National Conference on Computer, Electrical, Electronics and Communication Engineering (Khwopa CEEL 2026)

KU Smart Meter Monitoring and Analytics System

24th February 2026

Bijan B. Thapa, Manish Bhattari, Sadit Rasaili, Sameep K. Shrestha, Slok Pradhan, Suman Shrestha
Department of Computer Science and Engineering, Kathmandu University

Samundra Gurung
Department of Electrical and Electronics Engineering Kathmandu University

Presentation Outlines

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*

    i. Energy consumption

    ii. Voltage levels

    iii. Load variations

    iv. Outage events

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

1. Introduction

- *Objectives:*

    i. Develop a scalable web-based smart meter monitoring platform.

    ii. Integrate secure API-based real-time data acquisition.

    iii. Provide interactive dashboards for visualization and analysis.

    iv. Implement AI-based forecasting for energy prediction.

    v. 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*

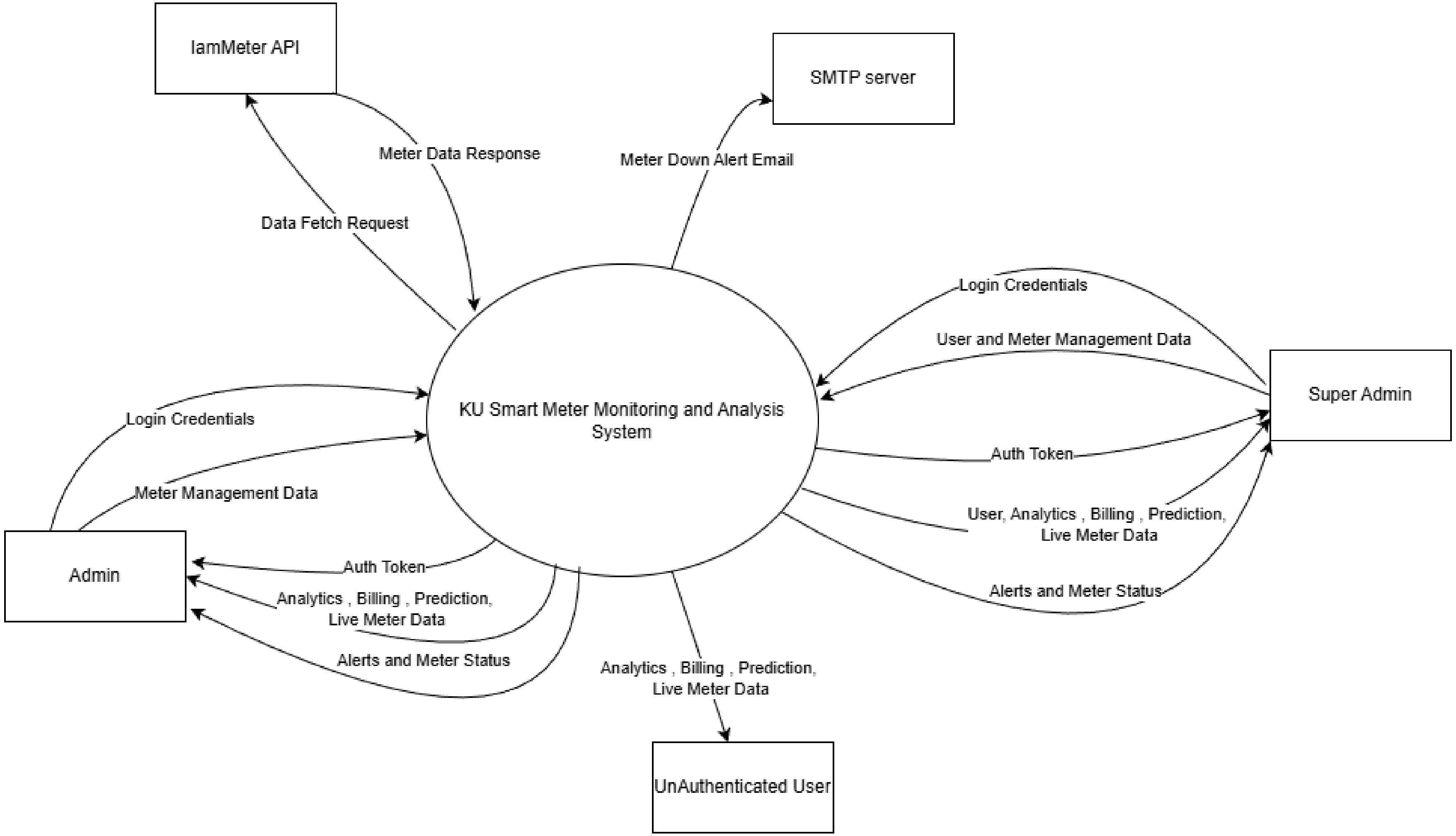

Figure 1- Context Diagram

3. Methodology

- *Development Approach*

  Agile development methodology adopted.

  Phases:

  i. Planning and requirement analysis

  ii. Research on smart meter APIs and forecasting models

  iii. Frontend development using React

  iv. Backend development using FastAPI

  v. Database design using PostgreSQL

  vi. Model training using Random Forest regression

  vii. System testing and validation

3. Methodology

- *Machine Learning Model*

  Model Used: Random Forest Regression

  Features:

  i. Hour of day

  ii. Day of week

  iii. Month

  iv. Historical lag values

  Dataset & Split:

  i. Total Dataset Size: 8,355 samples

  ii. Training Samples: 6,684 (80%)

  iii. Testing Samples: 1,671 (20%)

4. Results and Discussions

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

https://kusm-fend.vercel.app/, https://github.com/Rasaili-rain/KUSM

4. Results and Discussions

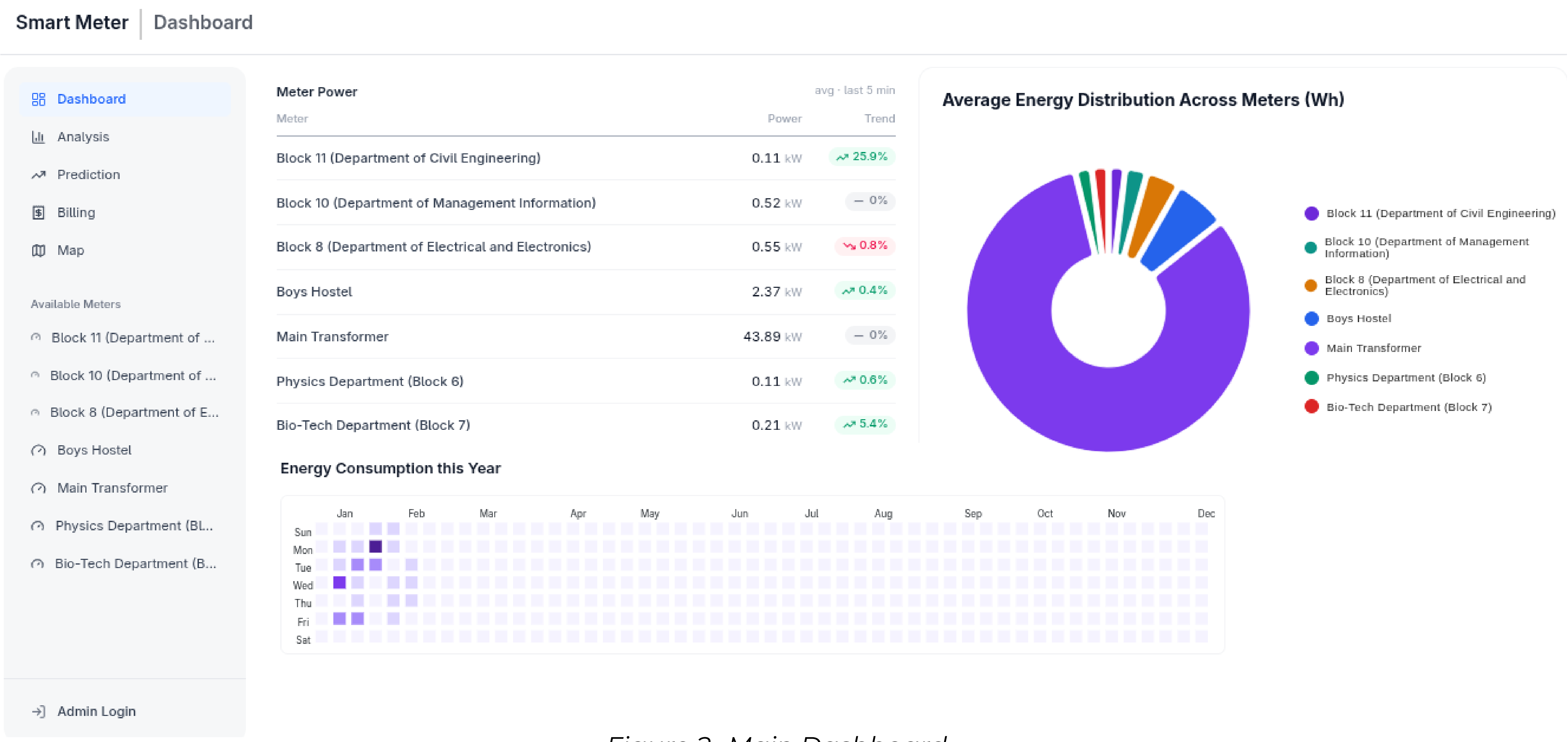

Figure 2- Main Dashboard

4. Results and Discussions

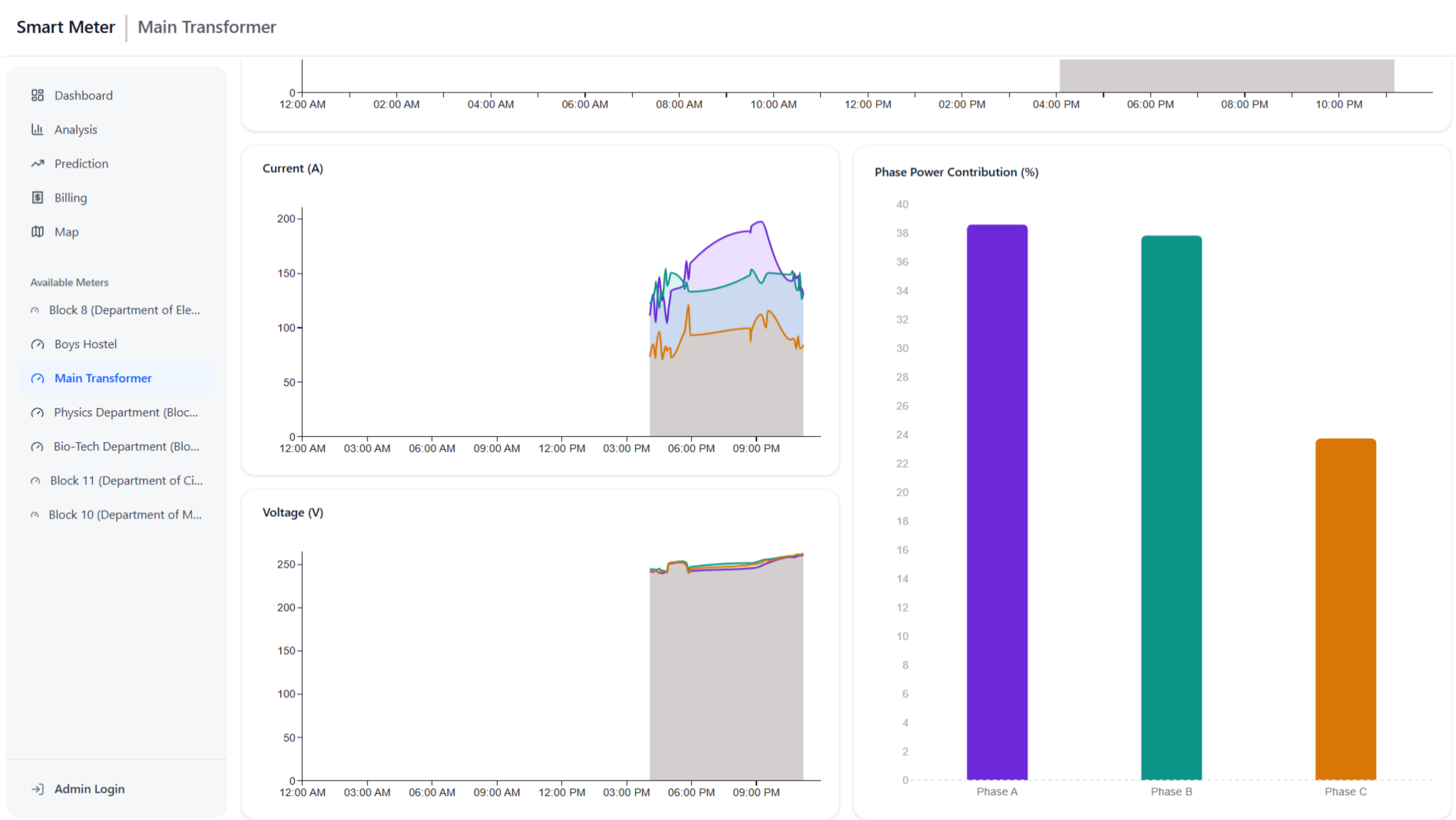

Figure 3.1.- Individual Meter Page

4. Results and Discussions

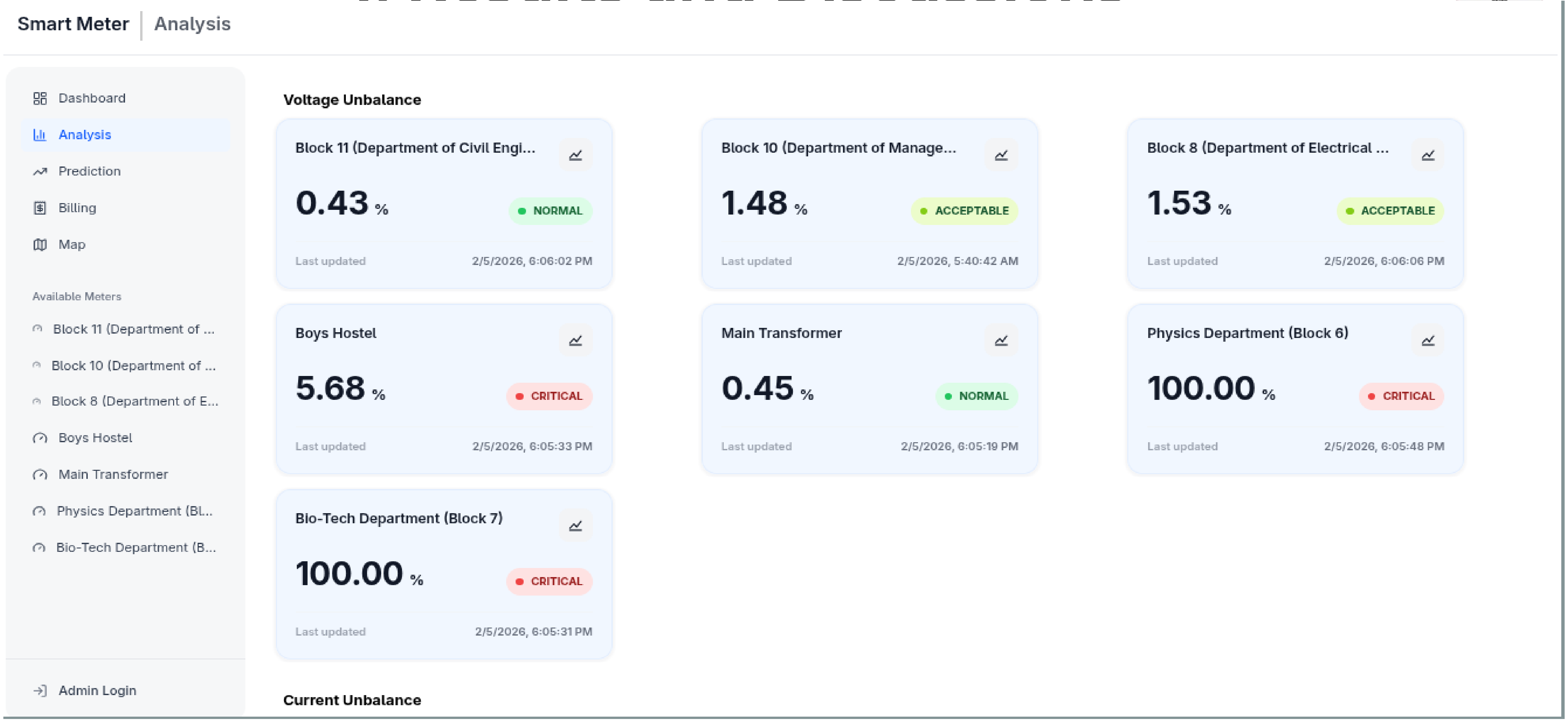

Figure 4- Analysis Page

4. Results and Discussions

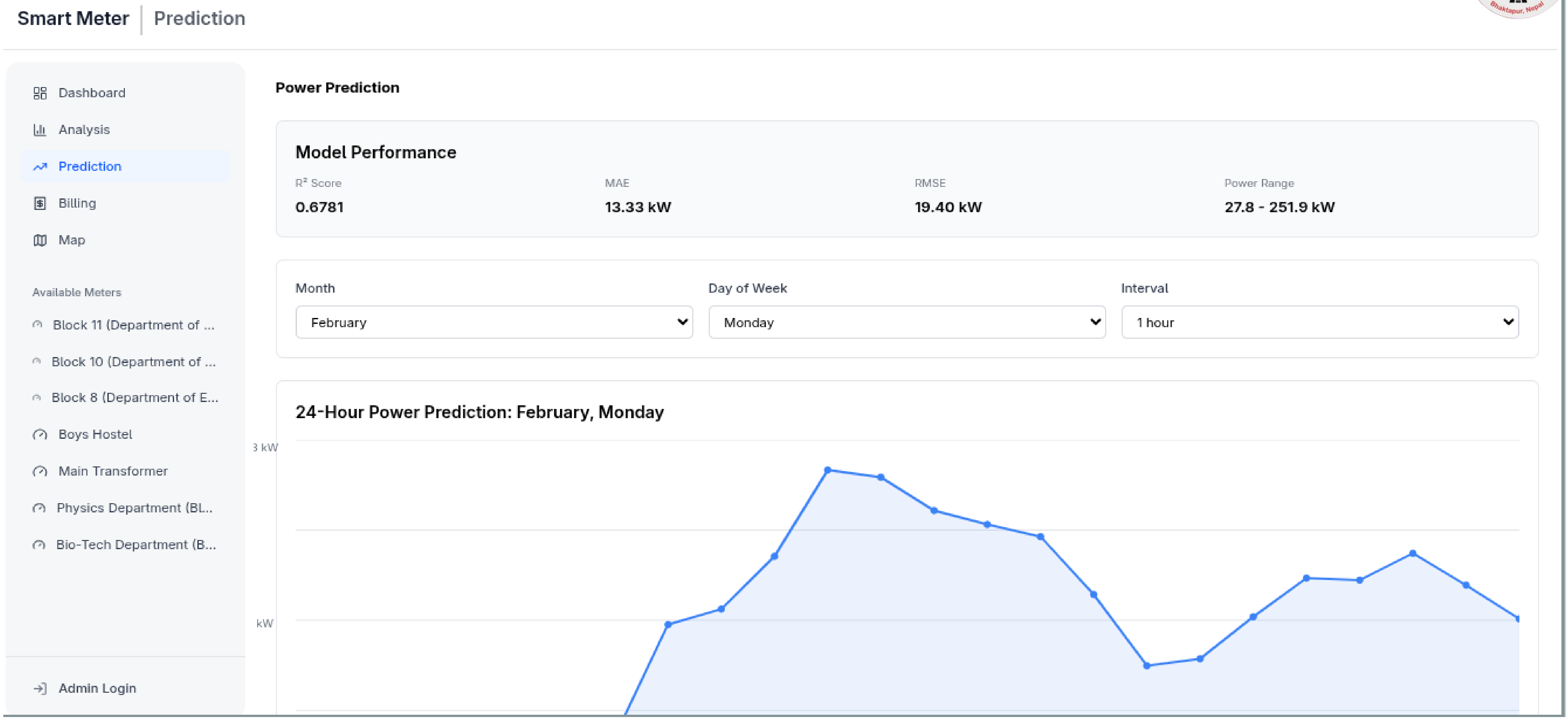

Figure 5- Prediction Page

4. Results and Discussions

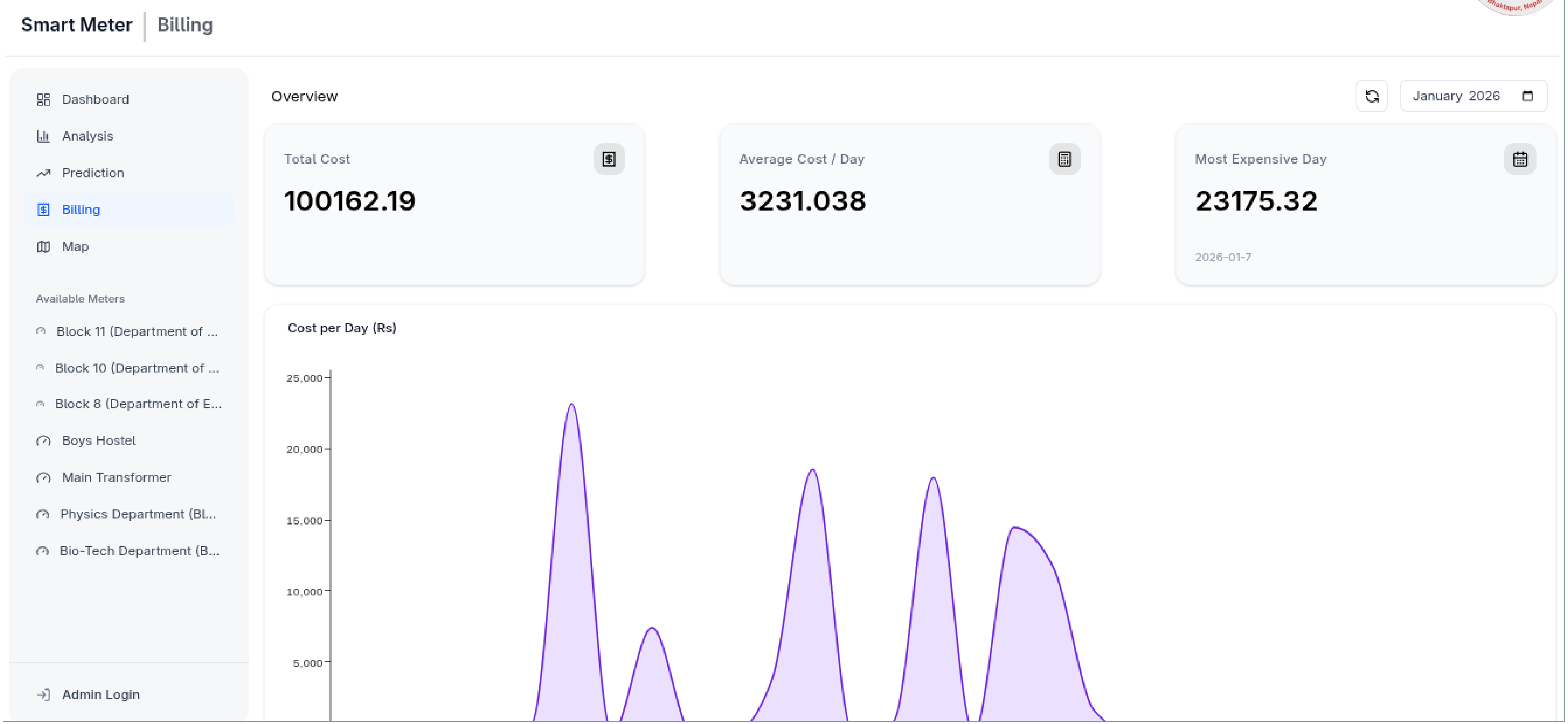

Figure 6 – Billing Page

4. Results and Discussions

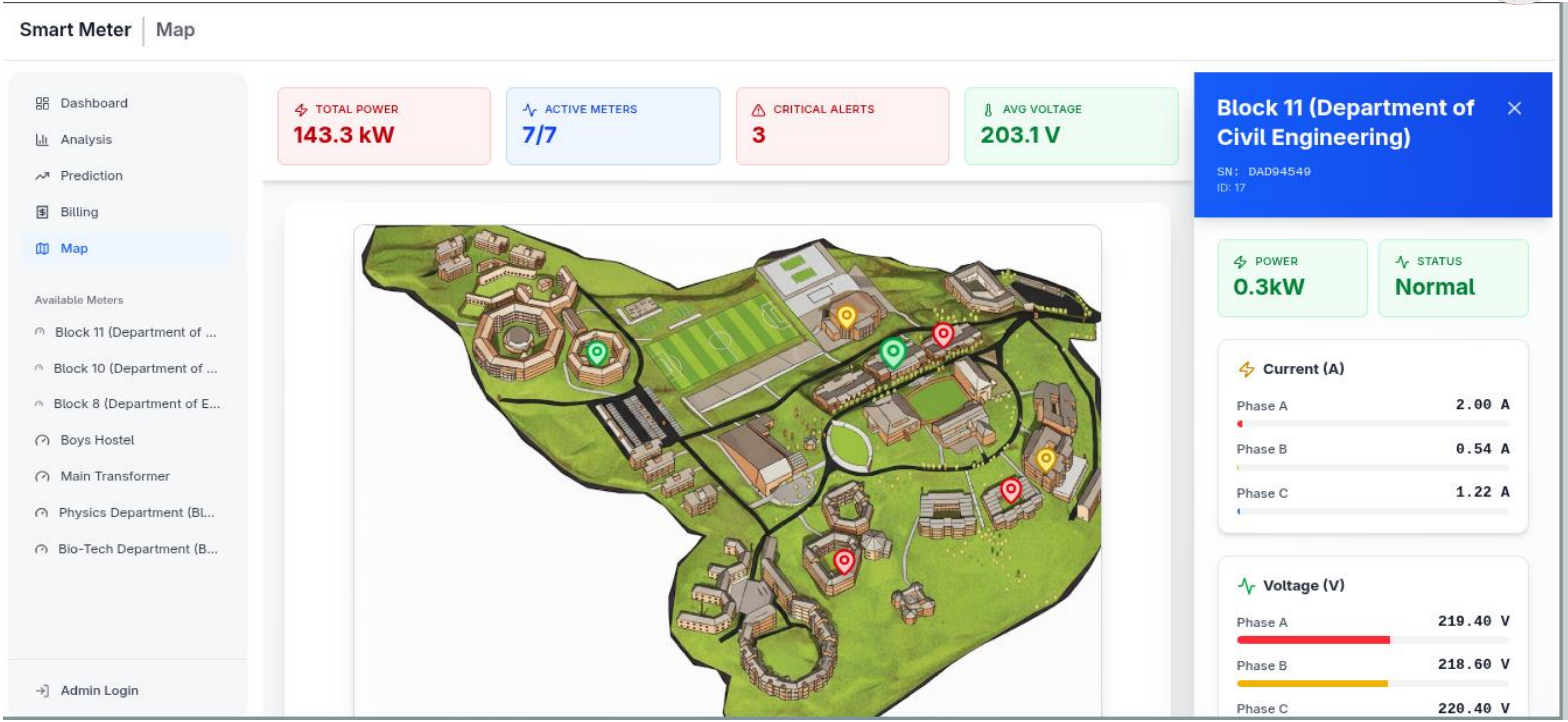

Figure 7- Maps Page

4. Results and Discussions

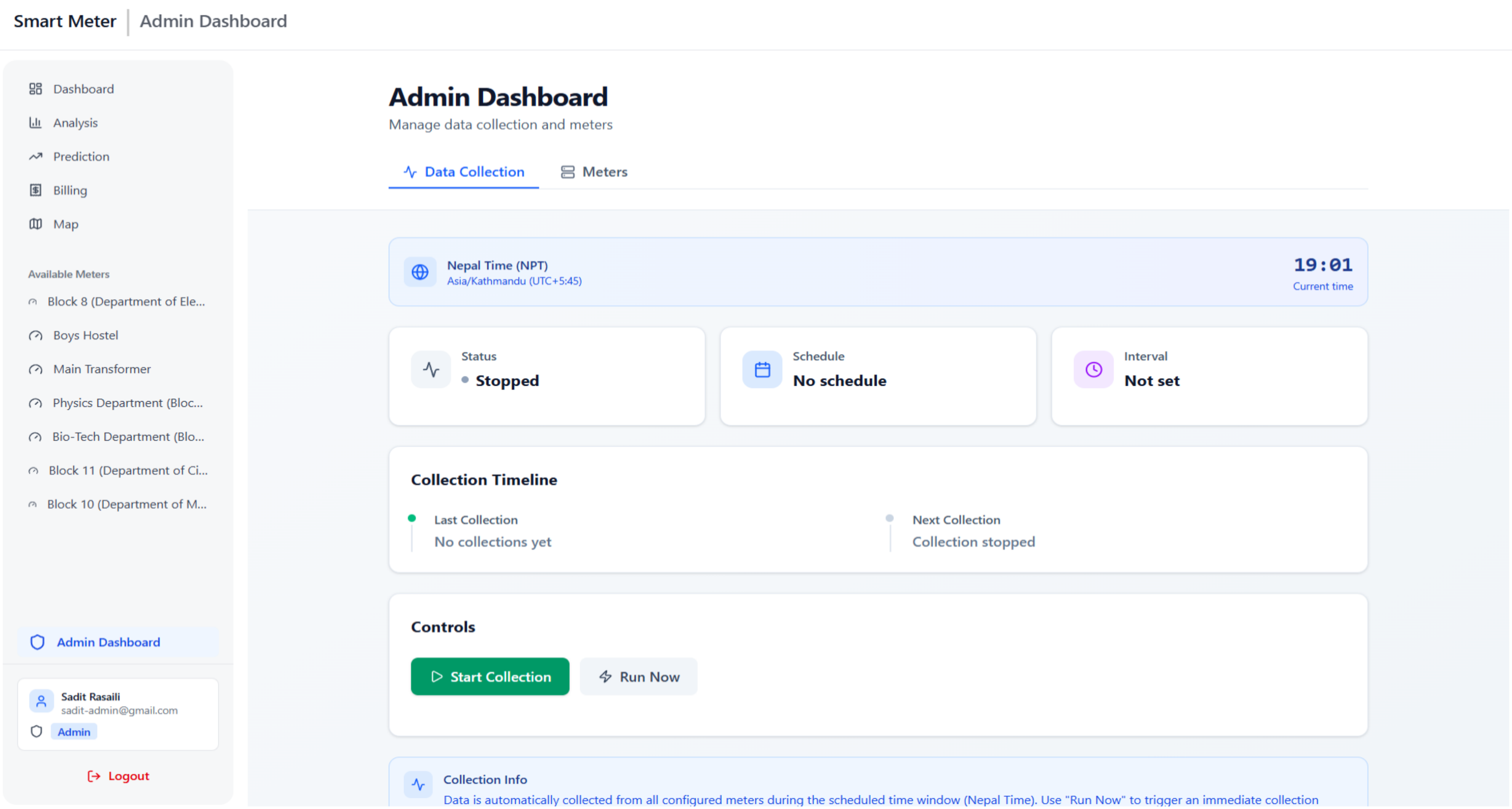

Figure 8. - Admin Dashboard

4. Results and Discussions

- *Visualization Results :*
  - *i. Clear visualization of consumption trends*
  - *ii. Voltage stability monitoring*
  - *iii. Peak load identification*
  - *iv. Monthly and daily billing summaries*
  - *v. Improved transparency in energy usage*

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

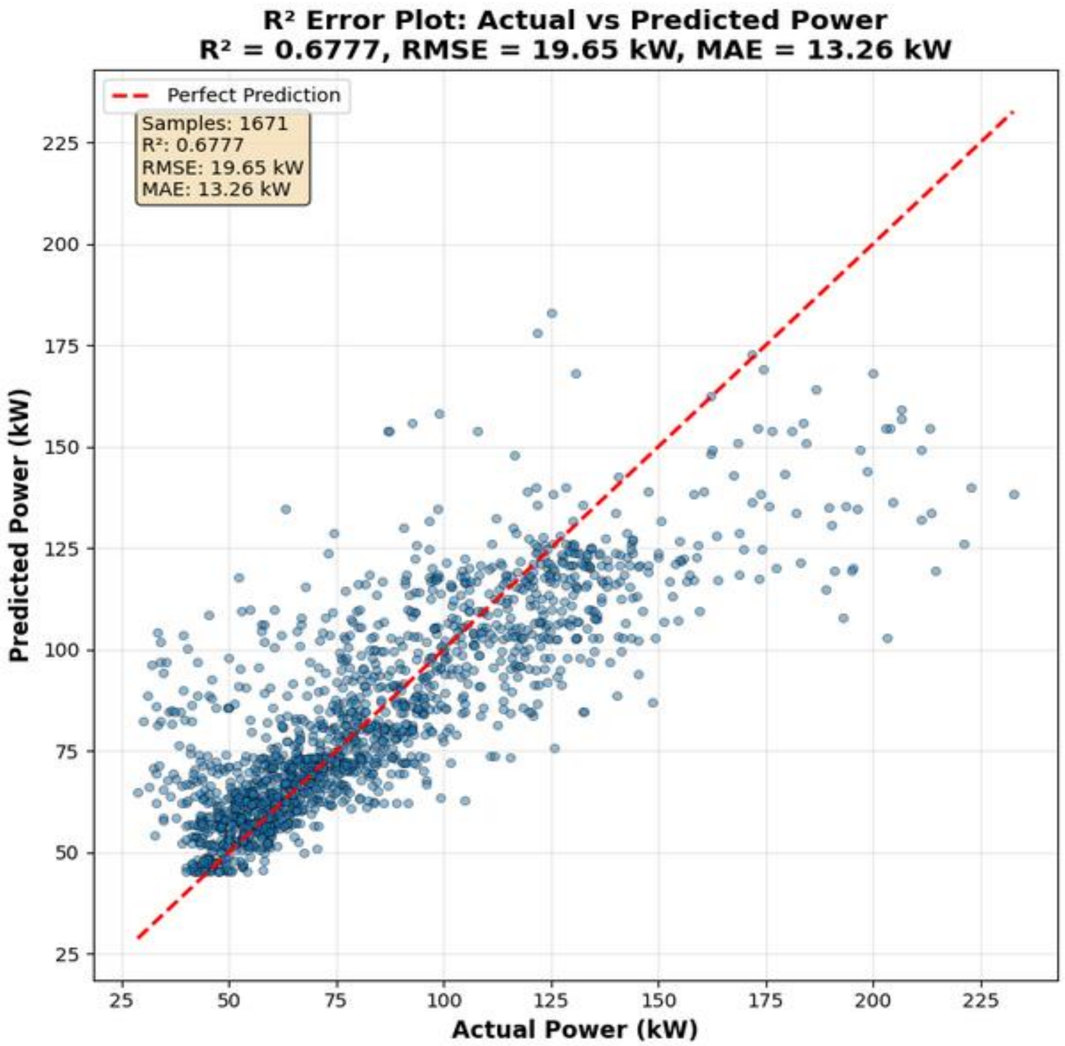

Figure 9 - R^2 Error Plot : Actual vs Predicted Power

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

Acknowledgment

- *The authors would like to thank project IGrid funded by RDI, Kathmandu University for providing access to the smart meter data*

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!