Remote Electricity Bill Calculator

IOT Based Real-Time Electricity Billing and Visualization System.

Bachelor of Science in Computer Systems Engineering

Sri Lanka Institute of Information Technology
Sri Lanka

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Objective

To Develop an Intelligent Electricity Bill Calculating System based on IoT.

Benefits

- Able to save 80% of the cost of issuing Electric bills in Sri Lanka.
- Enhanced consumer awareness of electricity consumption, leading to energy conservation.
- Reduced billing errors and disputes.
- Empowered utility providers with data-driven decision-making capabilities.
- Contributed to a sustainable and efficient energy ecosystem.

Implementation

The project involves a fusion of hardware and software components.

- Hardware - IoT sensors, microcontrollers, and secure data communication protocols.
- Software - Cloud-based server infrastructure, intelligent billing algorithms, user-friendly web/mobile applications, and robust data security measures.
- Workflow - Seamless data collection through IoT sensors, secure transmission to the cloud, real-time billing computation, and user-friendly visualization.

Conclusion

The IoT-Based Real-Time Electricity Billing and Visualization System is poised to revolutionize the energy sector by offering transparency, accuracy, and efficiency. This project proposal seeks support for its implementation, promising a brighter and more sustainable future for energy consumption and billing.

And, As the main conclusion of our project we are going to show that it is possible to fully automate the electric bills issuing process of Sri Lanka and save 80% of cost which requires in existing manual process.

1. INTRODUCTION

I. Problem Addressed

In an era defined by digital transformation and the relentless pursuit of efficiency, our "Remote Electric Bill Calculator" project emerges as a beacon of innovation. The mission is clear: to revolutionize the way we manage our electricity expenses, ushering in an era of cost reduction, time optimization, and unparalleled convenience for all.

The demand for a smarter approach to tracking and managing electricity consumption is more pressing than ever before. As households, businesses, and industries grapple with rising energy costs and environmental concerns, our project aims to provide a sophisticated yet user-friendly solution.

At its core, the "Remote Electric Bill Calculator" project is designed to simplify the intricate process of monitoring and analyzing electric bills. Gone are the days of manual data entry and cumbersome calculations; instead, we offer a streamlined and remote solution that empowers users to effortlessly gain insights into their electricity consumption patterns.

Our commitment to this project is not merely technological; it's a promise to empower individuals and organizations alike. By reducing costs and saving valuable time, we seek to enhance financial stability and foster a culture of sustainable energy use.

This project is not limited to a select few but caters to a broad spectrum of users, from homeowners' keen on reducing their carbon footprint to businesses striving for operational excellence. The "Remote Electric Bill Calculator" will be a game-changer, making energy management accessible to all, regardless of technical expertise.

As we embark on this journey towards a more efficient and sustainable future, we invite you to join us in our pursuit of cost-effective, time-saving, and user-friendly energy management. Together, we can reshape the way we interact with electricity bills, ushering in a new era of economic and environmental responsibility.

Welcome to the future of energy management, where the power to control your electric bills rests at your fingertips.

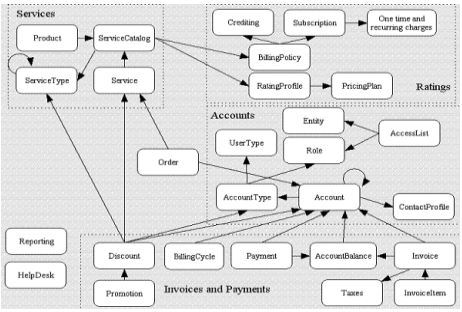
II. Background Context

Rising Energy Costs:

Over the past decade, the cost of electricity has been on a steady upward trajectory, impacting the financial stability of households and the operational expenses of businesses. This escalation in energy expenses has heightened the urgency for individuals and organizations to closely monitor and manage their electricity consumption.

The rise, linked to the increase of wholesale energy prices globally, started back in 2021 in the wake of the COVID-19 pandemic and growing international demand. The Russian invasion of Ukraine and climate conditions have had an aggravating effect.

Complex Billing Structures:



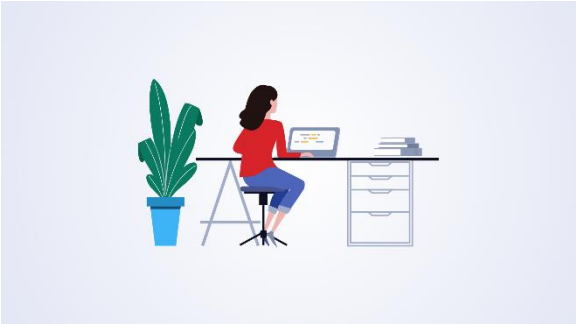
Traditional electric bills often come laden with complex billing structures, tariff variations, and demand charges that can baffle even the most astute consumers. Understanding the nuances of these bills has been a daunting task, leading to financial inefficiencies and missed opportunities for savings.

Environmental Concerns:

Concurrently, the global emphasis on environmental sustainability and the reduction of carbon footprints has prompted a growing interest in optimizing energy use. Individuals and organizations are seeking ways to reduce energy waste, make informed decisions about energy-efficient appliances, and align their operations with green initiatives.

Remote Work and Automation:

The advent of remote work and the proliferation of smart technology have reshaped the way we interact with our surroundings. The need for remote solutions, which allow users to access critical information and perform essential tasks from anywhere, has never been greater.



"Remote Electric Bill Calculator" project aligns seamlessly with this trend, offering a solution that adapts to the modern, connected lifestyle.

Considering these challenges and opportunities, the "Remote Electric Bill Calculator" project emerges as a timely and impactful innovation. By harnessing the power of technology, data analytics, and user-friendly interfaces, this project seeks to empower individuals and organizations to take control of their electricity bills, reduce costs, optimize energy use, and contribute to a more sustainable future.

As we delve into the intricacies of this project, we invite you to explore the transformative potential it holds for the way we manage electricity consumption in an era where every kilowatt-hour counts.

[1] H. Mostafa, “Billing system: Introduction,” CodeProject, https://www.codeproject.com/articles/10824/billing-system-introduction (accessed Sep. 3, 2023).

[2] Energy price rise since 2021 - consilium, https://www.consilium.europa.eu/en/infographics/energy-prices-2021/ (accessed Sep. 3, 2023).

2. MAIN OBJECTIVE

As the objectives of our project, we have a main objective and several sub objectives also. So, our main objective is as follows:

To Develop an Intelligent Electric Bill Calculating System based on IoT.

Apart from the main objective our sub objectives are as follows:

1. **To develop a reliable model of the IoT device**

To get the power usages of the buildings or the houses we need an IoT device which stores the data of power usages and send those data to the main web server securely and uninterruptedly. So, it is one of our sub objectives to develop such a reliable model of the IoT device which will be able to attach to every household electric meter.

2. **To develop a user-friendly and secure web application**

To issue electric bills for the users accurately and securely we need a proper web application. So, it is one of our sub objectives to develop a user-friendly and secure web application.

3. **To show that it is possible to save 80% of the cost for issuing electric bills in Sri Lanka by using this system as commercialized one.**

It is one of our sub objectives to show that implementation of this model system as a further developed commercialized version will save 80% of the cost for issuing electric bills in Sri Lanka with existing system.

3. BODY OF REPORT

I. Literature

Introduction

In our modern world, electricity is a fundamental resource that powers our homes, businesses, and industries. It lights up our lives, fuels our gadgets, and keeps our machines humming. But have you ever wondered how we are billed for the electricity we use? Welcome to the captivating realm of the Electricity Billing Project, where we delve into the fascinating intricacies of how our consumption is measured, calculated, and translated into those monthly statements.

Imagine a world without electricity bills – a world where you could use as much energy as you wanted without any worries. Sounds enticing, doesn't it? However, the reality is that electricity isn't free, and understanding how we're billed for it is essential for effective energy management. The Electricity Billing Project opens the doors to this often-overlooked domain, shedding light on the processes that determine how much we pay for the power we consume.

In this literature, we will embark on a journey to unravel the mysteries of electricity billing, using simple language to make even the most complex concepts accessible to all readers. We will explore the technology behind energy meters, uncover the methods used to measure consumption, and uncover the factors that influence the final numbers on our bills. Moreover, we'll touch on the importance of responsible energy usage, and how being conscious of our consumption can positively impact both our environment and our wallets.

Throughout this exploration, we'll encounter terms like kilowatt-hours, tariff rates, peak and off-peak hours, and more. But fear not! We'll break down these terms and concepts into easily digestible portions, making sure that by the end of this literature, you'll not only have a clearer understanding of how electricity billing works but also a newfound appreciation for the role it plays in our daily lives.

So, let's embark on this enlightening journey together. Whether you're a curious homeowner, a budding energy enthusiast, or simply someone who wants to gain a better grasp of the electricity billing process, this literature is designed to provide you with the knowledge you need to navigate the world of electricity consumption and billing with confidence. Ready to become an empowered energy consumer? Let's flip the switch and get started!

As we venture further into the realm of electricity billing, it's important to recognize that this process isn't without its challenges. From ensuring the security of our personal data to addressing ethical concerns, let's explore these crucial aspects that underpin the modern electricity billing project.

Challenges in Electricity Billing

Electricity billing might seem straightforward, but behind the scenes, there are intricate challenges that utilities and consumers face. One significant challenge is accurately measuring the electricity consumed. Traditional meters have their limitations and might not always provide precise readings, leading to discrepancies in billing. Modern technologies like smart meters aim to address this by providing real-time data and reducing errors.

Another challenge is dealing with seasonal variations in energy consumption. During peak months, when temperatures soar or drop, energy usage can spike, resulting in higher bills. Managing these fluctuations efficiently while keeping bills reasonable requires a delicate balance.

Technological Advancements: Powering Accurate Measurements

One of the significant challenges in electricity billing revolves around accurate measurement. Traditional electromechanical meters had limitations in precision, leading to potential discrepancies in billing. However, technological advancements have introduced smart meters, capable of recording consumption with higher accuracy. These devices enable real-time tracking, allowing both consumers and providers to monitor usage patterns more effectively.

Security Concerns

With the integration of technology in electricity billing, concerns about data security have emerged. Smart meters and digital systems collect detailed information about our energy usage. Protecting this data from cyber threats is paramount. Unauthorized access to consumption data could not only compromise privacy but also potentially lead to billing inaccuracies or even energy theft. Utilities and providers must prioritize robust cybersecurity measures to safeguard sensitive information.

Ethical Considerations

Ethics play a significant role in the electricity billing project, particularly concerning vulnerable consumers. Ensuring that billing practices are fair and transparent is essential. Low-income households and individuals with limited access to information or digital technology must not be disadvantaged. Transparent billing practices and readily available information empower consumers to understand their bills and make informed decisions.

Moreover, the shift toward renewable energy sources raises ethical questions. How should electricity from renewable sources be priced compared to conventional sources? Is it ethical to charge a premium for cleaner energy? These are questions

that utilities and society at large must grapple with to ensure a just transition to sustainable energy.

Balancing Act

Addressing these challenges while upholding security and ethics requires a delicate balancing act. Innovations in technology, such as secure data encryption and improved metering systems, can contribute to resolving many of these issues. Open communication between utilities and consumers is vital to building trust and ensuring that billing practices are transparent and fair.

In conclusion, our expedition into the intricate realm of electricity billing has illuminated a landscape riddled with complexities, security imperatives, and moral dilemmas. In an age where electricity sustains our modern lives, the imperative to forge pathways through these challenges while preserving data integrity and ethical principles stands as a paramount task. As we collectively engage with these facets, we propel ourselves toward a future where electricity billing transcends mere accuracy and security, evolving into a beacon of equity and ethics, accessible and just for all. In this journey, we find not only the quest for efficient energy management but also the pursuit of a brighter, more responsible energy future for our global community.

Scope

The scope of an Electricity billing IoT device includes monitoring and measuring energy consumption in real-time, enabling accurate billing, analysing usage patterns, and facilitating remote control. It enhances efficiency, reduces manual errors, and enables data-driven insights for both consumers and providers.

Relevant researches

1.Title: IoT-Based Real-Time Electricity Billing and Visualization System

Research Details:

Objective: Develop an IoT-based system that provides real-time electricity consumption data, calculates costs, and offers visualization tools for users to understand their energy usage patterns.

Methodology: Employ low-cost energy meters and IoT devices to collect real-time data. Develop algorithms to process consumption data and calculate costs based on applicable tariffs. Create a user-friendly web interface with graphs and charts to display consumption trends.

Contribution: The research contributes to user awareness of energy consumption, encouraging energy-saving behaviours. It demonstrates the feasibility of implementing real-time billing and visualization using IoT technology.

The Internet of Things (IoT) is a technology that enables the interconnection and communication of various devices and sensors over the internet. One of the applications of IoT is to monitor and manage the electricity consumption of households and businesses. In this research, we aim to develop an IoT-based system that provides real-time electricity consumption data, calculates costs, and offers visualization tools for users. The system consists of smart meters that measure the power usage of each appliance and send the data to a cloud server. The server processes the data and calculates the electricity bill based on the tariff and time of use. The server also provides a web interface and a mobile app that allow users to access their consumption data, view graphs and charts, set alerts and notifications, and compare their usage with others. The system can help users to reduce their electricity costs, increase their awareness of their energy consumption patterns, and promote energy efficiency and conservation.

2.Title: Machine Learning-Enhanced Energy Billing Analysis for Residential Users

Research Details:

Objective: Apply machine learning techniques to analyse historical energy billing data from residential users and provide personalized recommendations for reducing energy costs.

Methodology: Collect billing data from users and preprocess it. Use machine learning algorithms to identify consumption patterns and correlations with external

factors (weather, occupancy, etc.). Develop a recommendation system that suggests energy-saving actions based on analysis.

Contribution: The research contributes to data-driven energy-saving strategies, leveraging machine learning insights to help users make informed decisions about their energy consumption habits.

Energy consumption is a major concern for residential users, as it affects their budget and environmental impact. However, many users lack the knowledge and tools to optimize their energy usage and reduce their costs. In this research, we propose to apply machine learning techniques to analyse historical energy billing data from residential users and provide personalized recommendations for reducing energy costs. We collect billing data from users and preprocess it to extract relevant features. We use machine learning algorithms to identify consumption patterns and correlations with external factors (weather, occupancy, etc.). We develop a recommendation system that suggests energy-saving actions based on the analysis, such as adjusting the thermostat, switching to LED lights, or using smart appliances. The research contributes to data-driven energy-saving strategies, leveraging machine learning insights to help users make informed decisions about their energy consumption habits.

3.Title: Blockchain-Enabled Peer-to-Peer Energy Billing System

Research Details:

Objective: Create a blockchain-based platform that facilitates peer-to-peer energy transactions and billing among participants in a microgrid.

Methodology: Implement a blockchain network to record energy transactions securely and transparently. Develop smart contracts that automate billing based on energy exchanged. Explore consensus mechanisms suitable for energy trading scenarios.

Contribution: The research contributes to decentralized and efficient energy trading, offering an alternative to traditional centralized billing systems by utilizing blockchain's transparency and automation.

Microgrids are small-scale power systems that can operate independently or in coordination with the main grid. They enable local energy generation and consumption, enhancing reliability and resilience. However, current billing systems for microgrids are centralized and inefficient, relying on intermediaries and manual processes. In this research, we aim to create a blockchain-based platform that facilitates peer-to-peer energy transactions and billing among participants in a microgrid. We implement a blockchain network to record energy transactions securely and transparently, eliminating the need for trusted third parties. We develop smart contracts that automate billing based on energy exchanged, reducing

transaction costs and errors. We explore consensus mechanisms suitable for energy trading scenarios, balancing performance, and security. The research contributes to decentralized and efficient energy trading, offering an alternative to traditional centralized billing systems by utilizing blockchain's transparency and automation.

4.Title: Forecasting Commercial Energy Consumption for Demand Response Billing

Research Details:

Objective: Build a predictive model to forecast energy consumption for commercial buildings, aiding demand response initiatives and accurate billing.

Methodology: Gather historical energy consumption data and relevant external factors (season, day of the week, etc.). Develop time-series forecasting models (e.g., ARIMA or LSTM) to predict energy consumption. Test the accuracy of forecasts and apply them to demand response scenarios.

Contribution: The research aids utilities in managing peak loads efficiently by providing accurate energy consumption forecasts, ultimately leading to optimized billing practices.

Energy consumption forecasting is a crucial task for utilities and grid operators, as it helps them plan and balance supply and demand. This is especially important for commercial buildings, which account for a large share of energy demand and have variable consumption patterns. In this research, we aim to build a predictive model to forecast energy consumption for commercial buildings, aiding demand response initiatives and accurate billing. We gather historical energy consumption data and relevant external factors (season, day of the week, etc.). We develop time-series forecasting models (e.g., ARIMA or LSTM) to predict energy consumption. We test the accuracy of forecasts and apply them to demand response scenarios, where utilities offer incentives or penalties to customers based on their consumption behaviour. The research aids utilities in managing peak loads efficiently by providing accurate energy consumption forecasts, ultimately leading to optimized billing practices.

5. Title: Smart Charging and Billing for Electric Vehicle Charging Stations

Research Details:

Objective: Develop an intelligent charging and billing system for electric vehicle (EV) charging stations that considers user preferences, grid demand, and energy costs.

Methodology: Integrate EV charging stations with IoT devices to collect data on user preferences and grid conditions. Develop algorithms to schedule charging sessions

based on optimal times and calculate costs. Implement user interfaces for real-time monitoring and billing information.

Contribution: The research contributes to efficient EV charging, reducing strain on the grid during peak hours and providing users with cost-effective charging options.

Electric vehicles (EVs) are becoming more popular as a sustainable and eco-friendly mode of transportation. However, charging EVs poses challenges for both users and grid operators, as it requires high power and may cause congestion and instability. In this research, we aim to develop an intelligent charging and billing system for EV charging stations that considers user preferences, grid demand, and energy costs. We integrate EV charging stations with IoT devices to collect data on user preferences and grid conditions, such as time of use, battery level, and grid load. We develop algorithms to schedule charging sessions based on optimal times, considering user convenience and grid stability. We also calculate costs based on dynamic pricing schemes that reflect energy market conditions. We implement user interfaces for real-time monitoring and billing information, allowing users to track their charging status and pay for their service. The research contributes to efficient EV charging, reducing strain on the grid during peak hours and providing users with cost-effective charging options.

[1] “Main page,” Wikipedia, https://en.wikipedia.org/wiki/Main_Page (accessed Sep. 3, 2023).

[2] (PDF) IOT-based electricity bill for domestic applications - researchgate, https://www.researchgate.net/publication/344955771_IoT-Based_Electricity_Bill_for_Domestic_Applications (accessed Sep. 3, 2023).

II. Methodology

Introduction to Methodology:

In this methodology section, we are going to describe how we are going to achieve our objectives of the project step by step briefly. In this section we mainly focus on 8 subtopics.

1. Project Objectives and Approach
2. Project Design and Implementation
3. Techniques and Technologies
4. Resources and Equipment
5. Timeline
6. Budget and Funding Allocation
7. Risk Management
8. Conclusion

1. Project Objectives and Approach

As Project Objectives we have explained the main and the sub objectives in the section before. So, in this section we are not going to explain about the objectives but what we are going to explain about in this section is how we are going to approach those objectives.

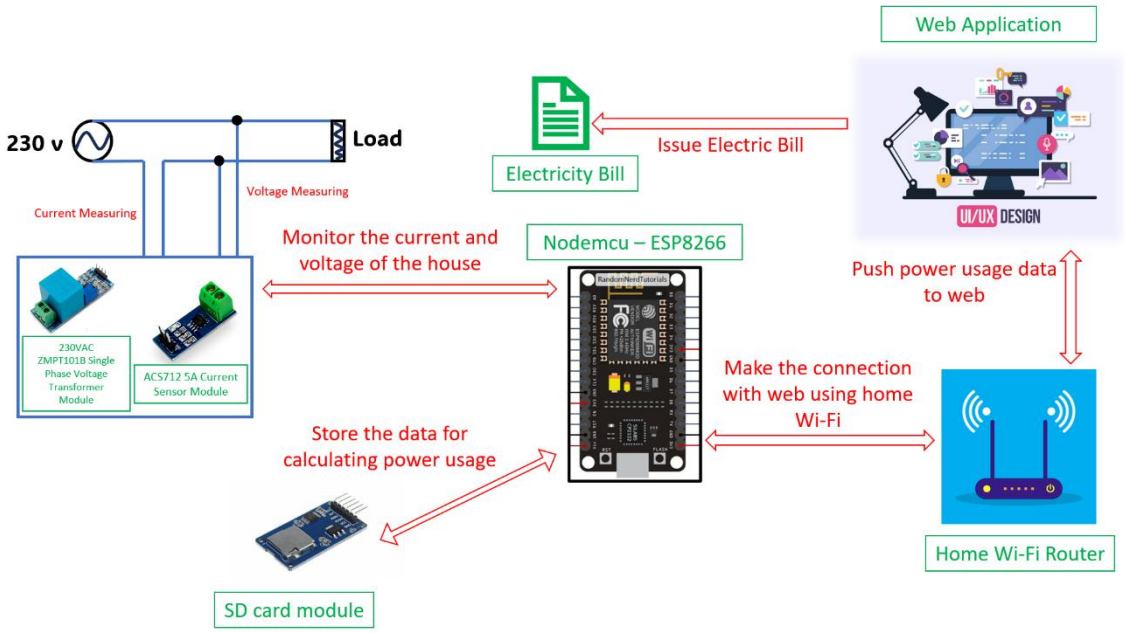
As an approach to our project, we must first know what a problem we got addressed and going to give a solution or solutions. However, we have briefly explained what the problem is we are going to give a solution in the Introduction section.

And, we have explained about our project approach in that section.

2. Project Design and Implementation

In the section project design and implementation, we are going to mainly explain about how our model project is planned and how we are expected it to implement to a testing source.

First, it is better to have a look at model system diagrams:



In the designing of the project, we mainly focused on building or developing a model versioned IoT device and a model web application. So as in the system diagrams we have used several low-end modules, as for measuring voltage and current to calculate power usage, storing data in the SD card and keeping tack on real time like tasks.

However, in this model system project those modules perform well for the purpose. So, it is better to have a brief explanation of every component one by one.

1. ACS712 5A Current Sensor Module

Sensing and controlling current flow is a fundamental requirement in a wide variety of applications including, over-current protection circuits, battery chargers, switching mode power supplies, digital watt meters, programmable current sources, etc. This ACS721 current module is based on ACS712 sensor, which can accurately detect AC or DC current. The maximum AC or DC that can be detected can reach 30A, and the present current signal can be read via analog I/O port of Arduino.

Specifications:

- Supply Voltage: 4.5V~5.5V DC
- Measure Current Range: -30A~ 30A
- Sensitivity: 66mV/A

2. 230VAC ZMPT101B Single Phase Voltage Transformer Module

Specifications:

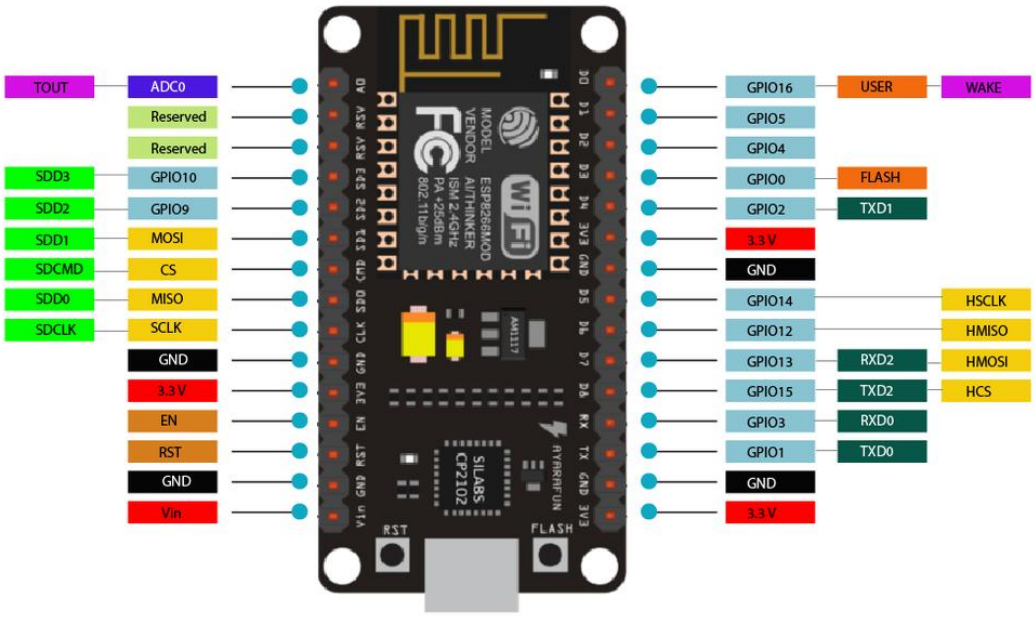
- Single-phase AC active output voltage mutual inductance module equipped with ZMPT101B series of high-precision voltage transformer and high-precision op amp current, easy to 250v within the AC power signal acquisition.
- Voltage Transformer: Onboard Precision Micro Voltage Transformer
- Operational amplifier circuit: high-precision on-board amplifier circuit, the signal to do the exact sampling and appropriate compensation and other functions
- Mode voltage output: the module can measure AC voltage within 250V, the corresponding output mode can be adjusted
- Output signal: the output signal for the sine wave, the waveform of the median (DC component)
- Supply voltage: 5-30V DC
- Adjust the potentiometer can change the amplitude of the output waveform (the adjustment process does not change the middle value)
- The waveform changes in the range of 0-VCC between; in the process of increasing the amplitude if the waveform distortion, can be appropriately increased by working voltage VCC to solve,
- If the median value of the waveform is shifted to 0, a capacitor of about 105 pF can be connected in series at the OUT terminal to filter the DC component in the waveform.

As mentioned above this module also has a little less accuracy and a latency. However, it has flexible connectivity as it can be connected to the Nodemcu micro controller through Rx/Tx pins as serial communication.

Using the connectivity to the Nodemcu module we get a way to get real time current flow and the voltage through the required AC power line and it make the way to

store those data and the calculate the power usage for a period like an hour. So, we can get power usage in kilowatt hours.

3. Nodemcu ESP8266 micro controller



We use Nodemcu micro controller as the controller in our IoT device because it supports Wi-Fi connection and can communicate through web requests. So, we can get the power usage data to the main web server from the IoT device as a HTTP request.

That feature of the Nodemcu module makes us use it as the micro controller. And we execute the code needed to calculate the power usage of the house / the building in the Nodemcu.

So, above mentioned facts are some reasons why we are using the Nodemcu module.

4. SD Card Module

Here we connect an SD card module to the Nodemcu module to save the data received from the PZEM-004T module to calculate the power usage. If send the real time power usage data to web server frequently it will generate a lot of traffic on the web server. So, to solve that problem and to have a temporary backup of the power usage data we use this SD card module to save those data in a SD card.

5. Home Wi-Fi Router

To use our remote electric bill system particular house / the building should have a Wi-Fi connection which gives internet access to the IoT device to connect to the web server.

We can use a GSM module instead of connecting to the internet through home Wi-Fi connection to send data from the IoT device to a main GSM data receiver and collect those data and upload those data to the web server from that GSM receiver through another Nodemcu module connected to that main GSM receiver.

However, in the model version of our project we have planned to use the Wi-Fi connection of the Nodemcu module to push data to the web server as it makes our model version project lighter.

6. Web Application

After the IoT device the main component of our project is the web application. That is where we generate the electric bills and issue to the users through an authenticated and validated user login with the help of power usage data sent from IoT devices.

So, it is very important to have a properly developed web application which can handle the data sent from IoT devices and generate electric bills accurately.

When developing the web application, we mainly focus on creating a user-friendly UI for the users and developing the API which manages data of power usages and generates the electric bills. So, we will explain about the technology use for web applications in the Techniques and Technologies section.

So, the above explained facts are about the planning methodology of our project and about the implementation that will be explained in the Testing and Evaluation section.

3. Techniques and Technologies

In this section we are going to explain about the technologies and techniques used in the key processes of our project.

Below are the key processes which will be explained in this section:

1. Process of measuring current and voltage
2. Process of storing data records of power usage
3. Process of sending data to web server from the IoT device
4. Process of generating electric bills through the web application

1. Process of measuring current and voltage

In this process we use the PZEM-004T Single Phase Power Energy Meter as the measuring device of current flow and voltage. This module has a CT sensor which we can measure the current flow through a wire without connecting to the wire or connecting to the circuit.

So, that is one of the main advantages of using this module. In this module we will be able to measure the AC current voltage up to 260V by directly connecting to the main AC power circuit. And this module can identify a high voltage and is able to give an alert. So, it is another one of the main advantages of using this module.

This PZEM-004T module can also be connected directly to the micro controllers through Rx/Tx pins. So, this feature is also very useful in our project.

Above mentioned are the techniques we used in the process of measuring current and voltage.

2. Process of storing data records of power usage

In this process we use Nodemcu micro controller as the component. This controller can run general Arduino Scripts and compatible with most Arduino libraries. This feature of the controller makes it easy for us to connect all the 3 modules we need in our project to this micro controller and use their libraries in our code.

To measure we connect PZEM-004T Single Phase Power Energy Meter directly to the Nodemcu and to store those data read through the PZEM-004T module with the real time we use SD card module and DS3231 clock module directly connected to Nodemcu. So, using this Nodemcu micro controller has made it easy for us to perform this process in our project.

3. Process of sending data to web server from the IoT device

In this process it is same as the process mentioned before, we use Nodemcu to perform this process also.

Through the Wi-Fi connection available in Nodemcu module it is able connect to home Wi-Fi and send HTTP requests to the web server. So, it can send GET and POST HTTP requests to a given URL and is able to receive requests sent from that server.

Through this feature of the Nodemcu micro controller we can perform several processes like sending data to web server, receiving commands from the web server, get the real time updates from the server etc.

So, altogether using Nodemcu module's connectivity has become a main technique in our project.

4. Process of generating electric bills through the web application

In the development of the web application, we mainly use PHP for the backend coding and for the development of the API for calculating the electric bill.

For the frontend of the application, we are going to use the CSS framework Bootstraps along with custom CSS codes to make a user-friendly and responsive UI.

In the user logins section of the application, we use password hashing like several security features and some validations to make the application more secure.

However, for the model version of our project we are not going to use Java, C# like more reliable languages, for the backend. To make it simple we use PHP.

7. Risk Management

As a risk we have some unsure conditions like:

- How can we configure the free hosting service URL with the Nodemcu controller?
- How can we make an accurate API for the calculation of the Electric bills?
- How can we reboot and connect the IoT device with Wi-Fi router after a power cutoff?
- How can we use a power backup for the IoT device?

As we have some problems with the development of our project, we are planning several modifications along with the progress of the development and looking forward to solving those problems in an accurate way.

8. Conclusion

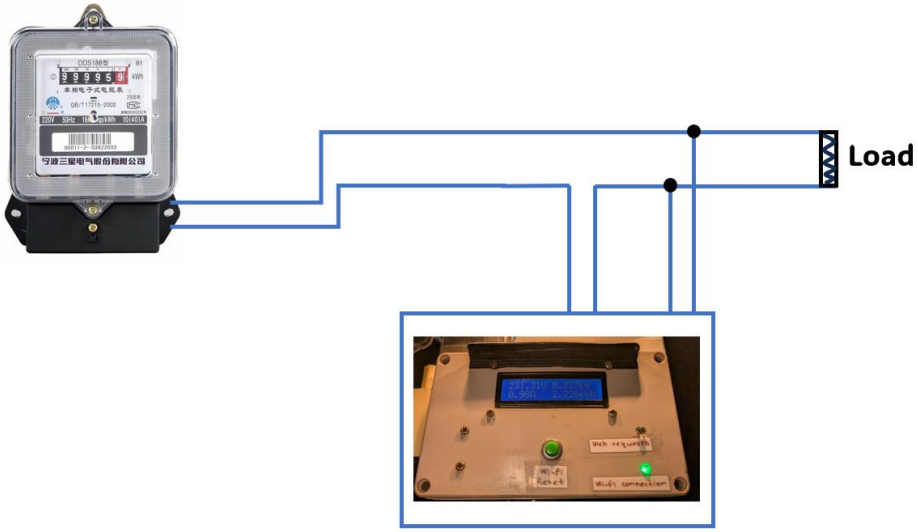
As the conclusion of our project, we are going to show that it is possible to fully automate the electric bills issuing process of Sri Lanka and save 80% of cost which requires in existing manual process.

4. TESTING AND EVALUATION

For the testing of our system, we will use one IoT device connected to the web server and with the data sent from the IoT device we will generate the electric bill.

However, we should keep track on the power usage of a house or building for 30days to generate a full electric bill. So, we will test the device for couple of days and we will generate the cost for those days using the backend API of the web application.

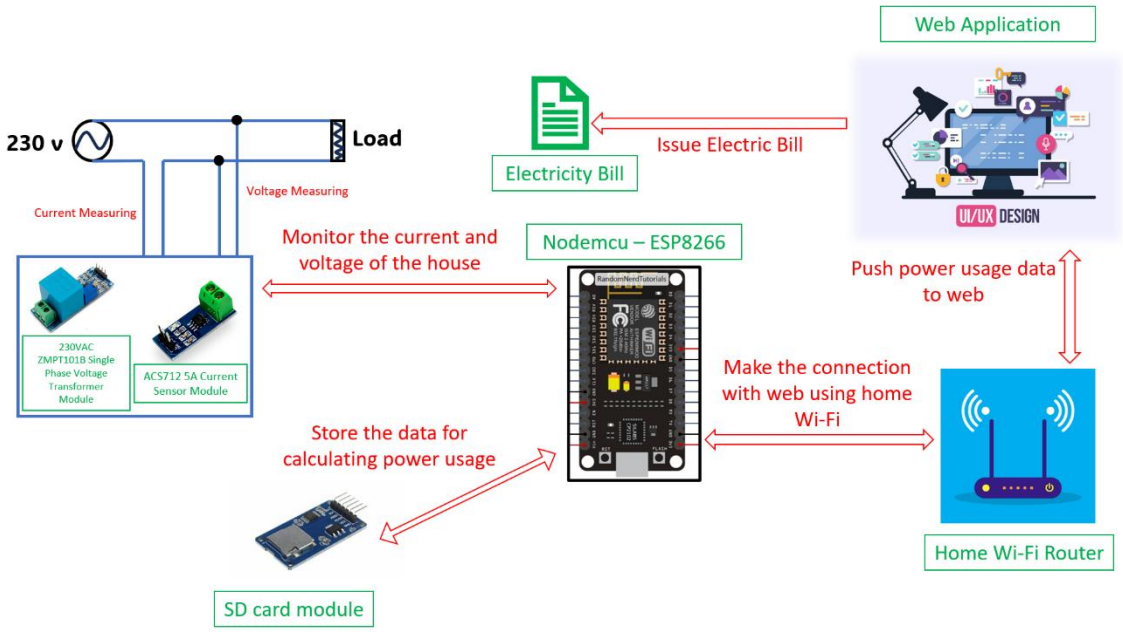
So, it is better to have a look at the testing system diagram:



Above we have the diagram for the connection of power meter module to the main AC current grid of a house or a building.

There we use the power line which comes out of the analog electric meter, and we use series connection to measure current flow with current sensor and get a L and N power line out parallel to connect to the voltage sensor module.

So, in that way we mount our IoT device near the power meter of the house or the building and we use Wi-Fi credentials of the home Wi-Fi in the Nodemcu Wi-Fi connection. If need to update the credentials it can be done using the web application.



So, it is the same system diagram which we explained in the methodology section with a more explanation to the connection of IoT device to the main grid.

After the configuring the connection of the IoT device we will test the process of sending web requests from the IoT device to the web server.

To do that we will monitor the web application UI and the database of the application to see the updates of data sent from the IoT device.

There after configuring the IoT device with the web we will keep the IoT device connected to the main grid of the house for about 5-7 days with frequent monitoring of web UI and the database in case of troubleshooting.

In the end of 5/7 days, we will get the cost of power used by the house or the building from the web UI and we will check the Analog meter of the house / building to verify the actual power usage with a comparison to our IoT device data.

After configuring that data, we will use the web of the CEB (https://cebcare.ceb.lk/Incognito/BillCalculator) of Sri Lanka to calculate the cost for the power usage and check whether there is a difference with the calculation of our web API.

At the end will troubleshoot our system in the above-mentioned scenarios and try the testing process for couple of times with a limited duration of days / time till we

get an accurate calculation compared to analog electric meter and the web of the CEB.

After the troubleshooting process, we will evaluate the progress, the accuracy of our system and the amount of roughly calculated cost saving with the use of our system instead of the existing manual electric bills issuing system in Sri Lanaka.

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Main Resources

1. Nodemcu Module (ESP8266):
   For controlling the process of recording power usage and pushing it to web server

2. ACS712 5A Current Sensor Module:
   For measuring the current flowing through the house

3. 230VAC ZMPT101B Single Phase Voltage Transformer Module:
   For measuring the voltage operating in the house

4. SD Card Module:
   To keep a backup of the power usage records.

5. Wi-Fi Router:
   To get internet connection to Nodemcu module to connect to the web server.

6. Web Server and Data Base Server:
   For hosting the web application

5. REFERENCES

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