



Project Title:

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

B25RVP01

Mentor:

Dr Raja Vara Prasad Y

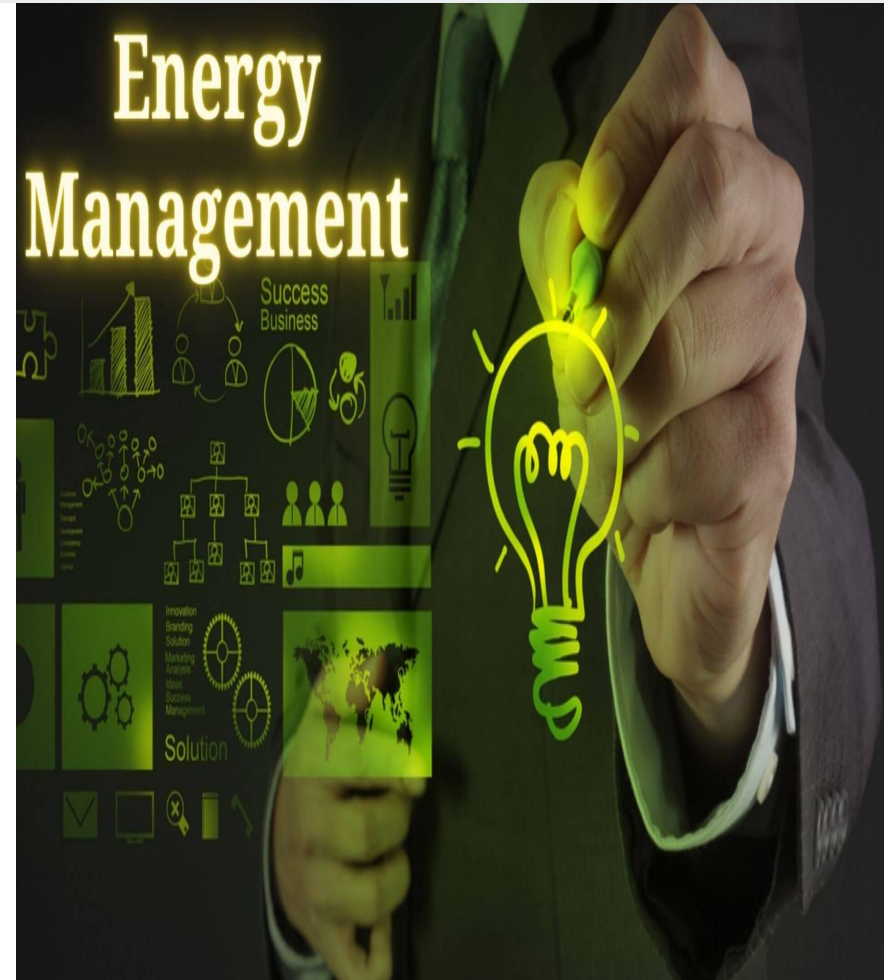
Presented By:

P HARISH RAGAVENDER (S20220020301)



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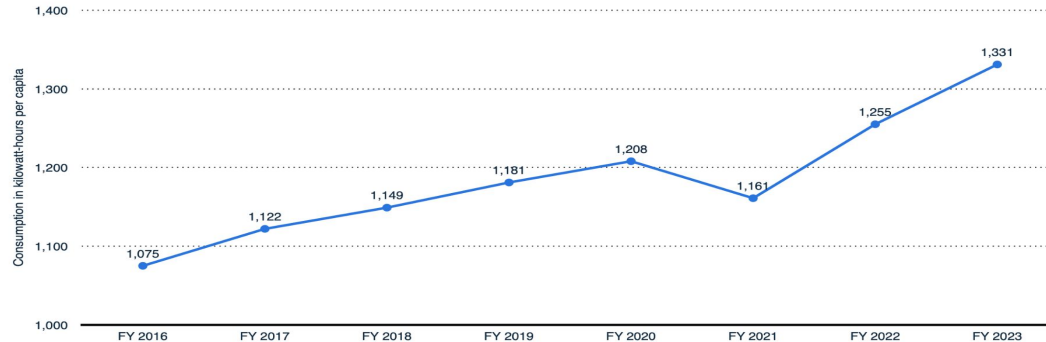
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1.Introduction & Motivation

Electric power consumption per capita in India from financial year 2016 to 2023 (in kilowatt-hours)

Electricity consumption per capita in India FY 2016-2023



Energy Management is crucial due to rising **demand**, **inefficiencies**, and **environmental concerns**. Traditional systems lack **real-time monitoring** and **optimization**.

1. Introduction & Motivation

1.1 Importance of Energy Management

1. Reduces **costs, carbon footprint, and grid load**
2. Traditional systems **lack real-time monitoring & analytics**
3. **AI/ML enables** load forecasting & anomaly detection

1.2 Facts & Statistics

1. **India** → 3rd largest energy consumer (after China & USA)
2. **Global demand** ↑ **25% by 2040**
3. **30% energy wasted** in buildings due to inefficiencies
4. **AI-based management** cuts energy costs by **10-30%**



2. Problem Statement

2.1 Challenges in Current Energy Management Systems

1. No Real-Time Monitoring
- 2.No Predictive Analytics
- 3.Manual & Inefficient
- 4.Limited Connectivity & Scalability



2. Problem Statement

2.2 Need for an AI/ML-Based IoT Solution

1. Smart Monitoring
2. LoRa Communication
3. Cloud Database
4. AI/ML Optimization
5. Automated Decisions



3. Objective



Develop an **AI/ML-based IoT framework** for **real-time energy monitoring and optimization** using **Modbus meters** and **LoRa communication**. Utilize **cloud storage**, **AI/ML analytics**, and a **real-time dashboard** for **load forecasting**, **anomaly detection**, and **efficiency improvement**. Optimize **energy consumption** to **reduce costs** and **support sustainability goals**.

4. System Architecture

4.1 Hardware Perspective

1. **Multifunction Meters** → Measure voltage, current, power, and energy (Modbus)

2. **LoRa Nodes** → Wirelessly transmit real-time data over long distances

3. **LoRa Gateway** → Connects LoRa nodes to the cloud for reliable data transfer

Low-power, long-range, cost-effective setup for seamless energy monitoring



MULTIFUNCTION METER



LoRa OUTDOOR GATEWAY

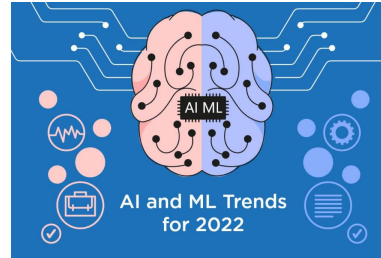


LoRa NODE

4. System Architecture

4.2 AI/ML Perspective

1. **Energy Consumption Patterns** → AI/ML analyzes usage trends for better planning
2. **Predicting** → ML forecasts energy demand using real-time and historical data
3. **Anomaly Detection** → AI/ML identifies faults, inefficiencies, and unusual consumption
4. **Insights** → Provides data-driven recommendations for optimization and cost reduction



AI/ML OPTIMIZATION



DASHBOARD VISUALISATION

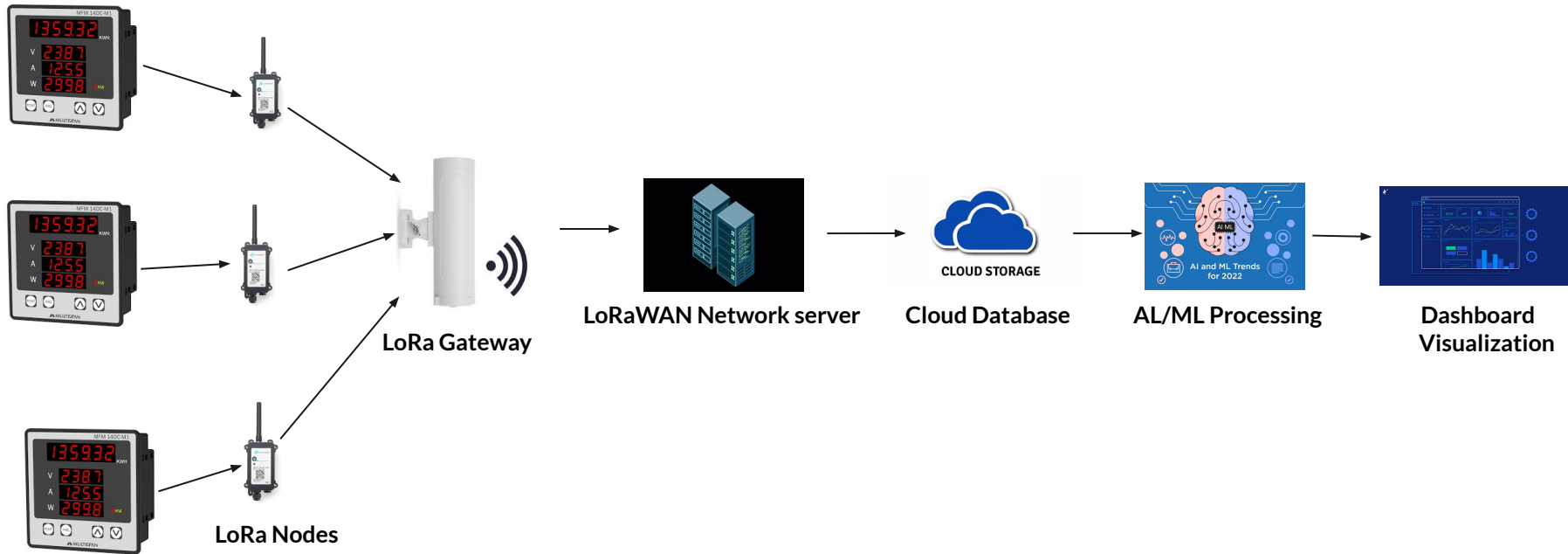


CLOUD STORAGE

5. Literature Survey/Review

YEAR	TITLE OF THE PAPER	AUTHOR	CONTRIBUTIONS	OBSERVATIONS
2023	<div><div></div><div>Unified Metering System Deployed for Water and Energy Monitoring in Smart City</div><div>A</div></div>	N Sushma H N Suresh	1.Integration of Wireless Technology for Real-Time Monitoring((LPWAN) 2.Scalable Smart Metering for Efficient Resource Management	1.Limited AI/ML-Based Energy Optimization 2.No Custom Hardware Implementation
2021	Smart Energy Metering For Cost And Power Reduction In Household Applications	C Komathi S Durgadevi	1.Integration of Modbus-Compatible Smart Meters 2.Automated Energy Monitoring & Consumer Awareness	1.Lack of LoRa-Based Communication 2.No AI/ML-Based Energy Optimization
2023	Design of IoT-Based Electrical Energy Meter	Heri Andrianto Yohana Susanthi	1.IoT-based energy monitoring using ESP32 and Modbus-compatible meters 2.Automated Energy Data Acquisition	1.Limited Communication Range 2.Lack of AI/ML-Based Optimization

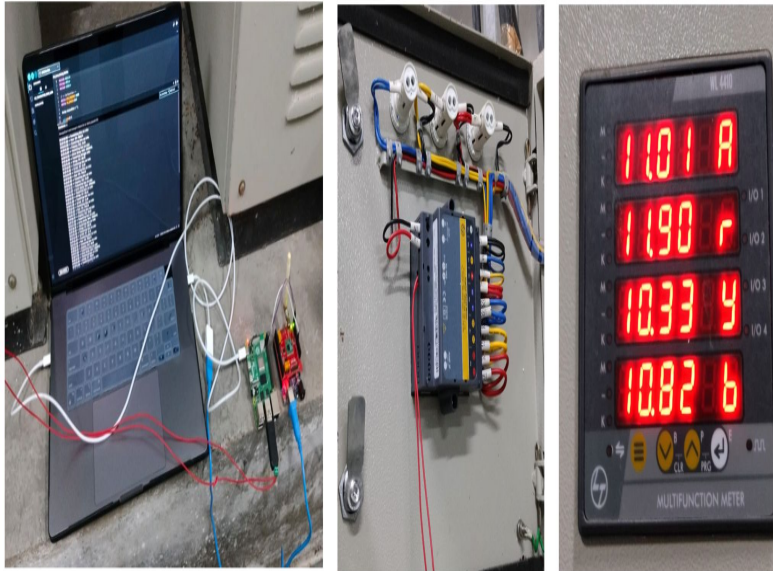
6. Proposed System Architecture



Multi Function Meters
(RS-485 compatible)

7. Current Status and Achievements

7.1 Hardware Implementation



Tested with our campus multifunction meter

```
genny_run_script_662K22.sh
File Edit Tabs Help
Received: Frequency (Hz): 50.00
Data sent to ThingSpeak: ('Frequency': 50.0, 'Active Energy': None, 'Voltage': None, 'Current': None, 'Power':
None)
Received: Active Energy (kWh): 133440952.
Data sent to ThingSpeak: ('Frequency': None, 'Active Energy': 133440952.0, 'Voltage': None, 'Current': None, 'P
ower': None)
Received: Current (A): 10.83
Data sent to ThingSpeak: ('Frequency': None, 'Active Energy': None, 'Voltage': None, 'Current': 10.83, 'Power':
None)
Received: Power (W): 5745.35
Data sent to ThingSpeak: ('Frequency': None, 'Active Energy': None, 'Voltage': None, 'Current': None, 'Power':
5745.35)
Received: Frequency (Hz): 50.00
Data sent to ThingSpeak: ('Frequency': 50.0, 'Active Energy': None, 'Voltage': None, 'Current': None, 'Power':
None)
Received: Voltage (V): 230.11
Data sent to ThingSpeak: ('Frequency': None, 'Active Energy': None, 'Voltage': 230.11, 'Current': None, 'Power':
None)
Received: Current (A): 10.83
Data sent to ThingSpeak: ('Frequency': None, 'Active Energy': None, 'Voltage': None, 'Current': 10.83, 'Power':
None)
Received: Power (W): 5745.23
Data sent to ThingSpeak: ('Frequency': None, 'Active Energy': None, 'Voltage': None, 'Current': None, 'Power':
5745.23)
Received: Active Energy (kWh): 133450152.
Data sent to ThingSpeak: ('Frequency': None, 'Active Energy': 133450152.0, 'Voltage': None, 'Current': None, 'P
ower': None)
Received: Voltage (V): 230.08
Data sent to ThingSpeak: ('Frequency': None, 'Active Energy': None, 'Voltage': 230.08, 'Current': None, 'Power':
None)
Received: Current (A): 11.18
Data sent to ThingSpeak: ('Frequency': None, 'Active Energy': None, 'Voltage': None, 'Current': 11.18, 'Power':
```

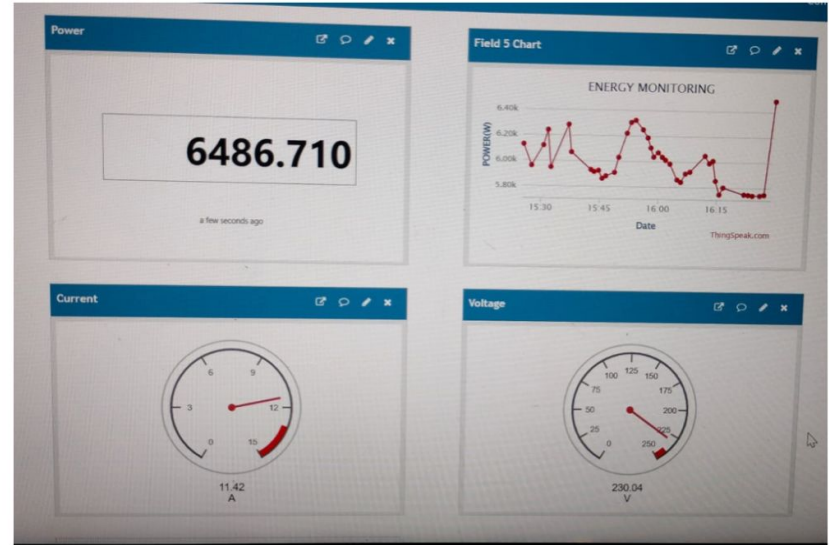
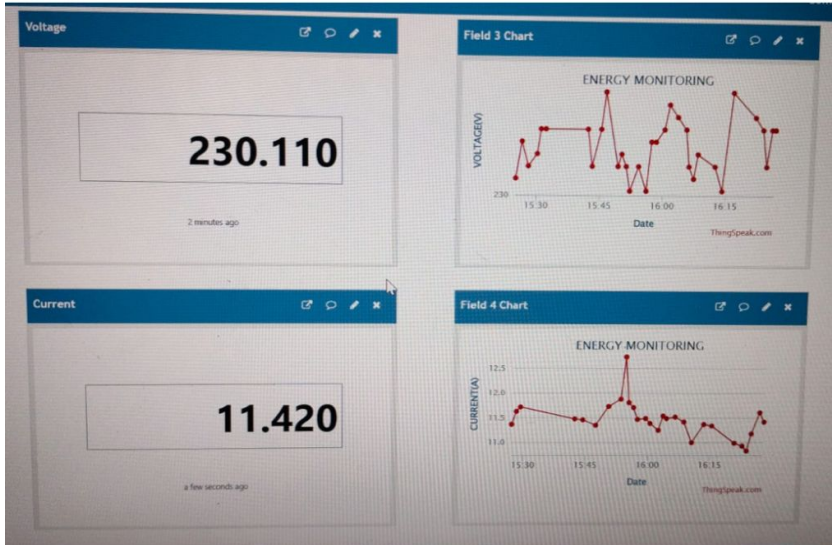
Data receiving on serial monitor

```
Final_receiverino
34
35 //delay(1000); // General delay between
36 }
37
38 // I2C Callback function (when Raspberry Pi
39 void sendData() {
40 if (receivedData.length() > 0) {
41 Serial.println("Sending Data to Raspberry
42 for (int i = 0; i < receivedData.length()
43 wire.write(receivedData[i]);
44 delay(50); // Delay between each byte
45 }
46 wire.write('\0'); // End of string marker
47 receivedData = ""; // Clear buffer after s
48 Serial.println("Data sent to Raspberry Pi
49 //delay(2000); // Delay after sending dat

Serial Monitor x Output
Message (Enter to send message to 'Arduino Uno' on 'COM1')

Received via LoRa: DVoltage (V): 230.04
Sending Data to Raspberry Pi 2 via I2C...
Data Sent to Raspberry Pi 2
Received via LoRa: DCurrent (A): 11.07
Received via LoRa: DPower (W): 5735.62
Received via LoRa: DFrequency (Hz): 49.99
Received via LoRa: DActive Energy (kWh): 133449776.
Sending Data to Raspberry Pi 2 via I2C...
Data Sent to Raspberry Pi 2
Received via LoRa: DVoltage (V): 230.05
Received via LoRa: DCurrent (A): 10.99
Sending Data to Raspberry Pi 2 via I2C...
Data Sent to Raspberry Pi 2
Received via LoRa: DPower (W): 5727.62
Received via LoRa: DFrequency (Hz): 49.99
Sending Data to Raspberry Pi 2 via I2C...
Data Sent to Raspberry Pi 2
```

7. Current Status and Achievements



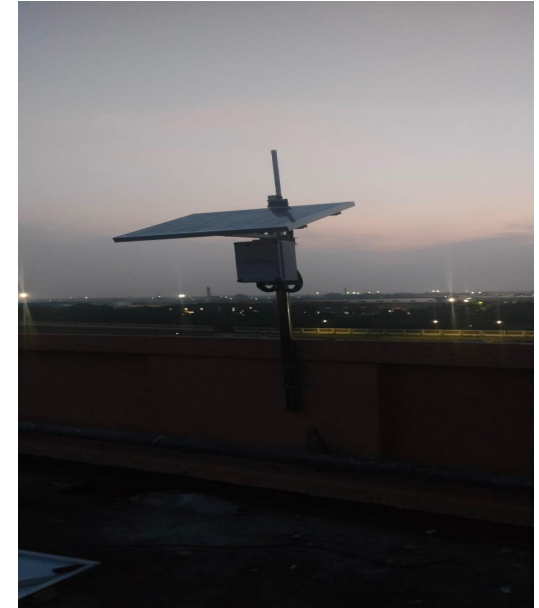
Data visualization on Things speak

7. Current Status and Achievements

7.1 Hardware Implementation



LoRa and Cellular Energy Meters Monitoring G08 and Faculty Wing



LoRa gateway

8. Future works



1. Creating an **AI/ML-based** for predictive energy analytics and optimization.
2. Develop a **custom hardware solution** for improved efficiency, scalability, and cost-effectiveness.
3. Deploy a **complete IoT framework** with real-time analytics and an advanced dashboard for energy management.

9. References



- 1.H. Andrianto, Y. Susanthi, V. Jonathan and N. Ismail, "Design of IoT-Based Electrical Energy Meter," *2023 IEEE 9th International Conference on Computing, Engineering and Design (ICCED)*, Kuala Lumpur, Malaysia, 2023, pp. 1-4, doi: 10.1109/ICCED60214.2023.10425406.
- 2.C. Komathi, S. Durgadevi, K. Thirupura Sundari, T. R. Sree Sahithya and S. Vignesh, "Smart Energy Metering For Cost And Power Reduction In Household Applications," *2021 7th International Conference on Electrical Energy Systems (ICEES)*, Chennai, India, 2021, pp. 428-432, doi: 10.1109/ICEES51510.2021.9383725
- 3.N. Sushma, H. N. Suresh, J. M. Lakshmi, P. N. Srinivasu, A. K. Bhoi and P. Barsocchi, "A Unified Metering System Deployed for Water and Energy Monitoring in Smart City," in *IEEE Access*, vol. 11, pp. 80429-80447, 2023, doi: 10.1109/ACCESS.2023.3299825.
keywords: {Meters;Water resources;Real-time systems;Water



THANK YOU