# Project Document

## IoT Sensor Data Transformer for Anomaly Detection in Smart Grids

### 🧠 Goal

The primary objective of this project is to utilize deep learning transformer architectures to detect anomalies in IoT-based smart meter sensor data. By leveraging the attention mechanism in time-series transformers, the project aims to improve the accuracy and transparency of anomaly detection systems within smart grid infrastructure. This project is particularly aligned with Prof. Md. Yusuf’s research in cyber-physical systems, smart infrastructure, and secure data analytics.

### 📊 Dataset

The dataset used in this project is the 'Smart Meter Energy Consumption' dataset, which contains time-series data representing electricity usage from various households. It is publicly available on Kaggle and is commonly used for energy consumption forecasting and anomaly detection tasks.

### 🛠️ Technologies & Tools

- Time Series Transformer (PyTorch implementation)  
- PyTorch (Model training and evaluation)  
- Matplotlib (Visualization)  
- SHAP (SHapley Additive exPlanations for model explainability)

### 📌 Tasks and Methodology

1. Preprocess and normalize smart meter sensor data for model input.  
2. Adapt transformer architecture to time-series anomaly detection using encoder-based attention.  
3. Train the model to detect sudden or unusual shifts in energy usage.  
4. Evaluate performance using precision, recall, and false positive rate.  
5. Use SHAP or attention heatmaps to interpret model predictions and visualize key decision areas.

### ✅ Significance

This project provides a scalable and interpretable deep learning framework for anomaly detection in smart grids. The ability to identify irregularities in real-time energy usage patterns can help utilities mitigate risk, optimize energy distribution, and enhance cyber-physical infrastructure security. These capabilities make the project highly relevant to advanced research in smart systems, aligning well with Prof. Md. Yusuf’s academic interests.