Project Title:

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

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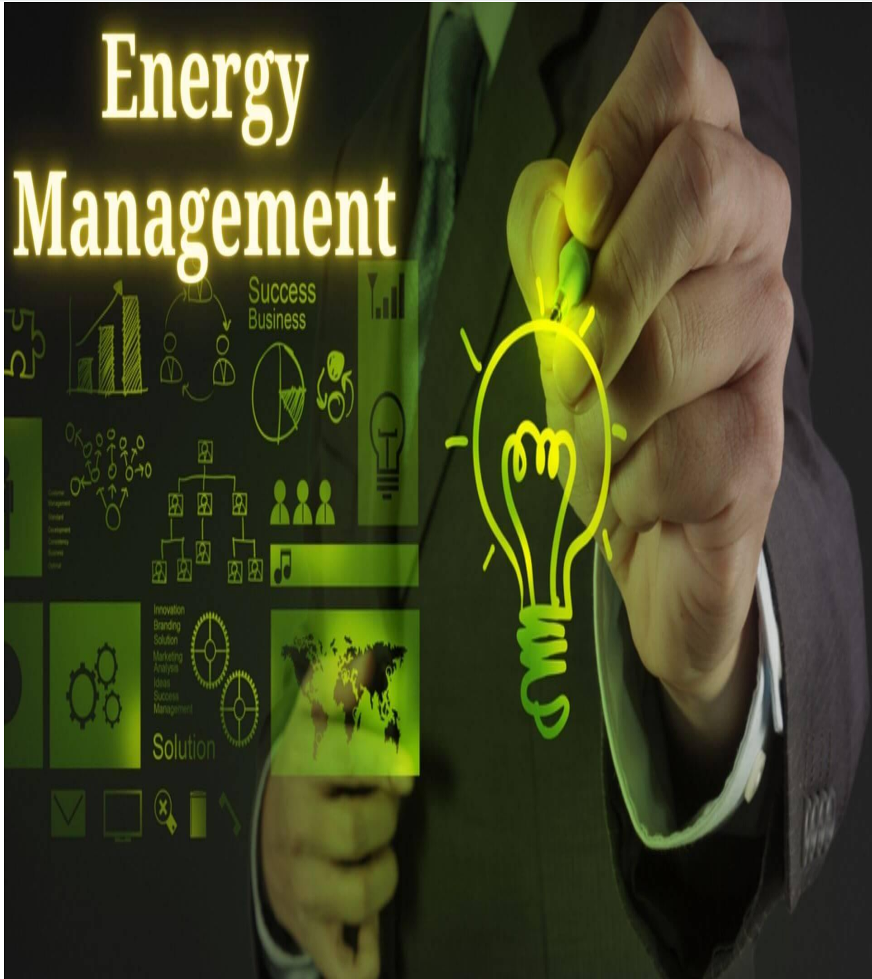
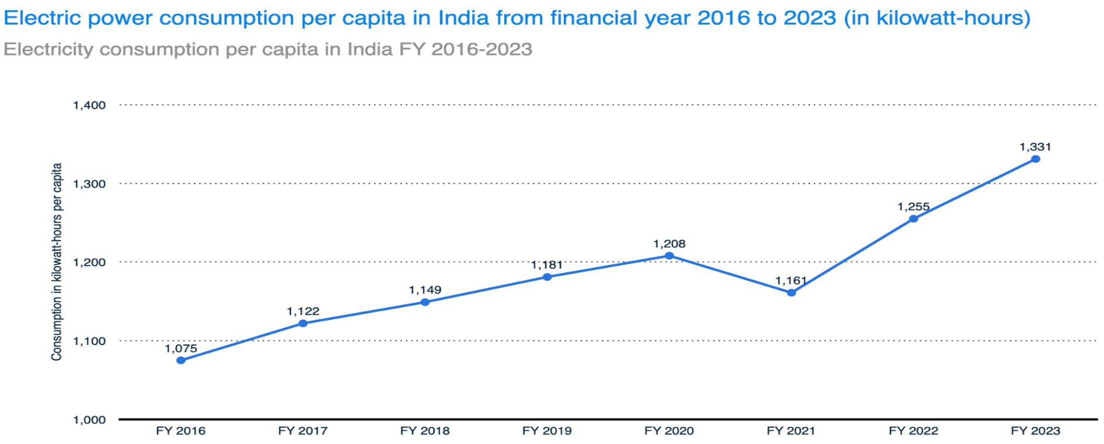
Table of Contents

1. **Introduction & Motivation**
   1.1 Importance of Energy Management
   1.2 Facts & Statistics
2. **Problem Statement**
   2.1 Challenges in Current Energy Management Systems
   2.2 Need for an AI/ML-Based IoT Solution
3. **Objectives**
4. **End-to-End Explanation**
   4.1 Hardware Perspective
   4.2 AI/ML Perspective
5. **Literature Survey/Review**
6. **Proposed Block Diagram**
7. **Our Work Progress**
8. **Future Plans**
9. **References**



1. Introduction & Motivation



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

- Efficient energy usage reduces **costs, carbon footprint, and grid load**.
- Traditional systems lack **real-time monitoring** and **predictive analytics**.
- AI/ML-driven solutions help in **load forecasting and anomaly detection**.

1.2 Facts & Statistics

- India is the **third-largest consumer** of primary energy globally, following China and the United States.
- **Global energy demand** is projected to increase by **25% by 2040**.
- **30% of energy** in buildings is **wasted due to inefficiencies**.
- AI-based energy management can **reduce energy costs by 10-30%**

2. Problem Statement

2.1 Challenges in Current Energy Management Systems

- **No Real-Time Monitoring** → Delayed response to inefficiencies due to lack of continuous insights.
- **No Predictive Analytics** → Reliance on past data without ML/AI forecasting hinders optimization.
- **Manual & Inefficient** → Human intervention leads to errors, slow decisions, and higher costs.
- **Limited Connectivity & Scalability** → Wired systems are costly and unsuitable for large-scale monitoring.

2. Problem Statement

2.2 Need for an AI/ML-Based IoT Solution

- **Smart Monitoring** → Modbus-compatible meters ensure real-time, accurate energy data.
- **LoRa Communication** → Wireless, long-range, and cost-effective connectivity.
- **Cloud Processing** → Centralized storage for seamless access and remote monitoring.
- **AI/ML Optimization** → Predicts consumption, detects anomalies, and improves efficiency.
- **Automated Decisions** → AI/ML-driven insights minimize wastage and cut costs.

3. Objectives

Develop an **AI/ML-based IoT framework** for **real-time energy monitoring** and **optimization** using **Modbus-compatible meters** and **LoRa communication**. **Leverage cloud storage**, **AI/ML-driven 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. End-to-End Explanation

4.1 Hardware Perspective

- **Multifunction Meters** → Measure voltage, current, power, and energy consumption **(Modbus compatible)**
- **LoRa Nodes** → Transmit real-time data wirelessly over long distances via LoRaWAN.
- **LoRa Gateway** → Bridges LoRa nodes and the cloud for reliable data transmission.

This **low-power, long-range, cost-effective** setup ensures **seamless, wide-area energy monitoring**.

MULTIFUNCTION METER

LoRa OUTDOOR GATEWAY

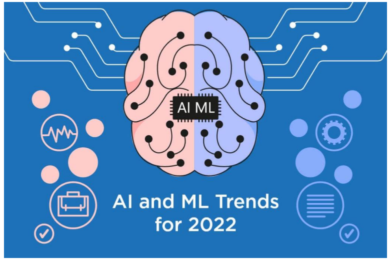
LoRa NODE

4. End-to-End Explanation

4.2 AI/ML Perspective

- **Energy Prediction** → ML models forecast demand using historical and real-time data.
- **Anomaly Detection** → AI/ML identifies faults, inefficiencies, and unusual consumption.
- **Optimization Strategies** → AI/ML-driven load balancing, peak shaving, and cost reduction.

Integrating **hardware with AI/ML** enables **real-time monitoring, predictive analytics, and optimized energy use** for **sustainability and efficiency**.



AI/ML OPTIMIZATION

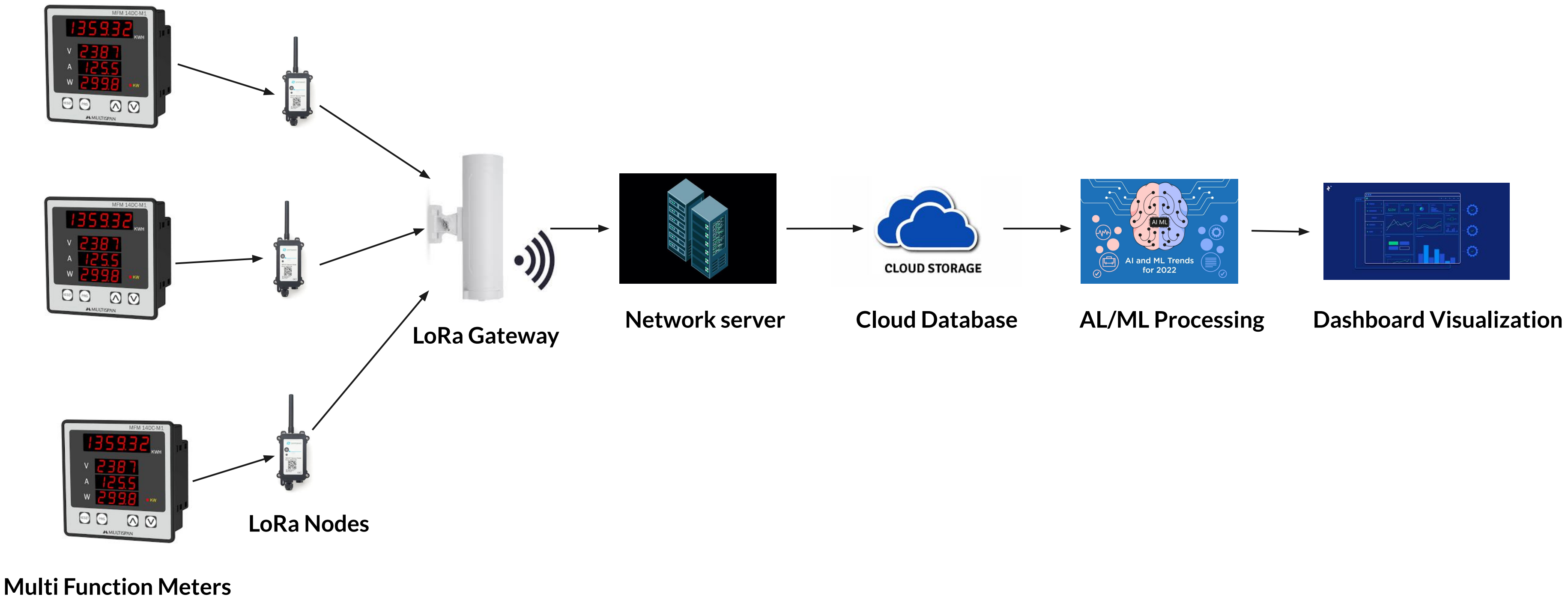
DASHBOARD VISUALISATION

CLOUD STORAGE

5. Literature Survey/Review

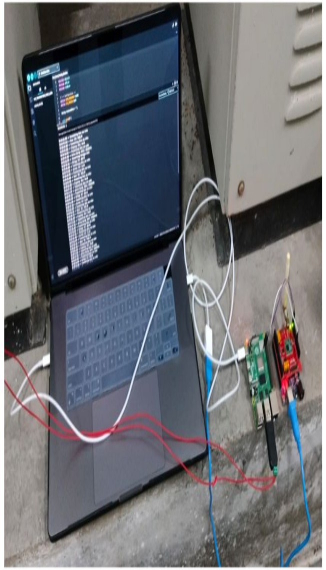
YEAR	TITLE OF THE PAPER	AUTHOR	CONTRIBUTIONS	OBSERVATIONS
2023	A **Unified Metering System Deployed for Water and Energy Monitoring in Smart City**	N Sushma H N Suresh	1.Integration of Wireless Technology for Real-Time Monitoring((LPWAN) 2.Scalable Smart Metering for Efficient Resource Management	1.Limited 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

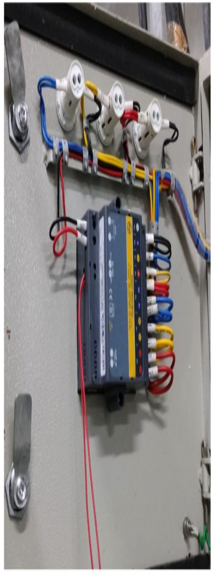
6. Proposed Block Diagram (System Architecture)



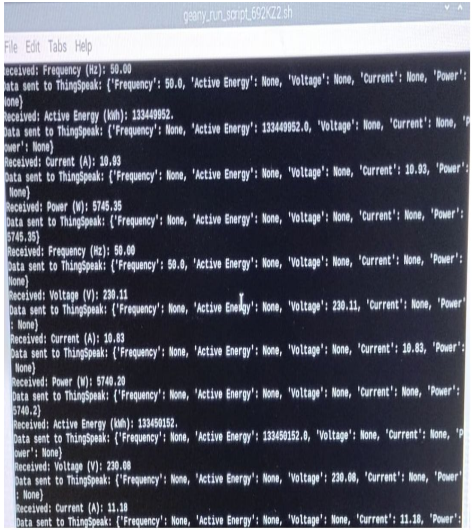
7. Our Work Progress

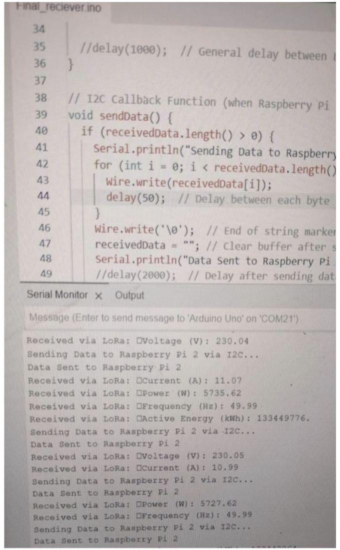
7.1 Hardware Implementation





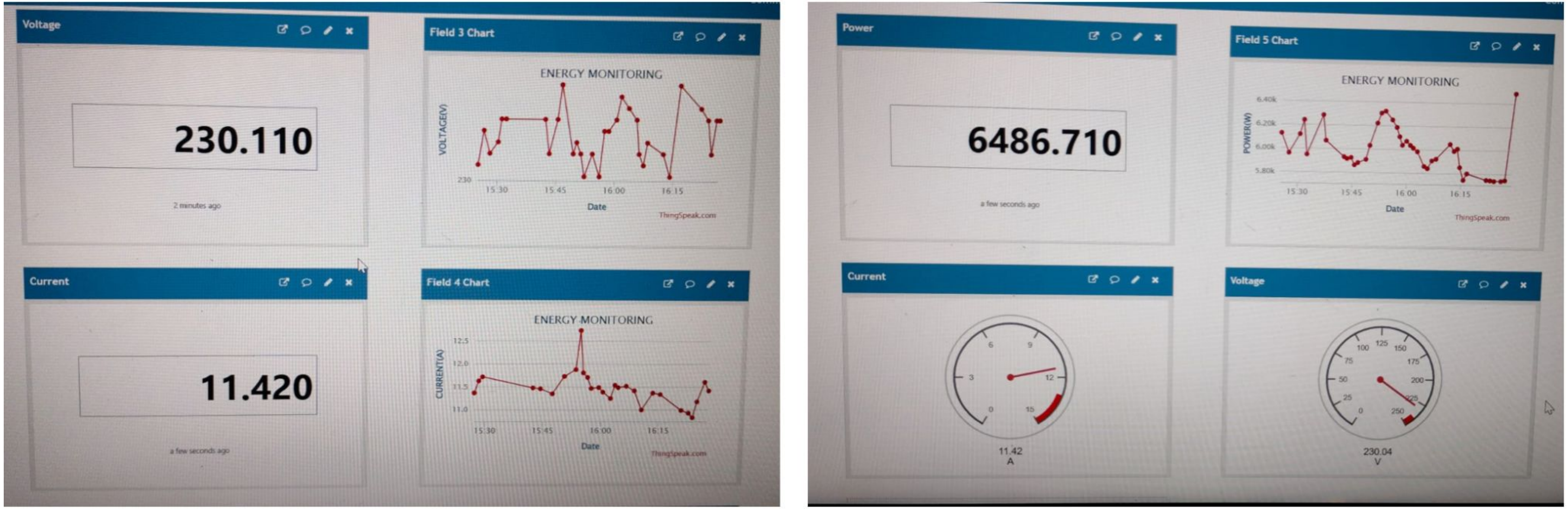
Tested with our campus multifunction meter





Data receiving on serial monitor

7. Our Work Progress

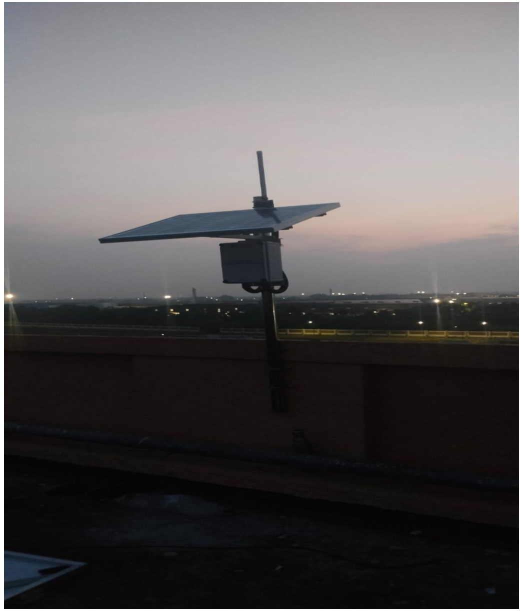


Data visualization on Things speak

7. Our Work Progress

7.1 Hardware Implementation

LoRa and Cellular Energy Meters Monitoring G08 and Faculty Wing



LoRa gateway

8. Future plans

1. Development of a **custom hardware solution** to enhance system efficiency, scalability, and cost-effectiveness.

2. Integration of a **custom AI/ML model with a recommendation system** for predictive energy analytics and optimization strategies.

3. Deployment of the **fully functional IoT framework**, incorporating **custom hardware, an optimized ML model, and an advanced dashboard** for real-time decision-making and energy efficiency.

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 House Hold Applications," *2021 7th International Conference on Electrical Energy Systems (ICEES)*, Chennai, India, 2021, pp. 428-432, doi: 10.1109/ICEES51510.2021.9383725

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THANK YOU