IT4010 – Research Project - 2024

Topic Assessment Form

Project ID: R25-065

1. Topic (12 words max)

An Intelligent Electricity Management Unit: AI-Driven Power Forecasting and Personalized Consumption Insights With Application Integration.

2. Research group the project belongs to

CI - Computing Infrasrtucture

3. Specialization of the project belongs to

Information Technology (IT)

4. If a continuation of a previous project:

Project ID	
Year	

5. Brief description of the research problem including references (200 – 500 words max) – references not included in word count.

The increasing demand for electricity, coupled with rising electricity costs and environmental concerns, necessitates efficient electricity management systems for households. With appliances like televisions, refrigerators, and air conditioners consuming significant electricity, it becomes essential to monitor, manage, and predict their energy usage. Current solutions often provide limited insights, focusing solely on aggregated energy consumption without offering actionable feedback for individual devices. These limitations hinder users from understanding and optimizing their electricity usage at a granular level, leaving them unable to take precise measures to reduce electricity bills and carbon footprints.

Furthermore, as climate change emphasizes sustainable practices, there is a growing interest in personalized energy-saving recommendations. Existing systems fail to leverage advancements in machine learning and artificial intelligence to predict future electricity consumption trends or offer tailored suggestions based on specific user behaviour.

The lack of integrated solutions that combine device-level electricity monitoring, predictive analytics, and personalized recommendations through an accessible platform represents a significant gap in home energy management. Addressing this gap requires an innovative approach that not only measures energy usage but also provides users with forward-looking insights and actionable advice.

The proposed research aims to develop a comprehensive *Intelligent Electricity Management Unit* that includes:

1. **IoT-enabled unit with threshold management system**: Measures and manages electricity usage for specific devices, enabling real-time electricity tracking and limitations.
2. **Time-series analysis**: Predicts future electricity consumption patterns using machine learning models.
3. **Generative AI capabilities**: Builds a large language model (LLM) to offer personalized electricity-saving suggestions based on specific device usage.
4. **User-friendly web application**: Displays analytical visualizations of electricity-trends and AI-driven insights through an intuitive interface with effective human-computer interaction (HCI).

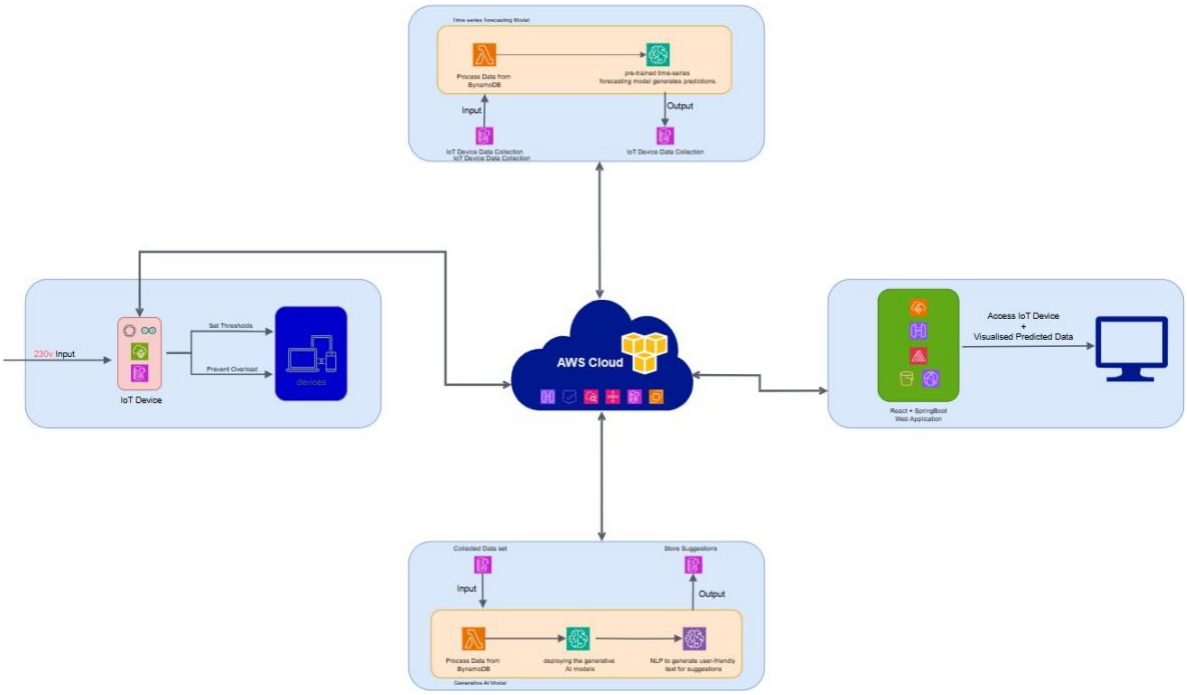
By combining IoT, machine learning, generative AI, and HCI principles, this system addresses the critical need for household energy optimization. It empowers users to make informed decisions, fosters energy-conscious behaviour, and contributes to sustainability goals by reducing unnecessary electricity wastage.

6. Brief description of the nature of the solution including a conceptual diagram (250 words max)

The proposed Intelligent Electricity-Management Unit is an innovative, multi-functional solution designed to optimize electricity usage at the device level. It comprises four core components:

1. **IoT Unit with threshold management system**: A compact hardware device monitors and manages the electricity usage of individual appliances such as televisions, refrigerators, and air conditioners. The unit collects real-time data on energy consumption and facilitates precise tracking of each device's usage patterns including the ability for users to put limitations in electricity consumption.
2. **Time-Series Analysis**: Leveraging advanced machine learning algorithms, this module analyses historical data to forecast future electricity consumption trends for specific devices. Users receive predictions to proactively plan their electricity usage, reducing both costs and environmental impact.
3. **Generative AI with Large Language Models (LLM)**: This module provides personalized recommendations for electricity -saving practices. For instance, it might suggest optimal usage schedules for a television or refrigerator based on observed patterns, seasonal variations, and electricity tariffs. The LLM generates insights tailored to the unique behaviour and preferences of each user.
4. **Web Application**: A user-friendly web app serves as the system's interface, offering clear and engaging visual representations of electricity data. It integrates time-series predictions and AI-driven insights, enabling users to interpret and act on the information effortlessly. The app's design emphasizes human-computer interaction (HCI) principles for an intuitive and accessible experience.

This holistic solution empowers users with actionable insights and advanced predictions, encouraging electricity energy-conscious behaviour and contributing to long-term sustainability goals. By integrating IoT, machine learning, and generative AI, the Intelligent Energy Management Unit offers a cutting-edge approach to managing


Input
Output
AWS Cloud
230v Input
IoT Device
Set Thresholds
Prevent Overload
devices
Access IoT Device
+
Visualised Predicted Data
Input
Output

7. Brief description of specialized domain expertise, knowledge, and data requirements (300 words max)

The development of the *Intelligent Electricity Management Unit* requires expertise and knowledge spanning multiple specialized domains:

1. **Internet of Things (IoT)**: Designing and implementing the IoT unit demands a strong understanding of hardware-software integration. Skills in microcontroller programming (e.g., Arduino, Raspberry Pi), sensor calibration, and communication protocols (e.g., MQTT, Wi-Fi, Bluetooth) are essential for enabling device-level electricity monitoring and data transmission.
2. **Machine Learning and Time-Series Analysis**: Expertise in developing predictive models is vital. Knowledge of algorithms like ARIMA, LSTMs, or Prophet is required to forecast electricity usage trends based on historical data. This includes data pre-processing, feature engineering, and model evaluation to ensure high accuracy and reliability.
3. **Generative AI and Language Models**: Building a large language model (LLM) for personalized electricity-saving recommendations requires experience with natural language processing (NLP) and generative AI frameworks (e.g., GPT, BERT). This involves fine-tuning the model to interpret user data and provide context-aware suggestions effectively.
4. **User Interface and Experience Design (UI/UX)**: Expertise in HCI and app development is needed to design an intuitive web application. Familiarity with front-end frameworks (e.g., Spring boot) and data visualization tools (e.g., D3.js, Tableau) is necessary for creating interactive and engaging user interfaces.
5. **Data Requirements**: The system requires granular electricity consumption data collected from IoT devices. Training the predictive and generative models will also need datasets such as appliance electricity usage patterns, household behaviour trends, and electricity tariff data. Ensuring data quality, privacy, and security is a key consideration.

This multidisciplinary expertise ensures the seamless integration of IoT, AI, and user-centric design, delivering a robust and impactful electricity management solution.

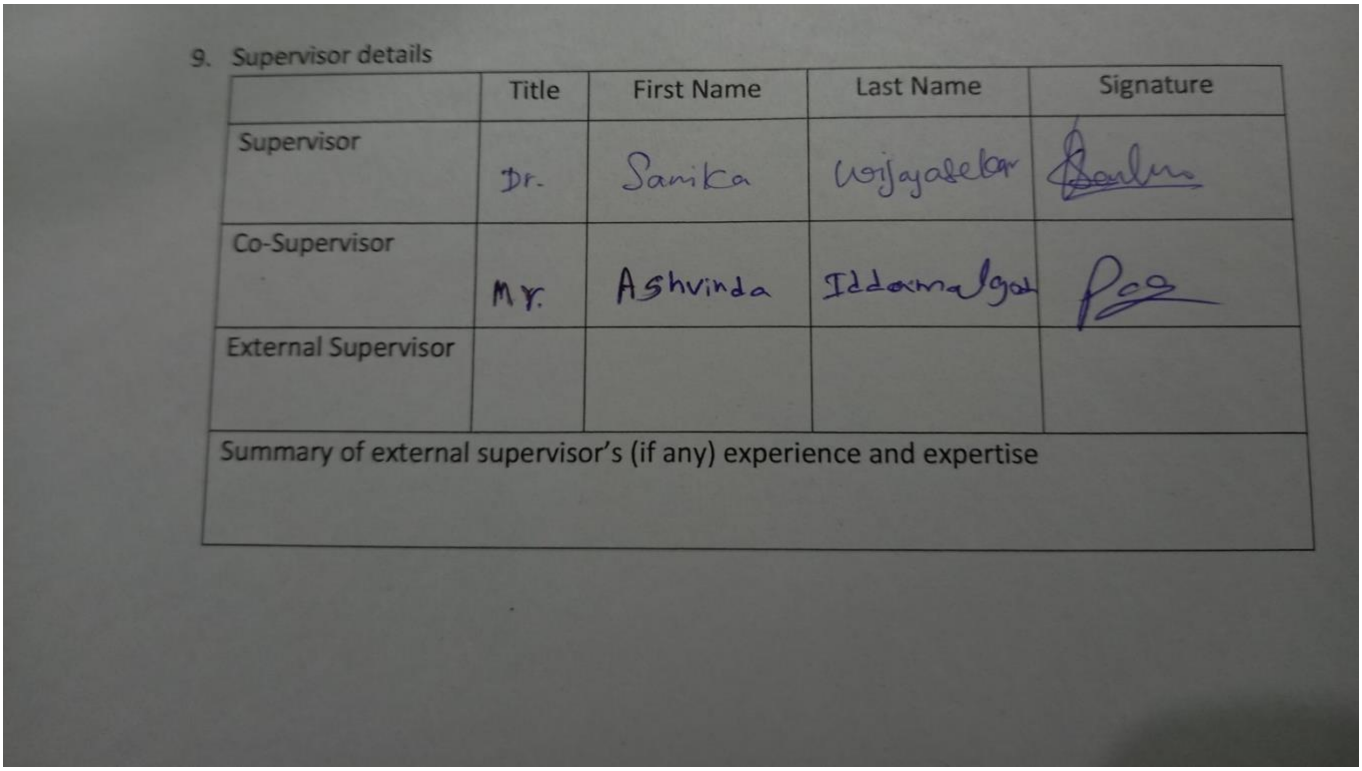
8. Objectives and Novelty

Main Objective To develop an integrated Intelligent Electricity Energy Management Unit that monitors, predicts, and optimizes household electricity usage by combining IoT-based device tracking, machine learning-based electricity energy forecasting, and generative AI-driven personalized recommendations through a user-friendly web application.			
Member Name	Sub Objective	Tasks	Novelty
Pivithuru N.H.A.S.	Develop a web application that visualizes time-series energy consumption data and generative AI predictions in an interactive and user-friendly manner. Enhance user engagement through HCI components, making insights accessible and	• Design interactive charts and dashboards for time-series data (e.g., line graphs, heatmaps, or area charts) and Include real-time and historical data representation. • Present predictions (e.g., next month's energy usage or potential savings) from generative AI models in an easy-to-understand format and Allow users to simulate "what-if" scenarios (e.g., impact of reducing appliance usage). • Implement gamified elements, such as badges for energy-saving milestones, add interactive tutorials to explain	The system introduces a unified platform combining AI-driven predictions with analytical visualizations for energy management. By incorporating dynamic, gamified HCI components and generative AI-based scenario simulations, it bridges the gap between data insights and user decision-making. Additionally, inclusive

	actionable for non-technical users.	energy trends and predictions and Provide accessibility features.	features such as adaptive color schemes ensure accessibility for diverse users.
Balasuriya B.L.I.S.	Develop a machine learning model using time-series analysis techniques to predict future electricity consumption for individual appliances based on historical usage data.	• Collect and pre-process electricity usage data from IoT devices. • Explore and implement suitable time-series forecasting models • Train and validate the model to ensure accurate predictions for specific appliances. • Integrate the predictive model into the system's pipeline for real-time forecasting.	The proposed model provides appliance-specific electricity usage predictions, enabling precise electricity energy optimization at the device level. Unlike traditional systems, this approach empowers users with actionable insights tailored to their unique energy consumption patterns.
Siriwardhana S.M.D.S.	Create an IoT device to manage and control electricity usage of home electrical devices. Enable users to set monthly usage thresholds for individual devices and control their functionality through a web application, ensuring efficient	• Design and implement IoT hardware capable of monitoring electricity usage for individual electrical devices in a home environment. • Develop functionality for users to set a monthly usage threshold for a specific device. • Program the IoT device to automatically block power supply to the selected device if the threshold limit is exceeded before the end of the month. • Enable an override feature through the web application to temporarily lift the threshold limit in emergency situations.	This system introduces a novel approach to energy management by enabling users to define monthly usage thresholds for individual electrical devices. The IoT device automatically enforces these limits, cutting off power supply when the threshold is exceeded. Unlike traditional energy management systems,

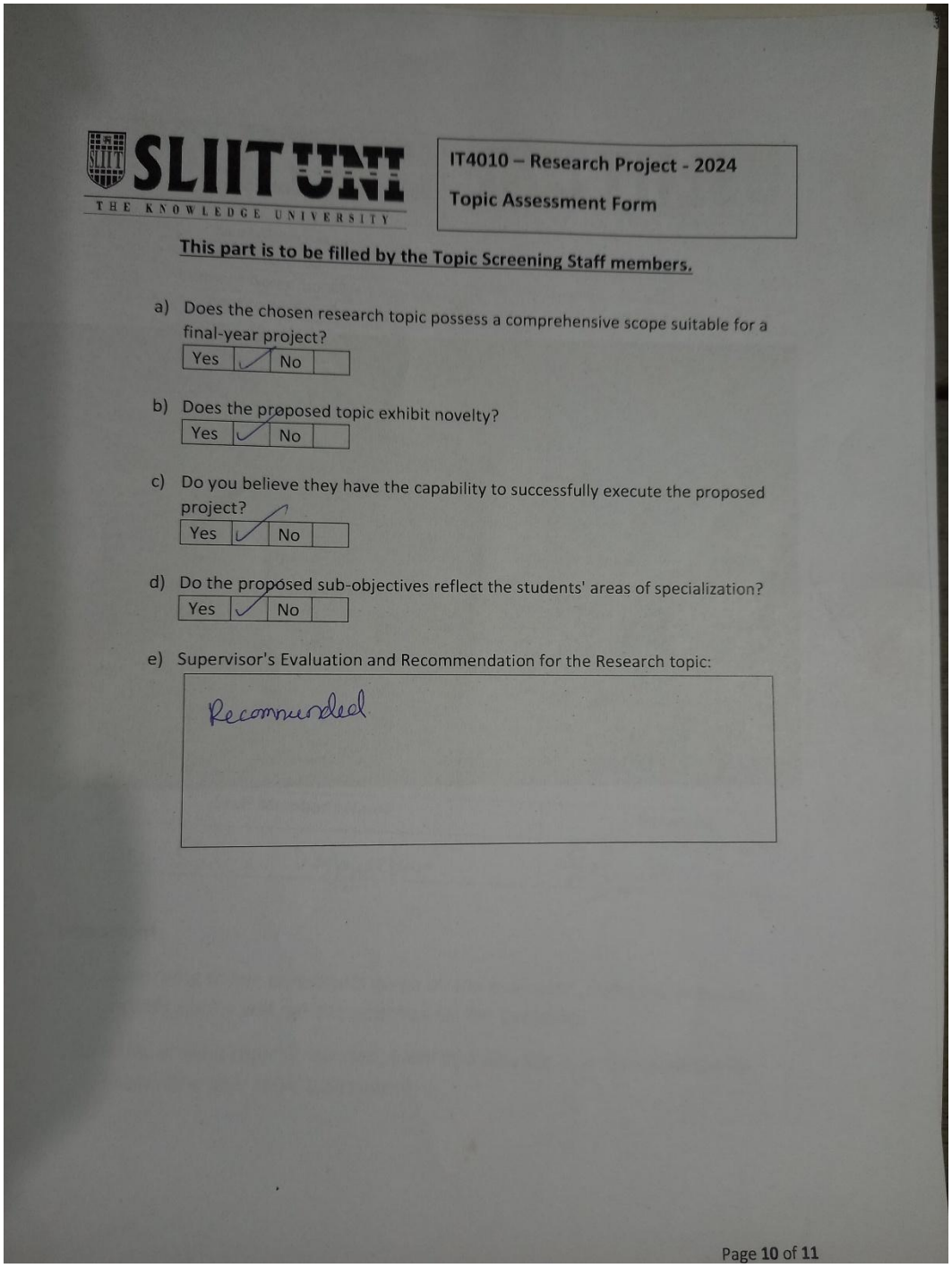
	energy management.	• Integrate the IoT device with a web application to allow real-time monitoring, control, and management of connected devices. • Ensure secure communication between the IoT device and the web application using industry-standard encryption protocols.	this solution provides a user-friendly emergency override feature via a web application, ensuring both control and flexibility.
Welikalage R.Y.W.	Implement a Generative AI-based system to provide personalized energy-saving recommendations tailored to individual user consumption patterns.	• Collect and preprocess electricity usage data - Gather and clean real-time usage data from IoT devices for analysis. • Develop personalized recommendation models - Use AI to create tailored energy-saving suggestions based on user consumption patterns. • Validate and fine-tune models - Test and refine AI models to ensure accurate and effective recommendations. • Simulate and visualize outcomes - Show potential energy savings and impact through interactive simulations. • Deploy generative AI in the pipeline - Integrate AI models into the system for real-time, actionable recommendations.	The system combines generative AI with detailed energy consumption data to offer personalized recommendations. By providing tailored insights, simulating outcomes, and incorporating gamification, it encourages proactive energy management. The inclusive design ensures accessibility, helping diverse users save costs and achieve sustainability goals.

9. Supervisor details



9. Supervisor details

	Title	First Name	Last Name	Signature
Supervisor	Dr.	Samika	Wijayatekar	
Co-Supervisor	Mr.	Ashvinda	Iddamalgoda	
External Supervisor				
Summary of external supervisor's (if any) experience and expertise				



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This part is to be filled by the Topic Screening Staff members.

a) Does the chosen research topic possess a comprehensive scope suitable for a final-year project?

Yes	✓	No	

b) Does the proposed topic exhibit novelty?

Yes	✓	No	

c) Do you believe they have the capability to successfully execute the proposed project?

Yes	✓	No	

d) Do the proposed sub-objectives reflect the students' areas of specialization?

Yes	✓	No	

e) Supervisor's Evaluation and Recommendation for the Research topic:

Recommended

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Topic Assessment Form

Acceptable: Mark/Select as necessary

Topic Assessment Accepted	✓
Topic Assessment Accepted with minor changes*	
Topic Assessment to be Resubmitted with major changes*	
Topic Assessment Rejected. Topic must be changed	

* Detailed comments given below

Comments

Staff Member's Name	Signature
Dr. Sanika Wijayasekara	

***Important**:

1. According to the comments given by the evaluator, make the necessary modifications and get the approval by the **Evaluator**.
2. If the project topic is rejected, identify a new topic, and request the RP Team for a new topic assessment.

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