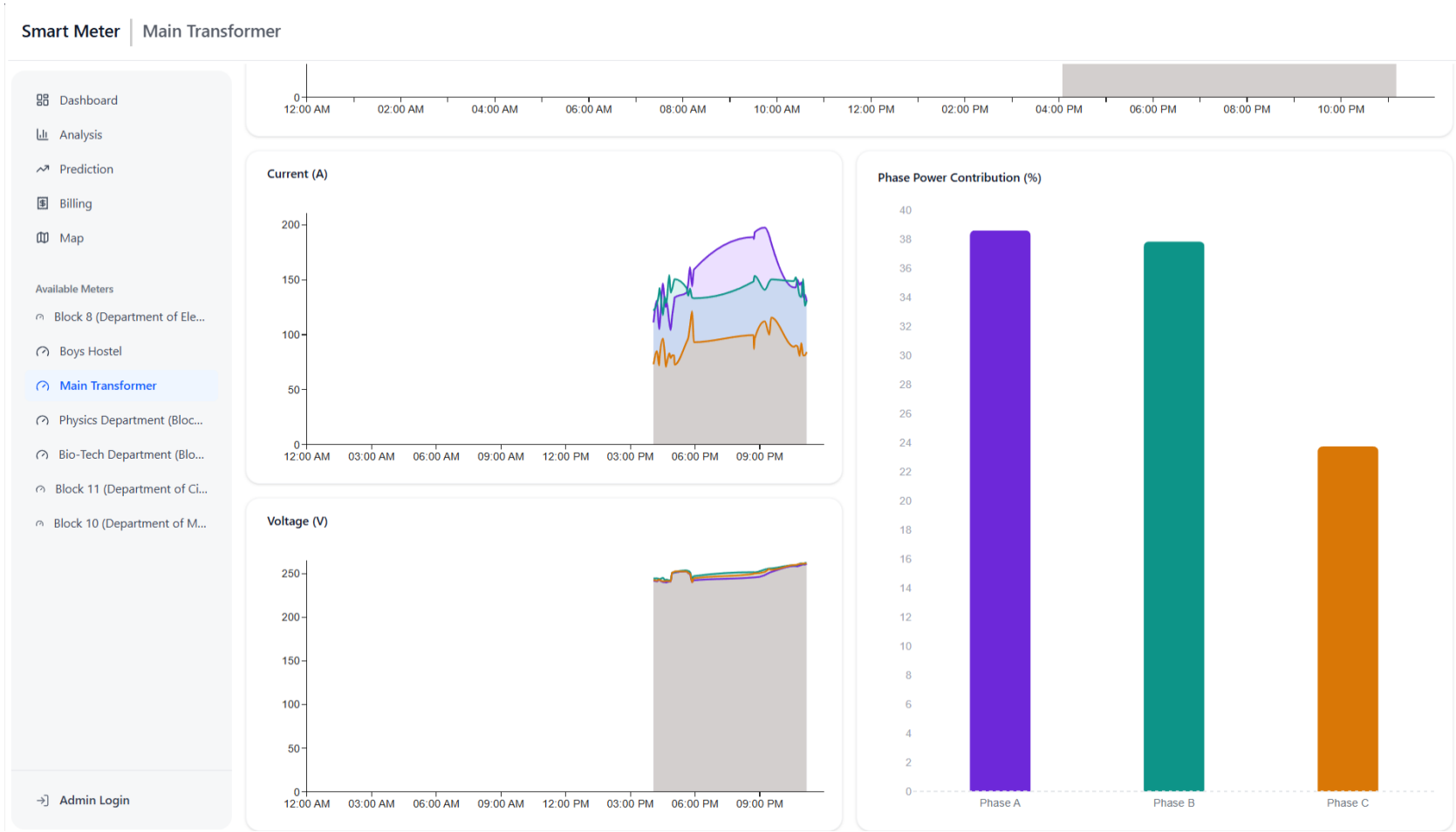

Figure 3.2. – Individual Meter Page

4. Results and Discussions

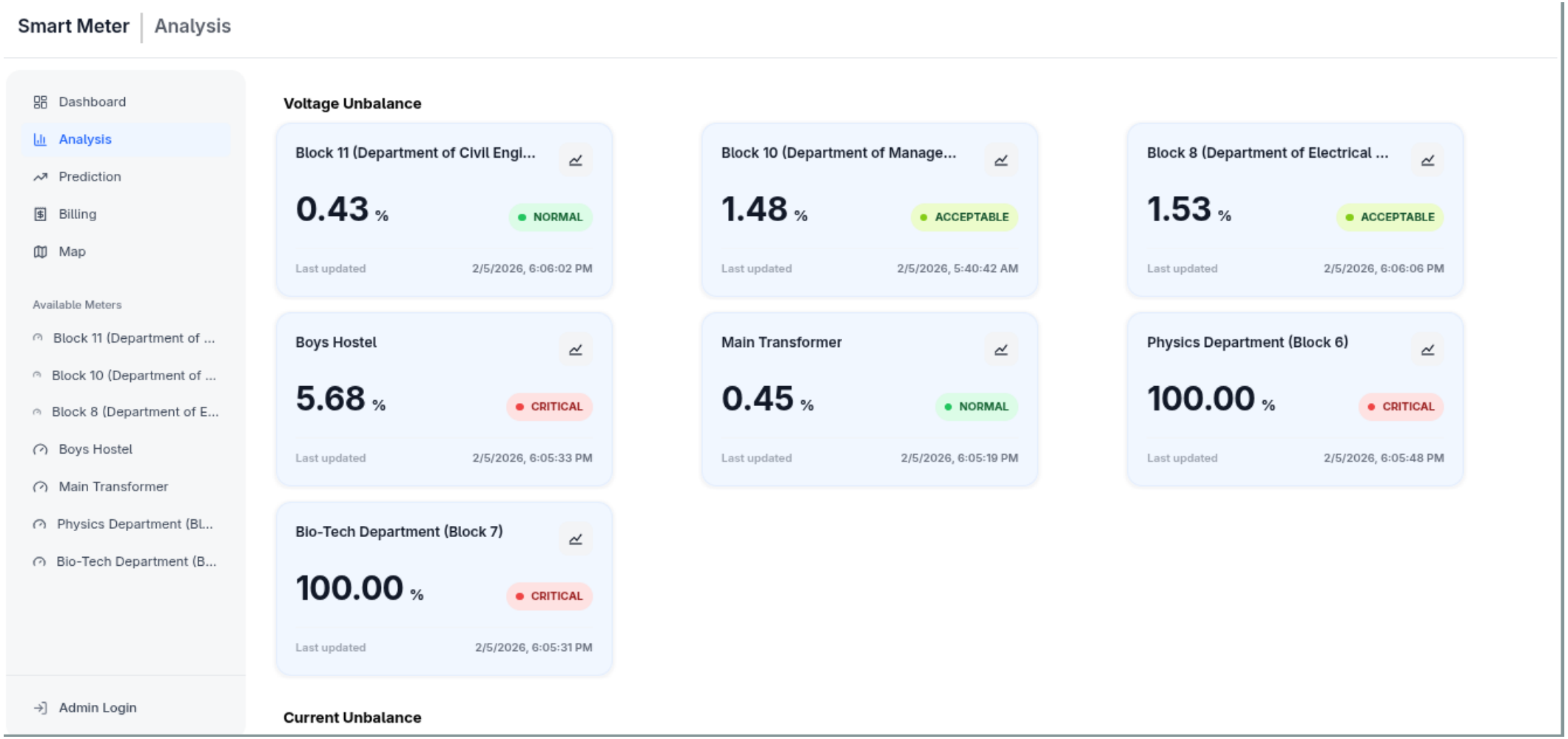

Figure 4- Analysis Page

4. Results and Discussions

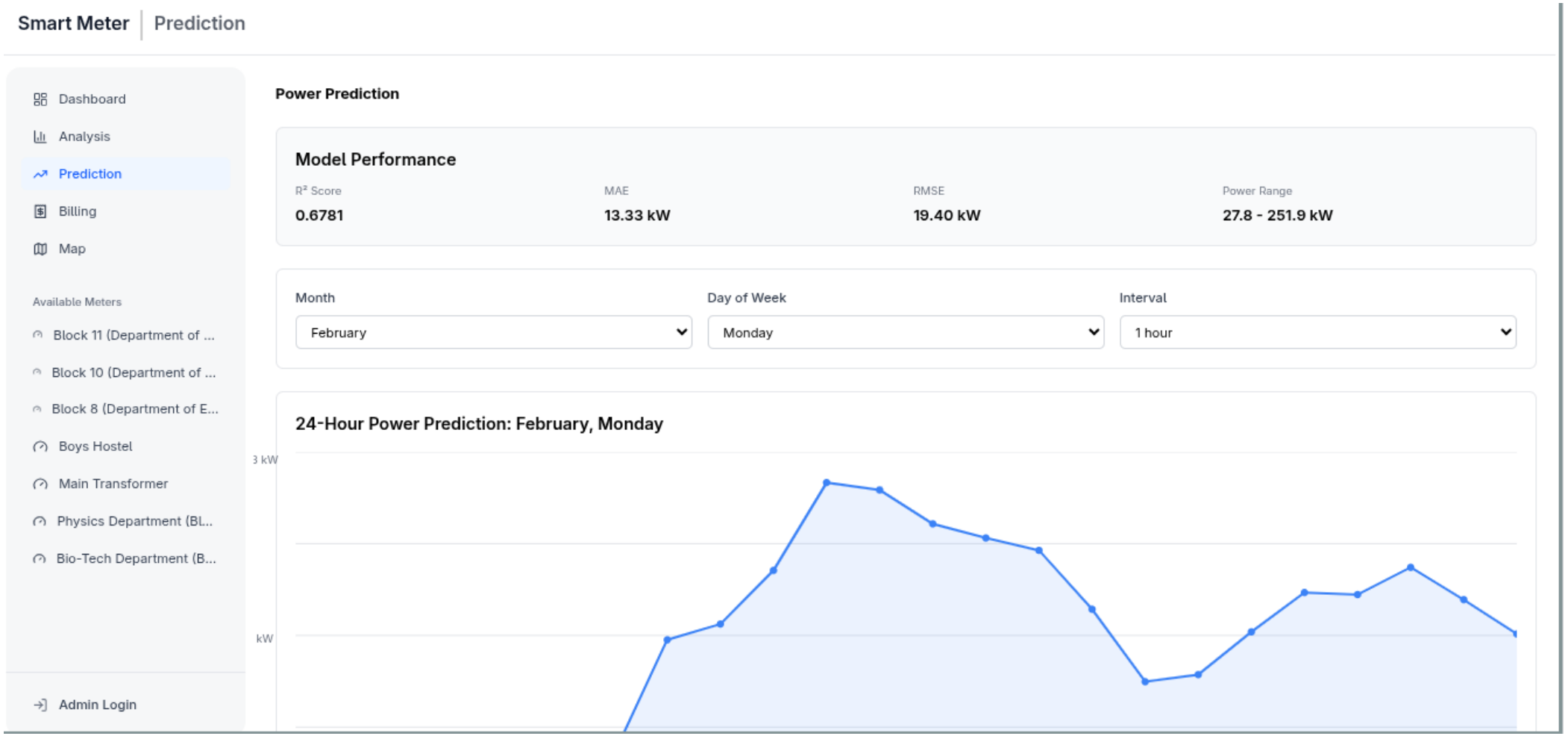

Figure 5- Prediction Page

4. Results and Discussions

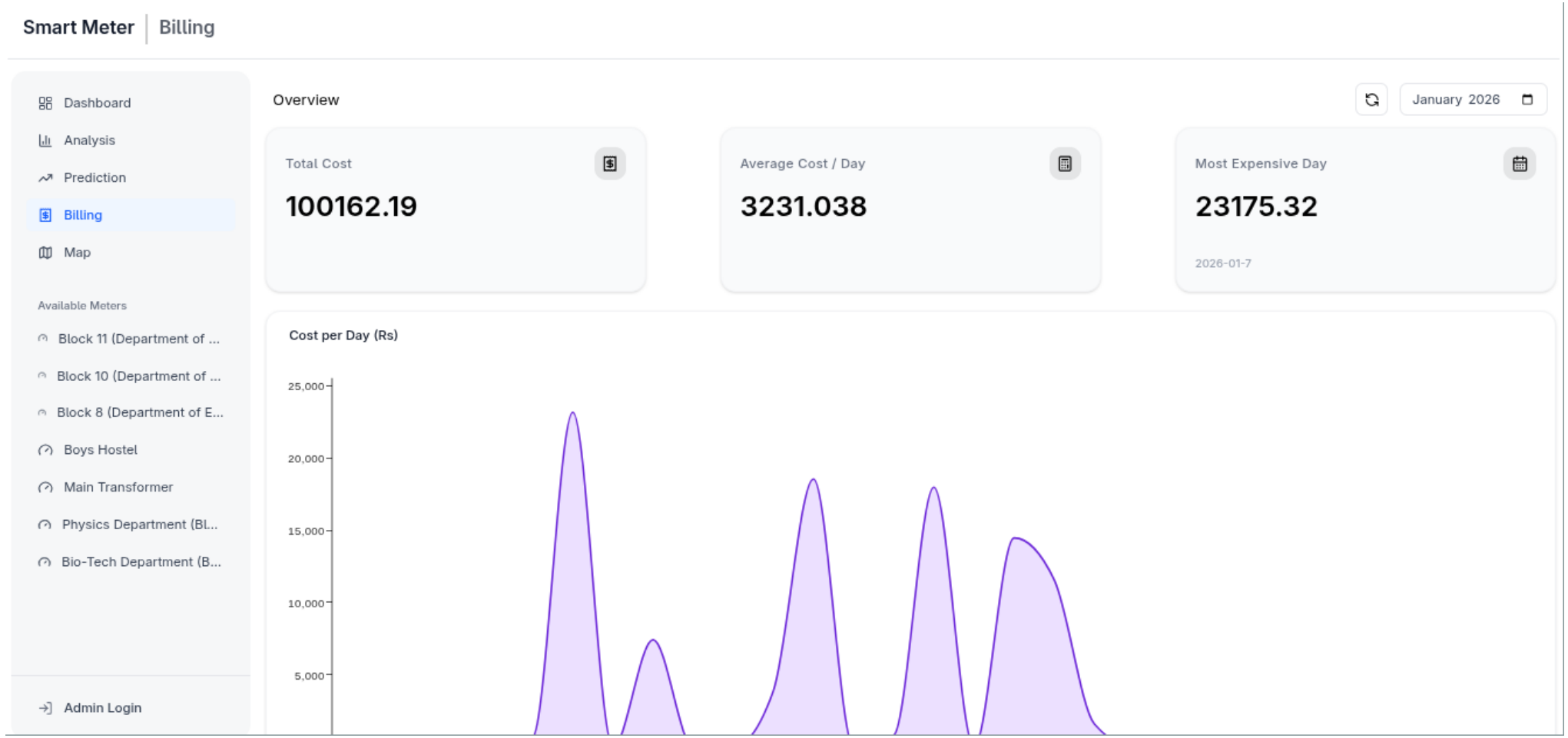

Figure 6 – Billing Page

4. Results and Discussions

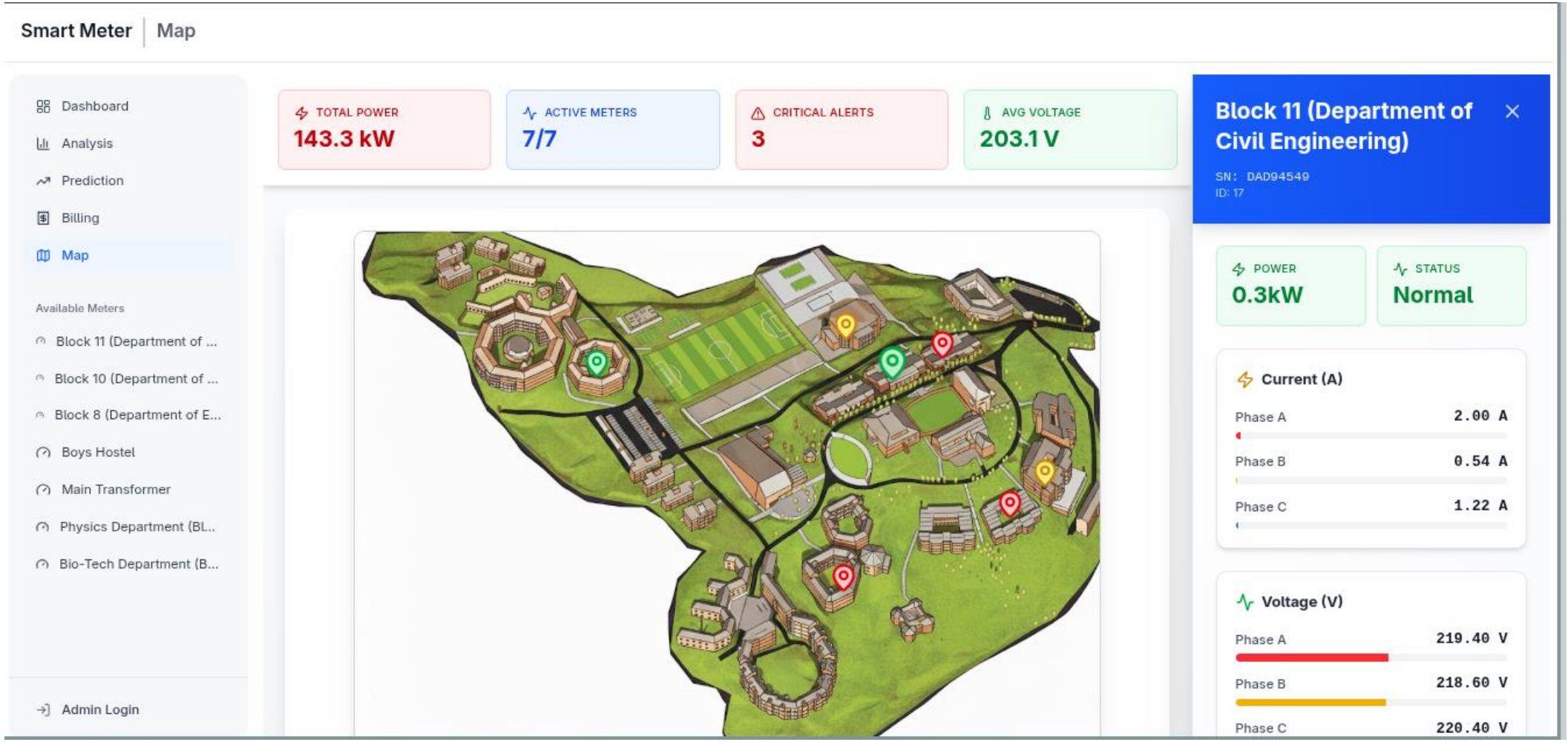

Figure 7- Maps Page

4. Results and Discussions

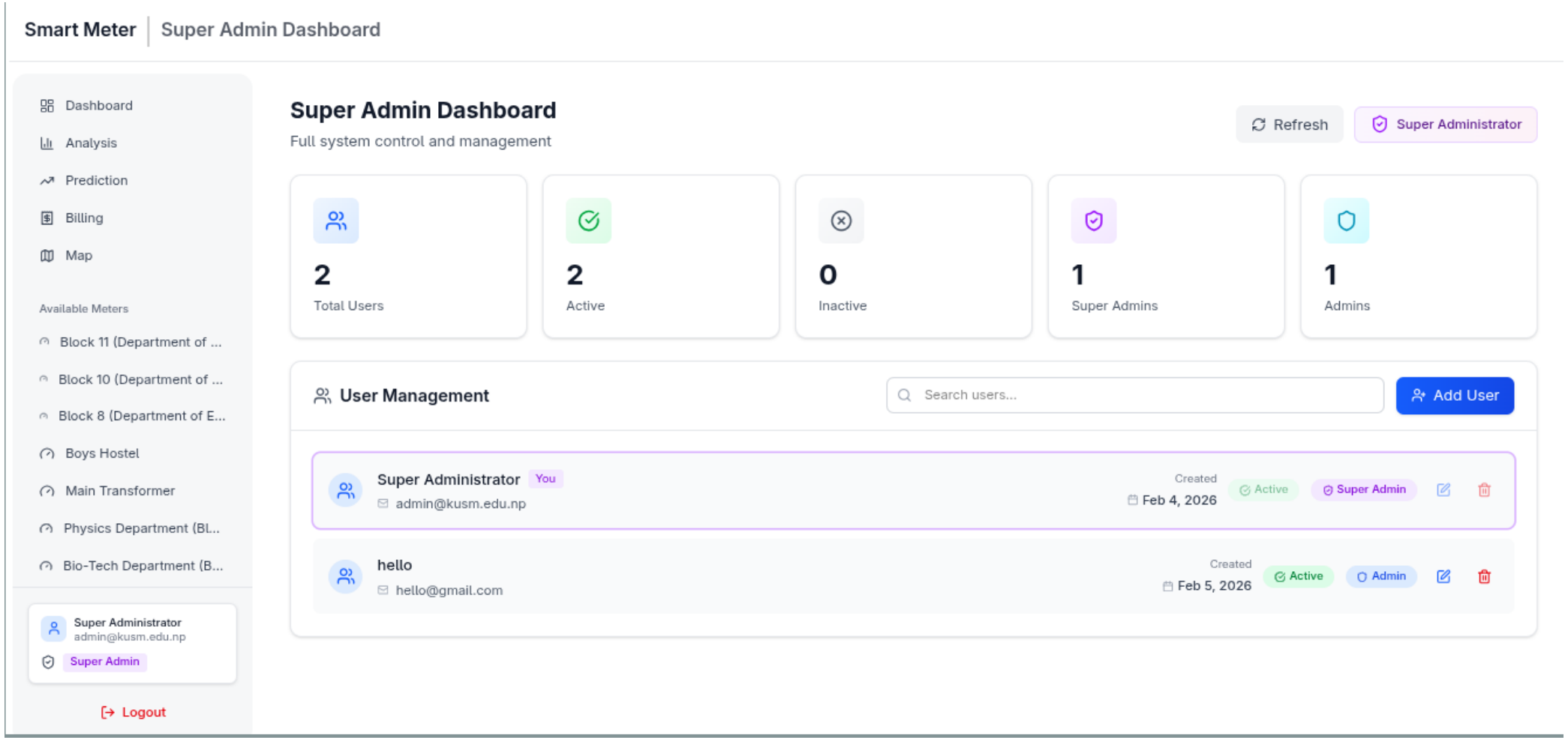

Figure 8- Super-Admin Dashboard

4. Results and Discussions

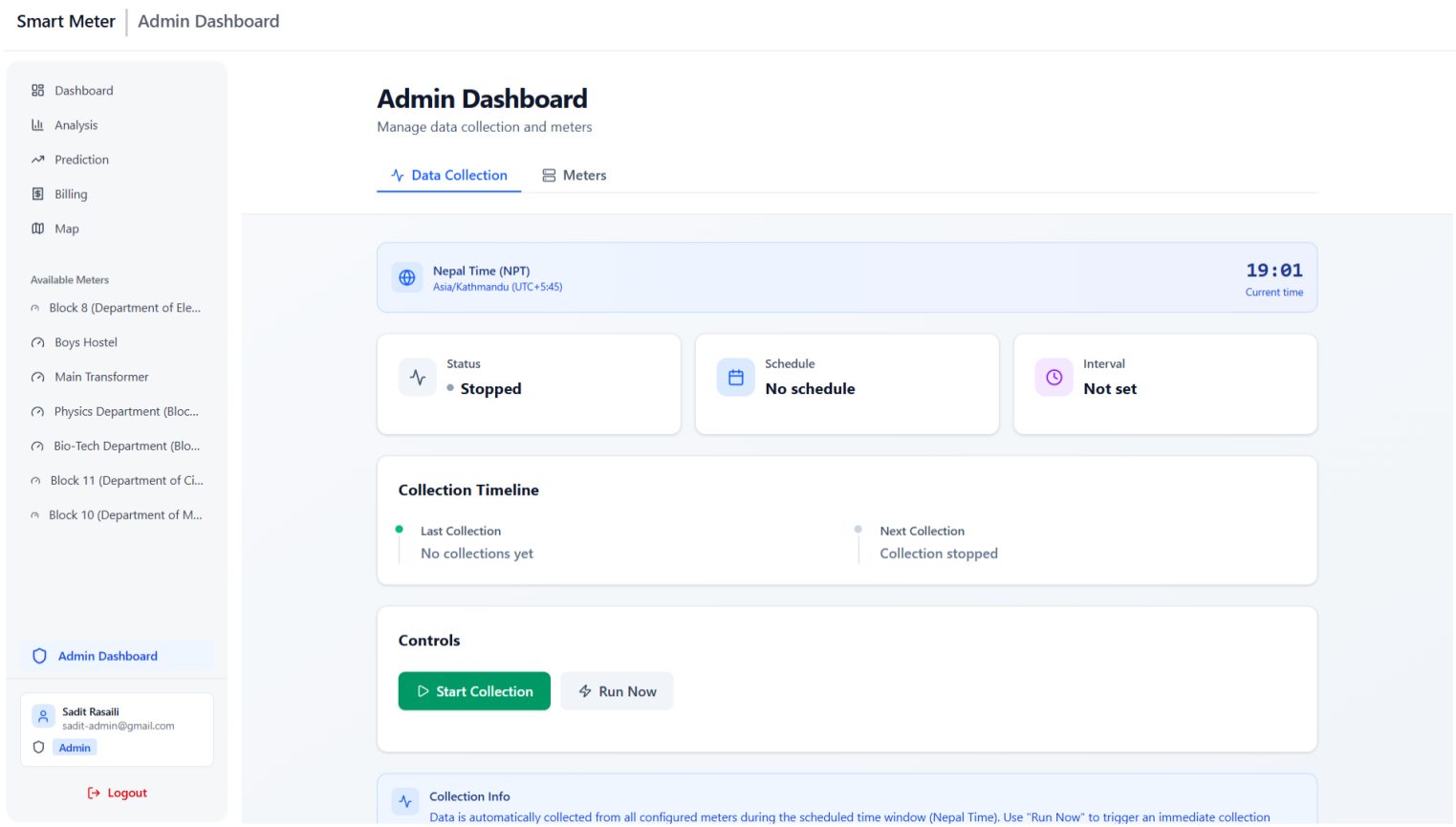

Figure 9.1. - Admin Dashboard

4. Results and Discussions

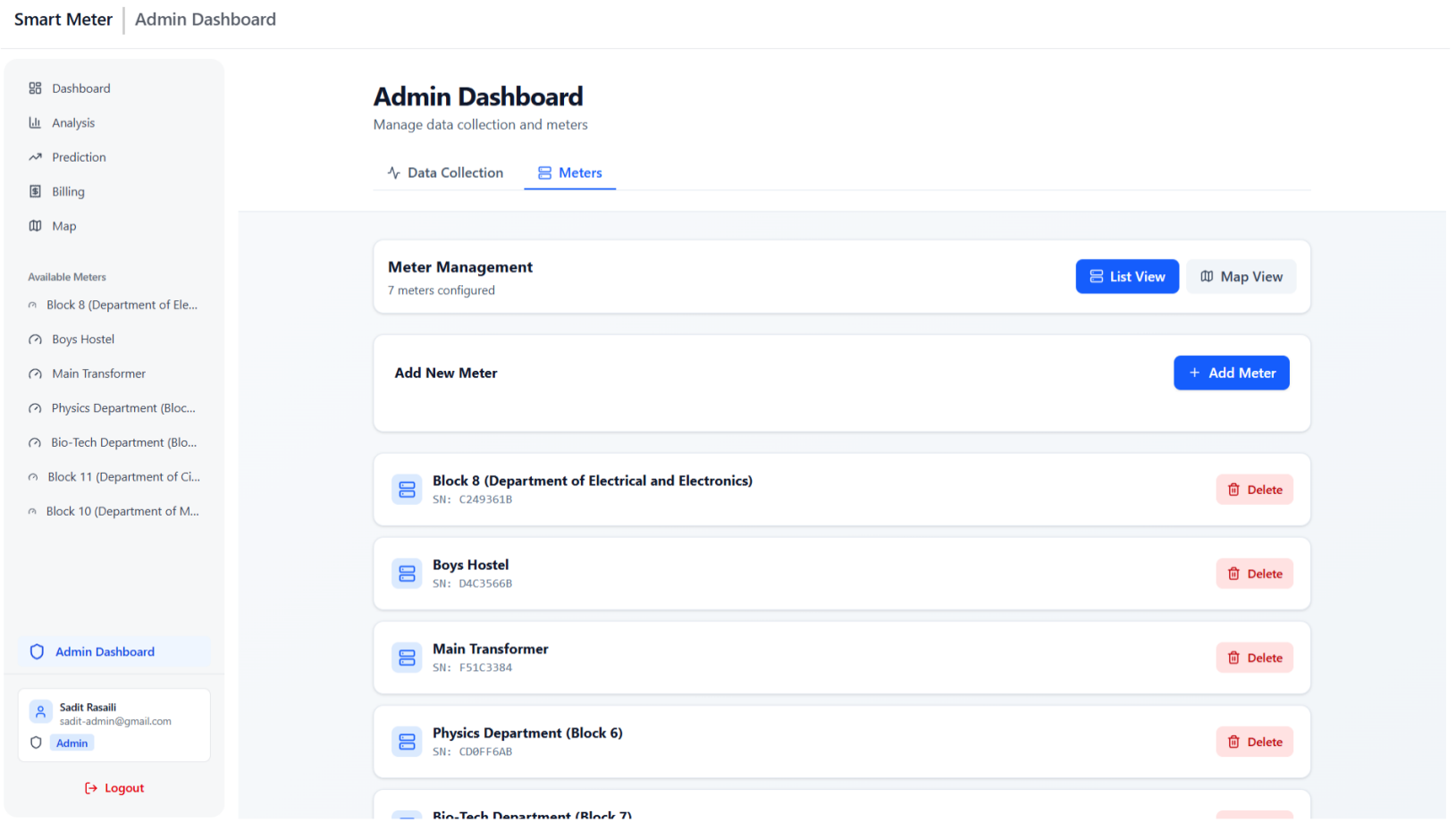

Figure 9.2. – Admin Dashboard

4. Results and Discussions

- *Results :*
    - *Clear visualization of consumption trends*
    - *Voltage stability monitoring*
    - *Peak load identification*
    - *Monthly and daily billing summaries*
    - *Improved transparency in energy usage*

System enables data-driven decision-making for energy planning.

4. Results and Discussions

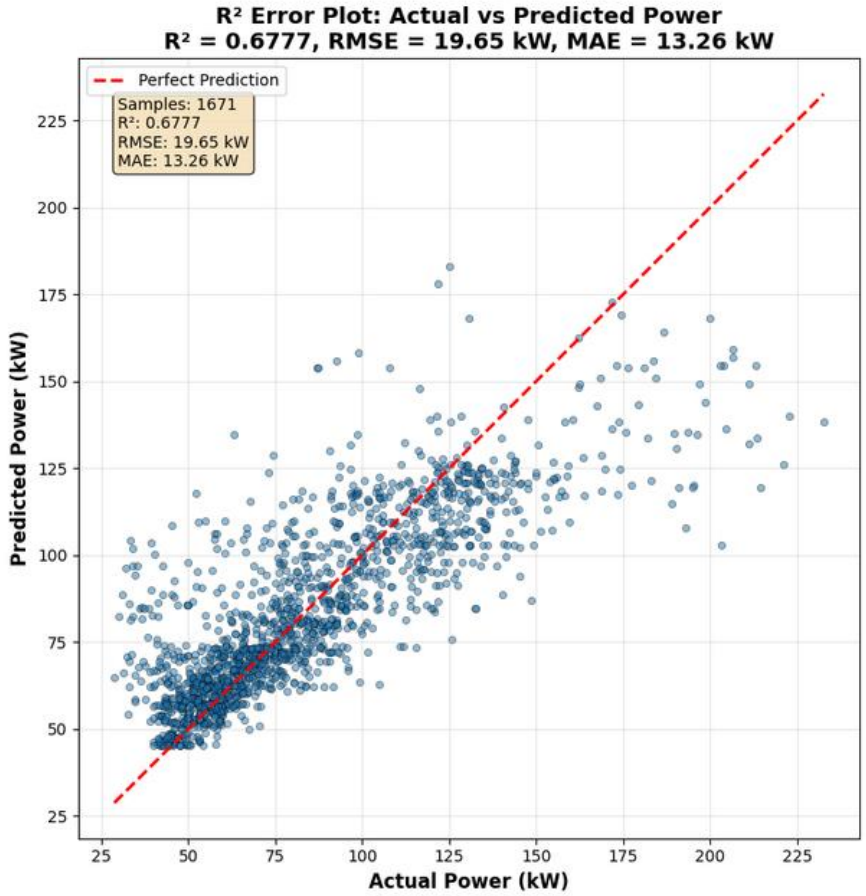

Figure 10 - R^2 Error Plot : Actual vs Predicted Power

4. Results and Discussions

- *Results :*
  - *Predictions closely follow actual values*
  - *Model captures non-linear consumption patterns*
  - *Useful for anticipating peak demand*
  - *Supports proactive energy management.*

5. Conclusion and Future Works

- *Developed a scalable real-time smart meter monitoring system.*
- *Integrated IoT APIs with a web-based analytics dashboard.*
- *Implemented AI-based forecasting for predictive insights.*
- *Enabled role-based secure access control.*
- *Provides a foundation for smart grid research and campus-wide energy optimization.*

5. Conclusion and Future Works

- *Limitations:*
  - *Dependence on external API availability*
  - *Forecast accuracy depends on historical data quality*
  - *Web-based access only*
- *Future Enhancements*
  - *Real-time anomaly detection and automated alerts*
  - *Mobile application support*
  - *Advanced deep learning forecasting models*
  - *Energy optimization and sustainability recommendations*

6. References

[1] ThingsBoard. Open-source IoT platform. https://thingsboard.io/

[2] Kaa IoT. Smart metering solutions. https://www.kaaiot.com/

[3] Oakter. OakMeter energy monitoring system. https://oakter.com/

[4] IAMMETER API Documentation. https://www.iammeter.com/docs/system-api

THANK YOU!