Final Year Project Showcase Batch 2021
Year 2025

Department: Electrical Engineering Programme: Electrical Engineering	
1	**Project Title** Design Intelligent Energy Measuring Device for Residential Consumers to Optimize Energy Consumption
2	**Project Idea** Increasing energy demand and inefficient energy consumption practices in residential sectors lead to unnecessary power wastage, higher electricity costs for consumers, and increased stress on power systems. Lack of real-time consumption monitoring and absence of user awareness regarding the energy usage of individual appliances contribute significantly to these problems. To address these challenges, there is a need for a smart energy measuring system that not only monitors the consumption of electrical appliances in real-time but also provides intelligent insights and optimization suggestions. Such a system will empower residential consumers to make informed decisions about their energy usage, reduce wastage, and contribute to energy conservation efforts in alignment with sustainable development goals. This project introduces an **Intelligent Energy Measuring Device** designed for residential users to monitor energy consumption at the appliance level. The device utilizes smart sensors, wireless communication, and data analysis algorithms to provide real-time energy usage data, highlight inefficient usage patterns, and guide users towards optimized consumption. By promoting responsible energy consumption, the device contributes towards sustainability and efficient power utilization at the household level.
3	**Process** This design of the **Intelligent Energy Measuring Device** included both hardware and software development phases. The **hardware domain** involved the selection and integration of voltage and current sensors with a microcontroller-based processing unit. This also included the design of the energy measurement circuitry, wireless communication modules, and housing of the device for safe residential deployment. The **software domain** consisted of the development of energy monitoring algorithms for accurate measurement of consumption parameters, real-time data acquisition, and processing. Cloud integration and mobile/web interface development were implemented to visualize live consumption data and provide optimized usage recommendations. The system also incorporates data analysis techniques to detect unusual consumption patterns and notify the user, thereby supporting smarter and more sustainable energy management in residential environments.

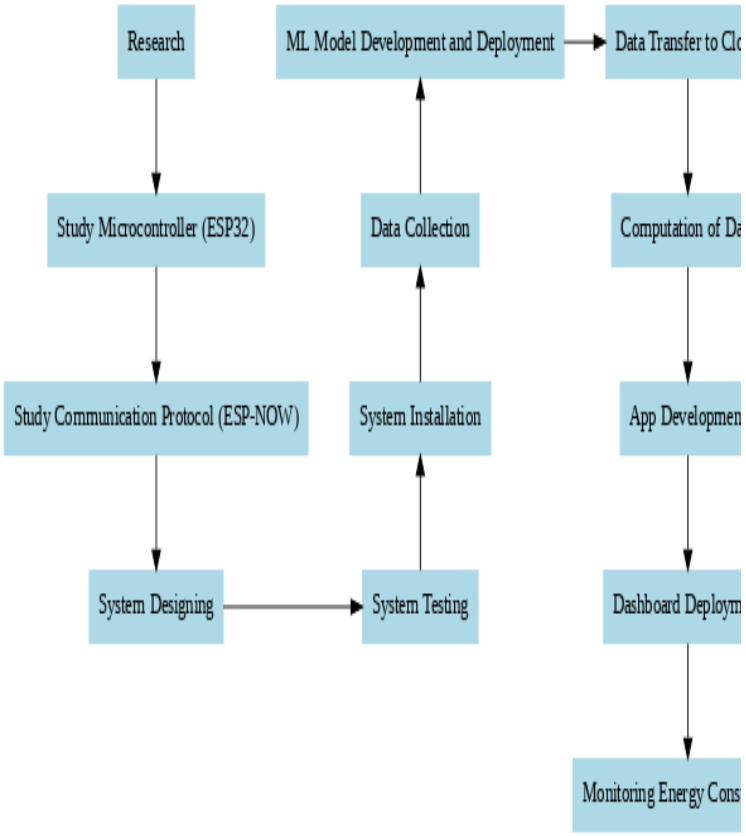

Fig 01: Flowchart of the project

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Outcome

The outcome of this project is a fully functional **Intelligent Energy Measuring Device** capable of accurately monitoring and analyzing real-time energy consumption in residential environments. The device successfully records voltage, current, and power consumption of appliances, transmits the data wirelessly, and displays it on a user-friendly dashboard accessible via web platforms.

It enables consumers to identify inefficient energy usage patterns, optimize their consumption behavior, and ultimately reduce their electricity costs. Moreover, the system promotes energy conservation, reduces unnecessary load on the power grid, and supports sustainable energy usage practices at the household level.

The project demonstrates the practical implementation of smart energy monitoring and management systems, contributing towards the global goals of energy efficiency and environmental sustainability.

5	**Evidence (Theoretical Basis)** In this project, we have concluded through practical implementation and testing that by utilizing **IoT-based microcontrollers** (such as ESP32) integrated with **voltage and current sensors**, it is possible to achieve accurate and continuous measurement of household energy consumption. Theoretical energy measurement principles, including **Ohm's Law, Power Law, and RMS calculations**, form the core computational basis of the system. The system software incorporates data acquisition and processing algorithms developed using **Arduino IDE and Python**, while wireless data transmission is achieved through **Firebase**, ensuring reliable and real-time cloud connectivity. Data visualization and user interaction are enabled through web and mobile dashboards, utilizing real-time databases to present consumption trends, generate alerts for excessive usage, and provide optimization suggestions through threshold-based and comparative analysis algorithms.. The device is powered by a stable DC power source, ensuring uninterrupted monitoring, and is housed in a compact, insulated enclosure suitable for residential environments. This approach combines theoretical energy management concepts with applied electronics and IoT communication technologies, resulting in a functional and sustainable energy optimization solution.
6	**Impact on Sustainability of Urban Regions or SDG-11 "Sustainable Cities and Communities"** This project primarily supports SDG 11: Sustainable Cities and Communities by enabling residential consumers to actively monitor and optimize their electricity usage. Through real-time energy data and intelligent consumption insights, the device helps reduce unnecessary load on the urban power grid, lowers household energy waste, and promotes sustainable living practices. This contributes to the development of resilient, energy-efficient, and environmentally responsible communities.
7	**Competitive Advantage or Unique Selling Proposition** (Cost Reduction, Process improvement, Attainment of any SDG (Sustainable Development Goal), increase of market share or capturing new market or having superior performance over a competitor. In summary, any striking aspect of the project that compels the industry to invest in FYP or purchase it. Some detailed description is required in terms of how, why when what. You can select one or more from the following dropdown and delete the rest of them). Please keep relevant options, delete the rest of them, and correct the sequence
a	**Attainment of any SDG** This project primarily supports SDG 11: Sustainable Cities and Communities by enabling residential consumers to actively monitor and optimize their electricity usage. Through real-time energy data and intelligent consumption insights, the device helps reduce unnecessary load on the urban power grid, lowers household energy waste, and promotes sustainable living practices. This contributes to the development of resilient, energy-efficient, and environmentally responsible communities. Additionally, it aligns with SDG 9: Industry, Innovation and Infrastructure by integrating IoT-based smart metering infrastructure at the consumer level. The project encourages the use of low-cost, scalable, and innovative technology to modernize energy systems, improve energy efficiency, and support technological

	advancement in the residential energy sector.	
b	**Environmental Aspect** (e.g. carbon reduction, energy-efficient, etc.) By optimizing household energy usage, the system helps in reducing electricity wastage, which indirectly decreases the demand on power plants, many of which still rely on fossil fuels. This contributes to lower greenhouse gas emissions and supports energy conservation, thus positively impacting the environment and aligning with climate change mitigation goals.	
c	**Cost Reduction of Existing Product** Existing smart energy meters with real-time monitoring and analytics are often costly and inaccessible to average residential users. Our project provides a **low-cost alternative** by using **open-source hardware and affordable sensors**, eliminating the need for expensive proprietary systems. This design significantly reduces implementation costs while delivering essential energy monitoring features, making it suitable for widespread residential adoption.	
d	**Process Improvement which Leads to Superior Product or Cost Reduction, Efficiency Improvement of the Whole Process** (e.g. What is the issue is current process and what improvement you suggests) In current residential energy systems, consumers are unaware of real-time appliance-level energy usage, leading to inefficient consumption and unnecessarily high electricity bills. Existing energy meters only measure total household consumption without actionable feedback. Our project improves this process by offering real-time, appliance-level monitoring, intelligent consumption analysis, and usage optimization suggestions. This results in a smarter energy management process, reduces overall consumption, and improves energy efficiency for households, all at an affordable cost.	
8	**Target Market** (Industries, Groups, Individuals, Families, Students, etc) Please provide some detail about the end-user of the product, process, or service The primary target market consists of residential consumers (families, individuals, and smart home users) aiming to optimize their household energy consumption and reduce utility bills. The secondary market includes utility companies, energy auditors, smart home solution providers, and energy efficiency consultants, who can deploy this system as part of their services to promote efficient energy usage.	
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11	**Video (If any)**	**https://drive.google.com/file/d/1rvETSAiTvqNDQpJYesLgR6fdVSceI7ZT/view?usp=sharing**