Project Title:

AI/ML-Based IoT Framework for Wide-Area Energy Management System

B25RVP01

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Presented By:

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1. ML MODELS

1.1 Data Set

Training Data: 1-year (Datetime vs Power)
Validation Data: 1 day (24 hourly points)
Target Column: `Power in watts`
Used For: Time series forecasting – predict next hour's power

Sample Training Data:

	Datetime	Power
0	2005-07-01 00:00:00	13981
1	2005-07-01 01:00:00	13162
2	2005-07-01 02:00:00	12699
3	2005-07-01 03:00:00	12464
4	2005-07-01 04:00:00	12599

Sample Validation Data:

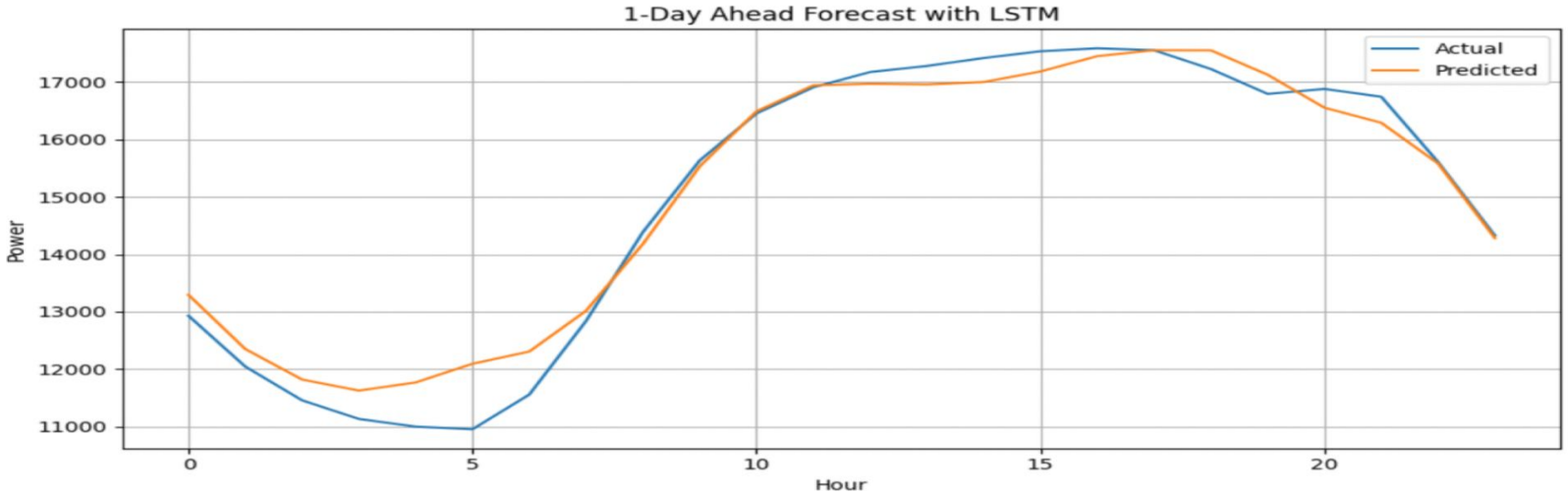
	Datetime	Power
0	2006-07-01 00:00:00	12930
1	2006-07-01 01:00:00	12045
2	2006-07-01 02:00:00	11457
3	2006-07-01 03:00:00	11133
4	2006-07-01 04:00:00	10999

1.2 LSTM Model

- **Data Processing:**
  - Extracted `Power`, normalized (0 to 1)
  - Created sequences of last 24 hours to predict the next hour
- **Model:**
  - 1 LSTM layer (50 units), 1 Dense layer
  - Trained for 20 epochs, batch size 32
- **Prediction:**
  - Used both training + validation sequences
  - De-normalized output to get actual values
- **Metrics:**
  - $R^2 = 0.971$, MAE ≈ 320 units

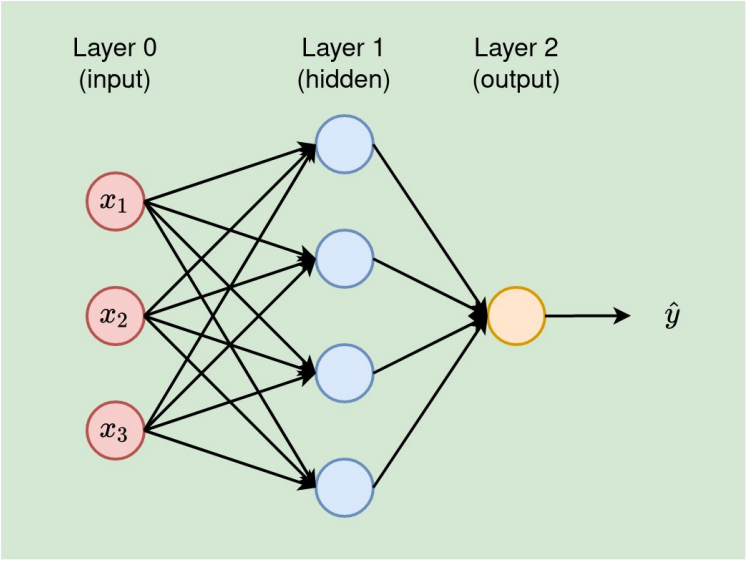
1.2 LSTM Model

```
273/273 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - loss: 8.2837e-04
Epoch 20/20
273/273 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - loss: 8.1529e-04
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 65ms/step
Evaluation Metrics:
MAE:    320.24
MSE:    172412.79
RMSE:   415.23
MAPE:   2.42%
R²:     0.9718
```



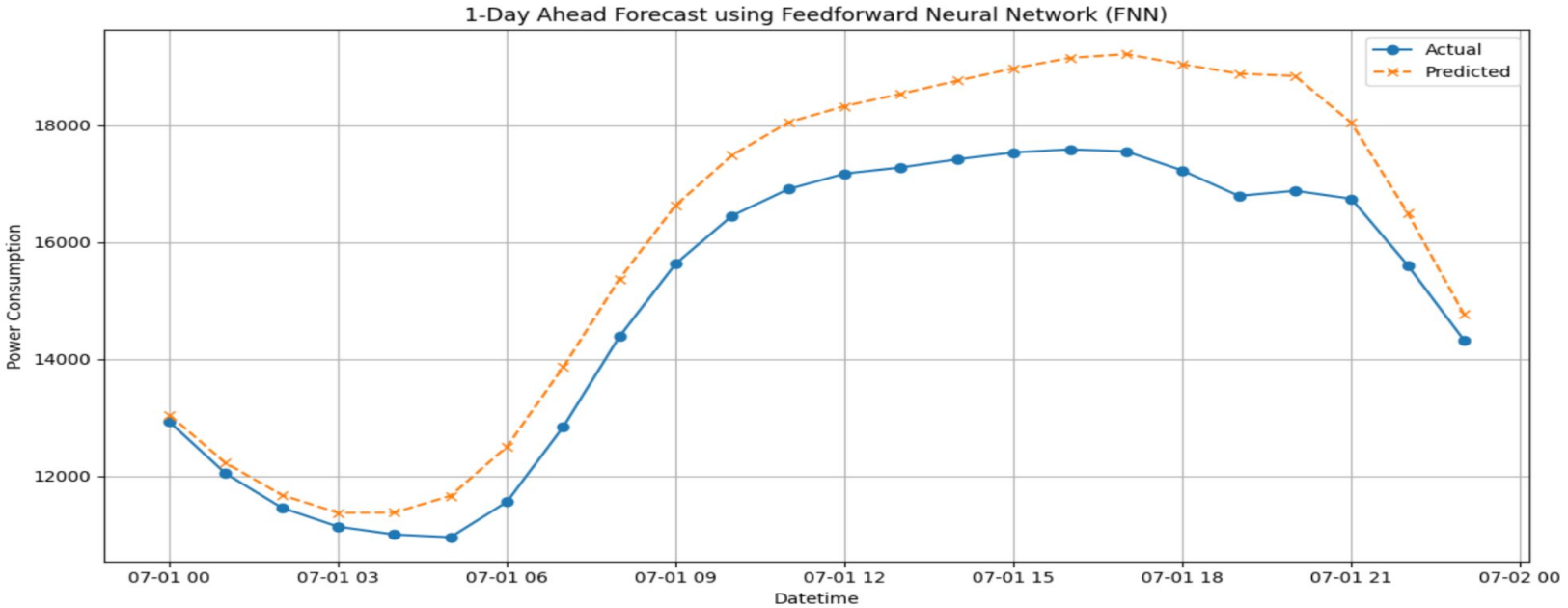
1.3 FNN Model

- **Architecture:**
  - Input: 24 lag values
  - Hidden layers: Dense layers with ReLU
  - Output: 1 value
- **Training:**
  - Epochs = 50
  - Batch size = 32
- **Evaluation:**
  - $R^2 \approx 0.7733$
  - MAE ≈ 1037
  - It is the least performer compare to LSTM and XGBoost



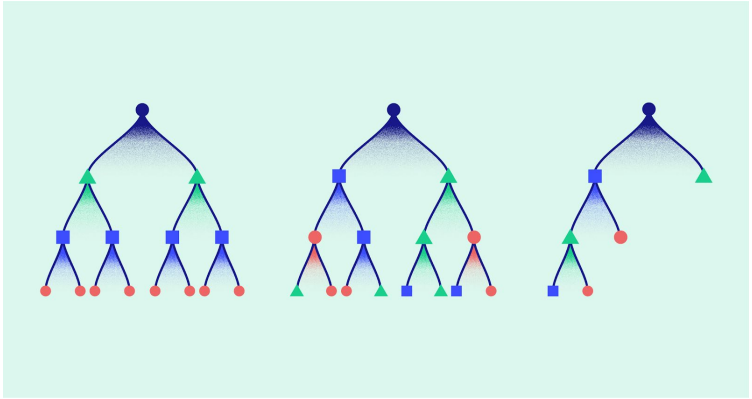
1.3 FNN Model

```
Evaluation Metrics:
MAE  = 1037.6221
MSE  = 1388160.8750
RMSE = 1178.2024
R²   = 0.7733
```



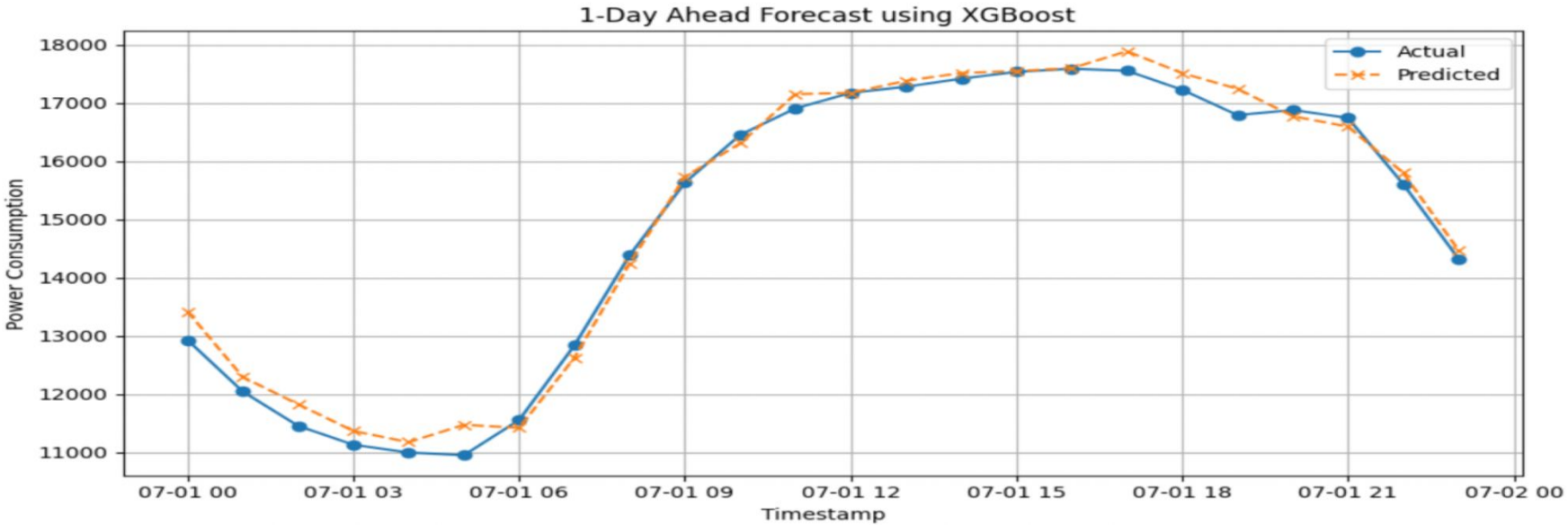
1.4 XGBoost Model

- **Preprocessing:**
  - Merged training + testing into one DataFrame
  - Created lag features: lag1 to lag24 (past 24 hours)
- **Model:**
  - `XGBRegressor(n_estimators=100, max_depth=5, learning_rate=0.1)`
- **Evaluation:**
  - $R^2 \approx 0.989$
  - MAE ≈ 204 (better than LSTM)



1.4 XGBoost Model

```
Evaluation Metrics for XGBoost Forecasting:
MAE    : 204.76
RMSE   : 248.66
R²     : 0.9899
MAPE   : 1.49%
```



2. Station S & IIITS

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 894 entries, 0 to 893
Data columns (total 4 columns):
 #   Column    Non-Null Count  Dtype
---  ------    --------------  -----
 0   Date      894 non-null    object
 1   Hour      894 non-null    int64
 2   Energy    894 non-null    float64
 3   Datetime  894 non-null    datetime64[ns]
dtypes: datetime64[ns](1), float64(1), int64(1), object(1)
memory usage: 28.1+ KB
None
```

2.1 Data Preprocessing

1.Removed empty (null) values from the dataset.

2.Selected only the **'Energy'** column for analysis.

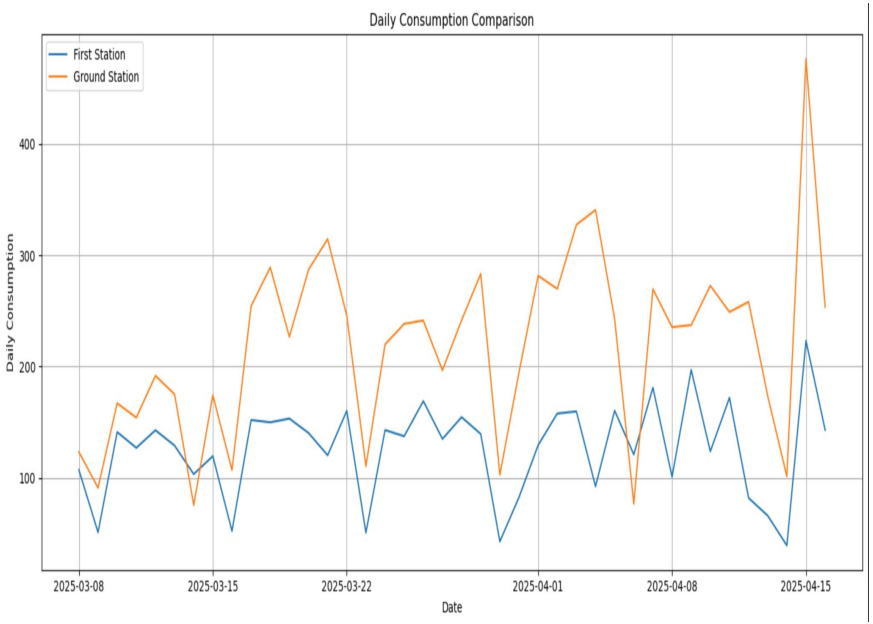
3.The data was recorded every 5 minutes, so we converted it to **1-hour intervals** by subtracting the minimum from the maximum value in each hour.

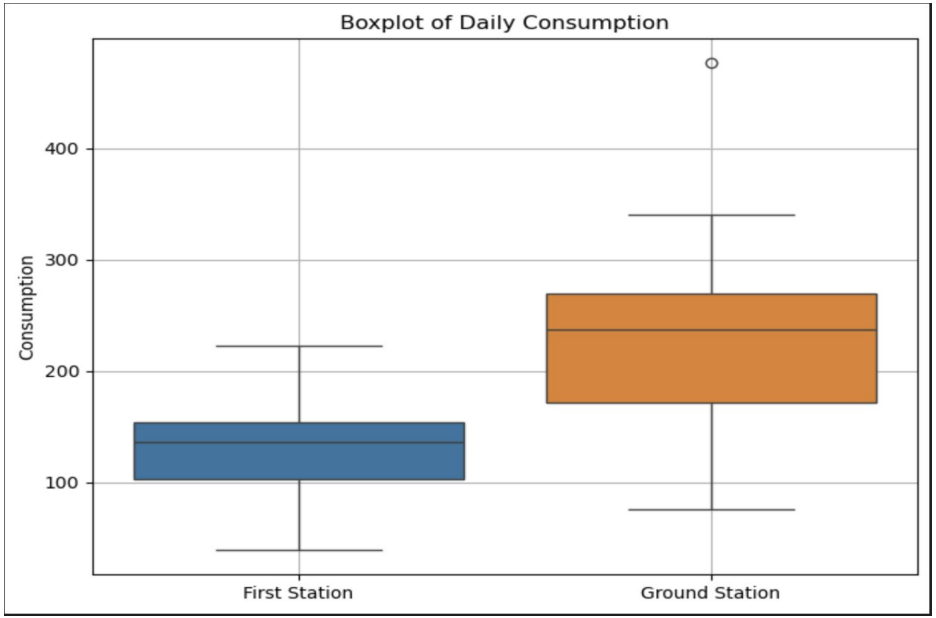
4.This gave us **24 energy values per day**.

5.The data used for this analysis ranges from **8th March to 17th April**.

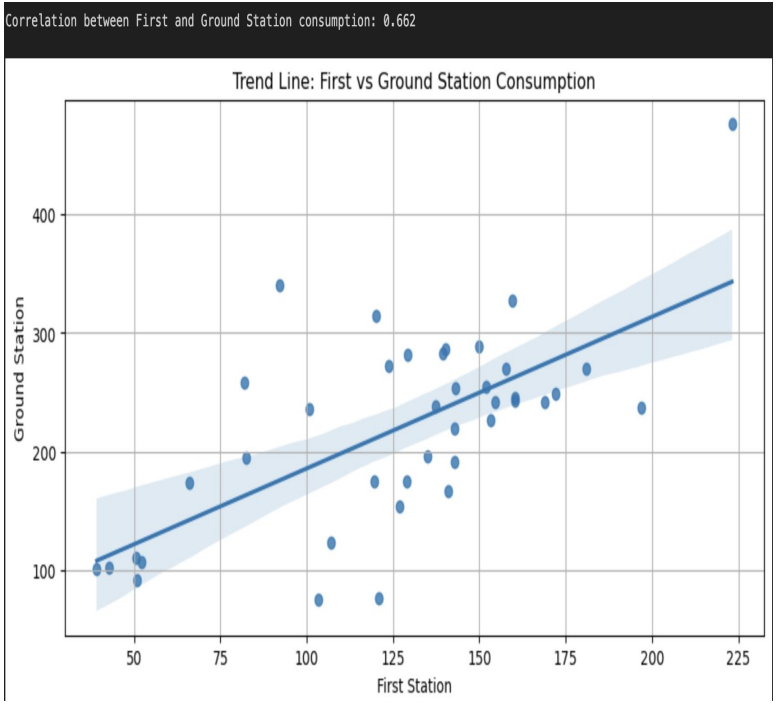
2.2 Data Analysis

STATION S GROUND AND FIRST FLOOR DAILY ENERGY CONSUMPTION





2.2 Data Analysis

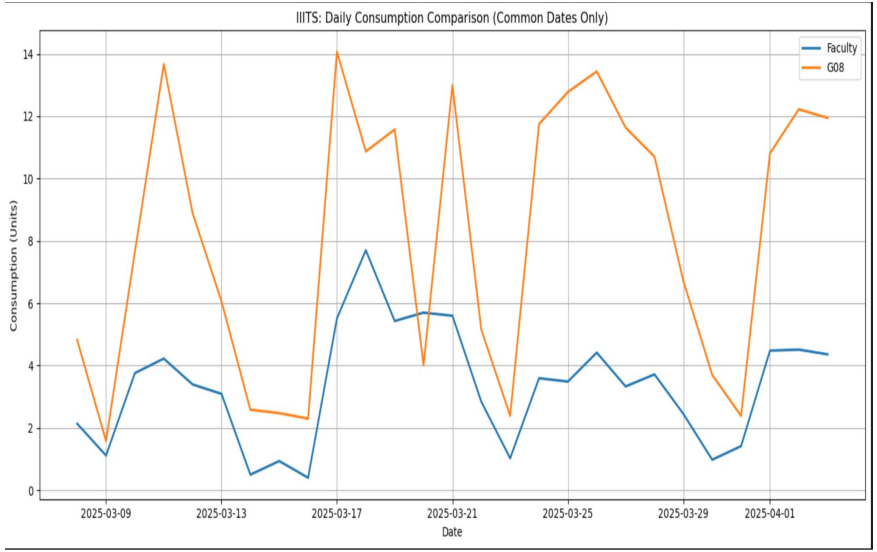


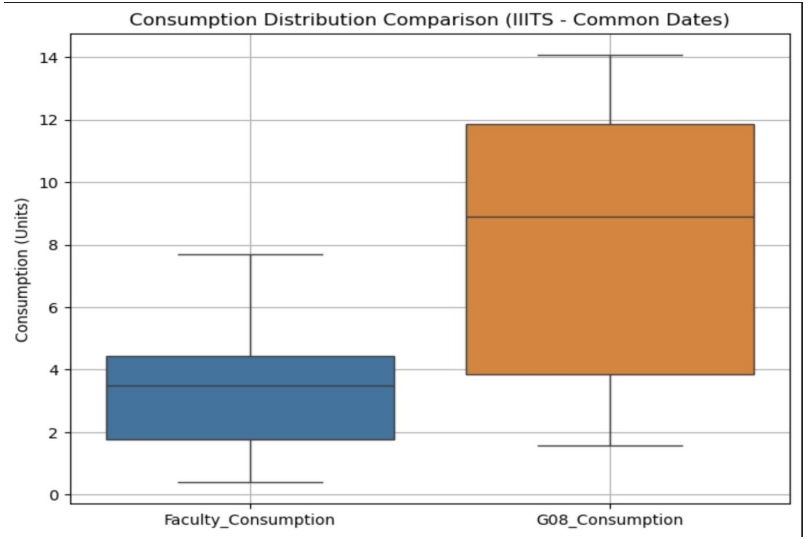

```
--- Basic Info ---
First Station:
                          Date  Daily_Energy_Consumption
count                       40                 40.000000
mean    2025-03-27 12:00:00                126.252550
min     2025-03-08 00:00:00                 39.190000
25%     2025-03-17 18:00:00                102.660250
50%     2025-03-27 12:00:00                136.147500
75%     2025-04-06 06:00:00                153.510000
max     2025-04-16 00:00:00                223.165000
std                     NaN                 42.920159

Ground Station:
                          Date  Daily_Energy_Consumption
count                       40                 40.000000
mean    2025-03-27 12:00:00                219.206475
min     2025-03-08 00:00:00                 75.426000
25%     2025-03-17 18:00:00                171.833500
50%     2025-03-27 12:00:00                237.718500
75%     2025-04-06 06:00:00                269.594000
max     2025-04-16 00:00:00                476.295000
std                     NaN                 82.971121
```

2.2 Data Analysis

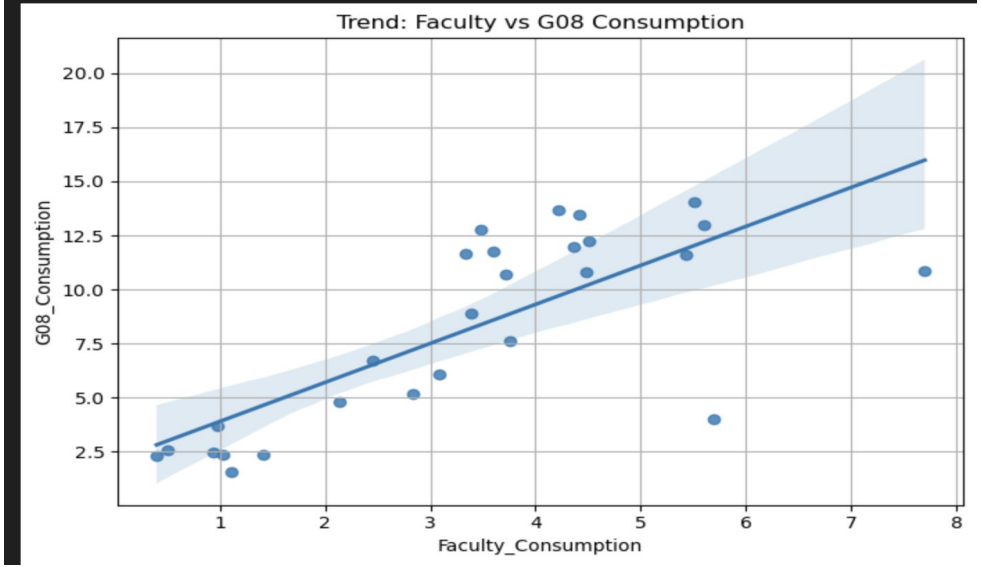
IIITS FACULTY WING AND G08 DAILY ENERGY CONSUMPTION





2.2 Data Analysis

Correlation between Faculty and G08 consumption: 0.763

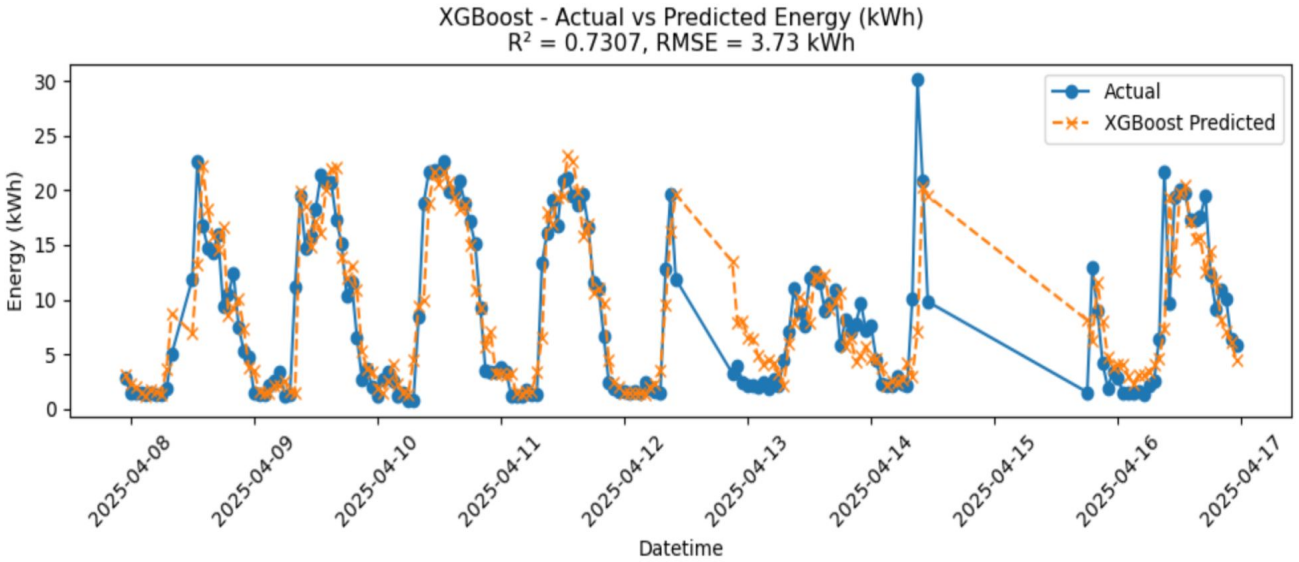



```
--- DESCRIPTIVE STATISTICS (Common Dates Only) ---
Faculty Consumption (Common Dates):
 count    27.000000
mean      3.336111
std       1.855421
min       0.398000
25%       1.774000
50%       3.486000
75%       4.446500
max       7.701000
Name: Faculty_Consumption, dtype: float64

G08 Consumption (Common Dates):
 count    27.00000
mean      8.11663
std       4.37884
min       1.57800
25%       3.85450
50%       8.88700
75%      11.84750
max      14.06800
Name: G08_Consumption, dtype: float64
```

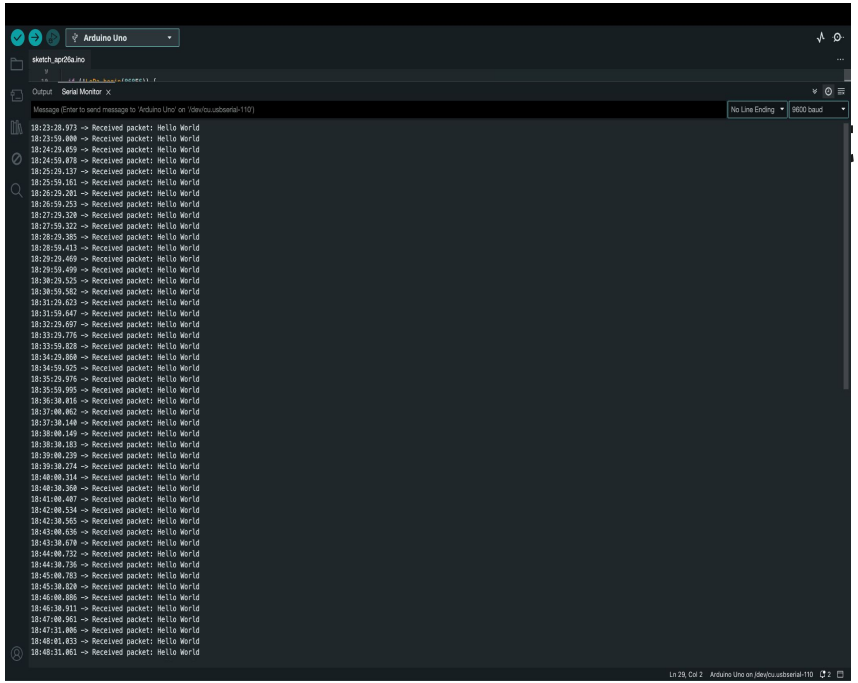
2.3 XGBoost Model

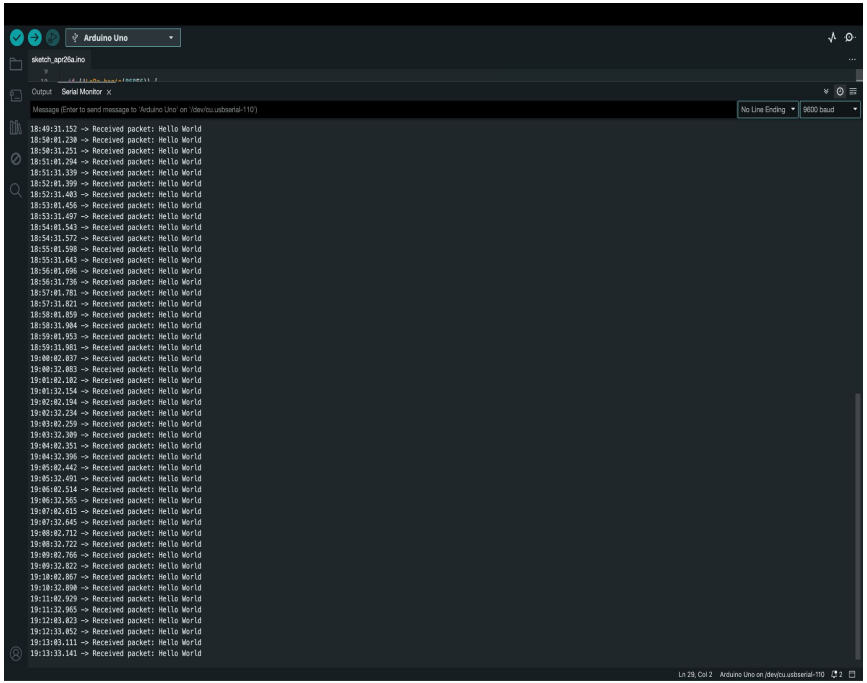
```
XGBoost Regression Evaluation Metrics:
R² Score  : 0.7307
MAE       : 2.37 kWh
MSE       : 13.94 (kWh)^2
RMSE      : 3.73 kWh
```



Date	Hour	Energy (in kWh)
2025-03-08	0	2.10500000000047
2025-03-08	1	2.125
2025-03-08	2	2.13599999999951
2025-03-08	3	2.1279999999997
2025-03-08	4	2.125
2025-03-08	5	1.73500000000058
2025-03-08	6	1.39599999999973
2025-03-08	7	1.32600000000002
2025-03-08	8	3.64899999999943
2025-03-08	9	5.28700000000026
2025-03-08	10	7.10300000000007
2025-03-08	11	7.19899999999961
2025-03-08	12	6.9970000000003
2025-03-08	13	6.43900000000031
2025-03-08	14	6.7460000000001
2025-03-08	15	6.61099999999988
2025-03-08	16	5.56999999999971
2025-03-08	17	5.39999999999964
2025-03-08	18	5.15900000000056
2025-03-08	19	4.55799999999999
2025-03-08	20	1.44500000000062
2025-03-08	21	3.31099999999969
2025-03-08	22	2.47599999999966
2025-03-08	23	2.03799999999956
2025-03-09	0	1.95799999999963

3.Lora Range Test





3.Lora Range Test

LoRa Range Test -C Block, A Block and Station-S
Data Interval:30 sec
Location:
1.Water Sump-From 6:25 to 6:27
2.DB Panel Room-From 6:28 to 6:31
3.A1 Energy Meter-From 6.33 to 6:40
4.Station-S(In/Out)-From 6:46 to 6:57
5.Return From Station-S to Campus-From 6:57 to 7:12
Inference:
1.NO data packet is lost
2.NO Bit Reversal
2.Data Comes seamlessly every 30 sec

4. Future works

1.Develop a **custom hardware solution** for improved efficiency, scalability, and cost-effectiveness.

2.Deploy a **complete IoT framework** with real-time analytics and an advanced dashboard for energy management.

THANK YOU