Project Report

Digitalization of Energy Meter Services

SUBMITTED BY

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DECLARATION

This project report is submitted to the Department of Information and Communication Engineering (ICE), Noakhali Science and Technology University, Noakhali-3814, in fulfillment of the requirements for a B.Sc. in information and communication engineering (ICE) under the course "ICE-4218." I guarantee that this project report has not been submitted elsewhere for consideration of any degree, diploma, or publication.

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ACCEPTANCE

With reference to the course "ICE-4218," this project proposal is submitted to the Department of Information and Communication Engineering (ICE), Noakhali Science and Technology University, Noakhali-3814, in order to complete the prerequisites for a B.Sc. degree in ICE.

Dr. Md. Ashikur Rahman Khan

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DEDICTAION

This work is dedicated to

the martyrs, the fighters, and every brave soul

of the **July Revolution 2024** in Bangladesh.

ABSTRACT

A digital meter is a polished metric device which shows greatly exact decimal values based on their entrant [1]. In Bangladesh, digital energy meters have become more common over the recent past, especially in the urban and the industrial areas. But its service system has hardly transformed to a modern one with facilities like remotely balance check, balance transfer, remote recharge etc. Therefore, Digitalization of Energy Meter Service proposes an all-inclusive and web application that will digitalize the digital meter services in a move to resolve this problem. The entire program is developed using separate dashboards of users and administrators to ease the communication of all the involved parties. Internet services are available like enquiry and recharge of services and will also have less time consumption. In this case, we shall use HTTP (Hypertext Markup Language), CSS (Cascading Style Sheet), Python, Flask and SQLAlchemy to come up with a user friendly and slick web application.

Keywords: Digital Meter Digitalization, Web-Based Application, User Dashboard, Admin Dashboard, Remote Services, Automation, Time Efficiency, Bangladesh, Utility Management.

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Chapter 1

INTRODUCTION

1.1 Introduction

In the modern era, careful monitoring and proper management of utilities are necessary to ensure that the product is sustainable and users are also enjoying using it. Being the advanced measuring instruments, digital meters play this role particularly because the instrument provides accurate decimal values of gas consumption, water consumption and electricity assault. Their use in Bangladesh has risen tremendously over the past years particularly in the cities and in industry. This trend indicates the rising demand on the precise and reliable technology solutions. The emergence of digital meters is increasing exponentially, however, the servicing systems which accompany them remain outdated and useless. Customers and those providing services are greatly challenged with the traditional methods of managing the services of digital meters like manual recharge, physical inquiry on the balance of meter and a failure to automate the service tracking process. These methods are labor intensive and time demanding and this often ends up in unsatisfied users and unproductive processes. The digital transformation in this sphere is required urgently as the difference between the advanced features of the digital meters and the pre-historic service infrastructure they rely on was sharp. The proposed research recognizes this gap of digitalization of energy meter services in Bangladesh and proposes a web-based tool that will change digital meter services in Bangladesh. The provision of dashboard implies that this program will lead to modern delivery of a service and allow efficient intercourse among all the participants. Online recharges, balance inquiry over the phone, and service usage tracking are some of the features that will enable users to save much of their time and efforts on such tasks. Service providers will have the opportunity to view transactions, maintain user accounts, and ensure system security, all of which will add efficiency in the running of operations through the administrator dashboard.

The application is expected to significantly transform the user experience with its automation and remote access functionality, provides better accessibility and convenience alongside an easier approach to the administration of digital meter services. The current report also views this as a step to an even bigger digital revolution in the management of utility in Bangladesh. This program provides progressive approach to utility management in the context of the world that is rapidly

becoming digitalized and can become more efficient, reduce or eliminate the amount of manpower engaged and can meet the expectations of evolving consumer needs. This research aims at correcting the weaknesses of the existing system and help provide a solid basis of digital meter services modernization. It will assist the ongoing process of digitalizing Bangladesh, as it comes up with a scalable and substantial solution that best suits the steep metamorphosis of technical changes.

1.2 Problem Statement

Digital meters are advanced instruments designed to provide precise and reliable meters on varieties of different utility services, such as gas, water, and electricity. These devices play the important role in the modern utility administration because of their decimal precision level ensuring fair billing and resource efficiency. Due to high population growth and infrastructure expansion, the need to adopt digital meters has grown notably in Bangladesh, particularly in the urban and industrial area. Although the fact that this type of the most high-tech technologies is exploited itself can be regarded as the sign of progress, the corresponding service systems remain rather ancient. Further, the key issues of the conventional energy meters are:

Balance Check by Manual Process

Users must manually check their balance using the system, which results in inefficiencies and possible delays while dealing with low-balance situations.

No Notice Prior to Power Outage

Power outages brought on the balance depletion are not announced to users beforehand, which results in unexpected interruptions and annoyance.

Not Balance Transfer Facility

Flexibility in emergency situations is limited by the system's inability to request or transfer balance from other users.

Load And Cost Calculation

Because the system's processes are not automated, there is a no system to real-time appliance wise load and cost of the user.

Before Balance Completes, No Reminder

Because they are not proactively notified when their balance is low, users find it challenging to plan ahead for recharges.

Utility Services in Physical Form

Compared to digital alternatives, relying on physical means to obtain services reduces system efficiency and increases the likelihood of delays.

On the execution of a workload such as monitoring service usage, reloading utilities and checking balances, the common practice of management of digital meter services involves manual processes. These archaic methods have been found to be so cumbersome, time consuming and erroneous in areas with high population densities and service requests. Moreover, the inefficiency in operations caused due to impaired absences of unified digital solutions often puts the users and the service providers at a disadvantage. The disparity between newly advanced features of digital meters and the service infrastructure associated with these devices is prompting the need of an immediate innovation.

An effective, automated, powerful solution is required in order to eliminate these gaps and fully realize the capacity of digital meter systems. Besides enhancing consumer convenience and satisfaction, this kind of solution would help achieve the greater goals of digitalization and efficiency in resource management within utility management. There is need to focus on this area of concern so that infrastructure may be made modernized, the service delivery may become better and innovation within the utilities sector of Bangladesh may be encouraged.

1.3 Motivation

The need to have a reliable and successful system in utility management can be evidenced in the rapid digital meter implementation in Bangladesh in the urban and industrial sectors [2]. The already established structure of the digital meter service does not meet the needs of modern users. As an example, consumers often experience significant problems when trying to perform such simple actions as checking their balance, accessing the use history, or recharging the account. These are

besides being inconvenient, what is usually involved involves manual interventions, long waiting times, and in-person visits to service facilities.
In the era of convenience and machine automation, the lack of digital services which digitally managed meters can avail is very surprising compared to the technological solutions embraced in other sectors. The potential of such a simplified but web-based solution which allows the consumer to recharge his account online, access services remotely and monitor consumption instantly, is enormous. Besides volition, this digital transformation must take place in order to accommodate the increasing needs of a multi technological society.

Also, service providers are limited on the existing system. Security of the system, monitoring of transactions, and management of accounts of the users are complicated processes, which in large part relies on human participation. This is followed by inefficiencies, increase in operating costs, and increased likelihood of errors or fraud. With a properly thought-out automation, providers would have the chance to manage said issues effectively to the point that their operations efficiency and customer satisfaction, overall, improve.

What motivated this inquiry was the need to bridge the gap between the current technologies of measurement and the ancient-service platforms. This study aims to develop the digital counterpart to address the problems with the existing model and ensure the smoothing of the process of all participants instead of through the application of automation and modern web technologies.

1.4 Objectives

The primary aims of the project are to design and implement a web application that reconnects the way the digital meter services are handled and offered. This comprehensive application will satisfy the needs of the user and ensure that the system will be working without any glitches. Specific objectives of the study are the following:

i. To enhance user experience by developing an intuitive and user-friendly dashboard for tasks like balance inquiries, online recharges, load and cost calculation, low balance alert, average and monthly billing.
ii. To optimize service provider operations through a dashboard with tools for user account management, transaction monitoring, report generation, and system maintenance.
iii. To promote time and resource efficiency by introducing automation in routine processes such as balance checking and recharging, reducing effort.
iv. To facilitate digital transformation in Bangladesh by demonstrating the potential of web-based solutions in modernizing utility management infrastructure.
v. To ensure scalability and adaptability by designing a system that can be extended to other regions and utility services, maximizing long-term impact.

1.5 Scope of the Study

This project seeks to reduce its operations to a modern style and enhance the experience of the users through the use of digital technology over the challenges with the traditional power management systems. This project will transform the management of the power meters in a digital format by designing a web-based application that will be comprehensive in terms of the efficiency, transparency, and sustainability. The research will bridge the lines between the barbarous service infrastructure and advanced meter attributes, and users as well as service providers are the target. The specific subjects which are to be registered within the frame of the research are as follows:

I. Digitalization of utility service systems for electricity management.
II. Development of user-friendly dashboards for consumers.
III. Automation of tasks like meter reading, billing, and service tracking.
IV. Bridging gaps in traditional systems with tailored digital solutions.
V. Enhancing customer satisfaction and operational efficiency.
VI. Establishing a foundation for advanced research in utility management systems.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

Digitalization of utility administration has, especially the use of digital power meters, become an increasingly popular topic in the academic and industrial field. Energy meters have changed to be digital instead of analog meters and the digital meters are of the forms of prepaid and postpaid meters. Being advanced measuring tools, digital meters contribute to the efficient usage of resources as they provide realistic charging and tracking. Nevertheless, the current research discovered that a full-scale digitalization of the service architecture is still a complex task when it comes to the integration of such meters. In order to prepare the foundation of proposed project, this literature review discusses the past researches, technical advancements and case studies, which are concerned with the digitalizing the digital power meters.

2.2 Related Works

Digitalization of the utility management, especially the introduction of digital power meters, attracted a lot of attention both in academic and industrial circles. As smart meters, digital meters offer high precision of monitoring and billing, thus, contributing to effective resource use. Nonetheless, the introduction of these meters into fully digitalized service infrastructure is a problematic issue as recognized in the present study. This literature review seeks to review available literature, technological innovations, and case studies with regard to the digitalization of digital power meters to offer some background to the proposed project.

Digital meter has developed in stages to become a very crucial part of the utility management systems which have these advantages including accurate readings, low operational costs and the ability to monitor in real time. Tushar et al. (2022) believe that smart meters installation in utility services improve resource management through giving detailed information of usage and predictive analysis [2] . Likewise, Zhang et al. (2020) point out that the digital meters play a meaningful role in energy

saving because they allow dynamic pricing and consumption patterns analysis, thereby facilitating sustainable practices [3].

In as much as these benefits abound, shortcomings like inefficient service systems and manual operational systems still exist. According to Rahman and Chowdhury (2021), the inability to offer automated solutions that would complement the functions of digital meters devalues their potential, creating inefficiencies in user satisfaction and the provision of services offered by various service providers. This brings to the fore the view of the urgency of implementing comprehensive tactics towards digital change of utility services [4].

Use of manual procedures to execute activities such as checking balance, recharging utility and monitoring consumption has been a major problem in most developing countries. Ahmed et al. (2021) monitored in Bangladesh that digital meters seem to be more common in the urban environment, but the service systems related to them are not so advanced in automation and effectiveness. Such shortcomings leave a distance between the newly gained technological capabilities and the sensible utilitarian management whereby creative solutions are required to fill in such a gap [5].

The case of Bangladesh is no different as projects such as the Smart Utility Management Project have shown exactly what a digital platform can do with respect to transforming utility services. Nevertheless, such projects tend to be narrow, and they overlook these aspects of scalability and user-friendliness.

The usability and design of aiding the user should be regarded as a key success factor of digital solutions to utility management. Taylor and Wilson (2021) emphasize that by integrating such elements as customized dashboards, real-time alerts, and fluid communication channels, it is possible to increase the user responsiveness and satisfaction to a high degree. This approach is reflected in the proposed system because it is designed to separate administrator and user dashboards, which is why a specified experience can be achieved to address various requirements [6].

Automation also is crucial in improving the efficiency in terms of operations. Automatic activities including meter reading, billing, service tracking etc. as mentioned by Sinha and Roy (2022) reduce the chances of errors made by human aspect and speed up the services. By incorporating these features

in the suggested system, they will transform the scene of digital meter services in Bangladesh by curbing the existing inefficiencies [7].

Although the estimated results of implementing digitalization in digital meter services are clear, there are problems that need to be handled, which include security of data, costs involving infrastructure, and adoption by the users. An article by Chen et al. (2021) highlights the need to have powerful cybersecurity systems when it comes to deterring unauthorized access to sensitive user information. Furthermore, Ali and Hasan (2020) point at the direction toward cost-efficient solutions that would be affordable to users in developing world so that their efforts would obtain equal returns in terms of digital transformation [8].

The scalability of digital meter management systems and their compatibility with the emerging technologies, e.g., artificial intelligence (AI) and machine learning (ML) is an avenue of future research. The advanced technologies can support such features as advanced analytics and predictive capabilities that can additionally increase the efficiency and sustainability of utility services.

Digitalization of the digital power meter services is an important milestone in the way of modernization of utility management and the target of sustainability. The read literature also highlights the need to incorporate the automated user driven solutions to overcome the shortcomings of existing systems. The proposed study would aim at fixing the gap between digital meter capabilities and service delivery platform infrastructures by exploiting the latest web-based application developments and the use of the Internet of Things. The project is on the trend with the worldwide utility management initiatives and also has much potential in redefining the utilities industry in Bangladesh.

2.3 Summary

The topics of research into the future should be the scalability of digital meter management systems and their combination with the new developments, such as machine learning (ML) and artificial intelligence (AI). These technologies have the ability to also facilitate more utilitarian and efficient

utility services by bringing to play the power of sophisticated analytics and predictive capabilities. To sum up, digital power meter services are an important milestone to transform the utility management to a modern one and reach the goal of sustainability. The suggested research will provide access to the bridge between infrastructures of service delivery and digital meter operation based on the latest tendencies of complementing web-based platforms and IoT technologies. In line with the trends in the global utility management business this project has a huge prospect of transforming the utilities industry in Bangladesh.

Table 2.3: Summary of Key Literature on Digitalization of Utility and Power Meter Services

Author(s) & Year	Focus Area	Key Findings	Limitations
Tushar et al. (2022)	Smart Meter Integration	Smart meters provide detailed usage data and predictive analytics.	Limited discussion on integration.
Zhang et al. (2020)	Energy Conservation	Enables dynamic pricing and consumption pattern analysis.	Effectiveness depends on user awareness.
Rahman & Chowdhury (2021)	Service System Limitations	Lack of automation leads to inefficiencies.	Focuses more on identifying issues.
Ahmed et al. (2021)	Implementation in Bangladesh	Urban areas have digital meters, but service systems lag behind.	Rural implementation and equitable access not addressed.
Taylor & Wilson (2021)	User-Centric Design	Dashboards and real-time notifications improve user satisfaction.	High development and maintenance cost.
Sinha & Roy (2022)	Operational Automation	Automating routine tasks improves efficiency and reduces errors.	Requires reliable infrastructure.
Chen et al. (2021)	Cybersecurity	Strong data protection needed for digital platforms.	Did not explore specific frameworks.

Chapter 3

METHODOLOGY

3.1 Introduction

Digital meters have the big decimal accuracy and precise readings and this is a significant technological advancement. The application of the digital meter has risen enormously in the last many years in Bangladesh, mainly in industrial areas along with the urban area. Nevertheless, the affiliated digital meter service platforms remain obsolete and lack such modern functions as balance verification, remote charging, balance transfer, and auto-recharge functions.

To combat these, the Digitalization project proposes the use of a web-based application that would digitize the entire service ecosystem to make it more efficient and one that could be a game changer. Combining different user and administrator dashboards, the given solution is aimed at optimization of user experience and ensuring effective and convenient interaction of all participants. The user dashboard saves time by allowing online recharges, distant balance inquiries as well as monitoring of service uses.

This program is estimated to reduce considerably customer unhappiness, accessibility and efficiency in management of digital meter services. It is expected that the proposed system will impose a new quality standard on management of utilities in Bangladesh as it will merge digital technologies with automation of key processes. It may transform the provision of the digital meter services entirely, which would be a part of the objective of the technological development of the utility industry on the whole.

3.2 Project Development Process

The development of the digital meter service system is systematically organized into the following modules to ensure comprehensive functionality and efficiency:

I. User Module

II. Recharge Module
III. Balance Check Module
IV. Payment and Transaction Module
V. Fund Transfer Module
VI. Load and Cost Calculation Module
VII. Energy Uses and Monthly Billing Module
VIII. Statement Generation Module

Module for Users: By offering simple functionality for account administration and service engagement, the User Module aims to improve the user experience. Users may utilize a safe and intuitive interface to accomplish a wide range of activities.

I. Verification and login using a password and safe email address.
II. Availability of tools to view extensive usage logs, recharge history, and current balance.
III. Recharge start, automated payment management, and issue report submission options.

Module for Payment and Recharge: This module guarantees smooth financial transactions, making it simple for consumers to handle payments and recharge their accounts. It incorporates cutting-edge capabilities for real-time and automated transactions.

I. Integration for safe and dependable transactions with well-known payment gateways.
II. Processing recharge requests in real time to ensure service continuity.
III. Convenient auto-recharge capabilities based on user-specified thresholds.

Module for Notification and Communication: This module manages all alerts and notifications, guaranteeing prompt communication regarding account activity and service upgrades to keep users informed and involved.

I. Recharge confirmations, low balance alerts, and account status updates.
II. Alerts regarding planned maintenance and interruptions in service.
III. Using email and SMS platforms to improve the effectiveness of communication.

Module to Send Money: By allowing users to move money inside the system, the Send Money Module improves user ease and flexibility. It has strong security features to guarantee secure transactions.

I. The ability to transfer funds to other system users.
II. Verification of recipient information prior to transfer processing.
III. To monitor money transfers and stop abuse, secure transaction records.

Module for the Balance Request: This module streamlines communication between users and administrators by facilitating user requests for refunds or balance changes.

I. Submit a request for the addition of balances or for repairs resulting from system mistakes.
II. The administrative review and approval procedure to guarantee precision.
III. Informing users of the progress of their requests.

Module for Statement Generation: By giving administrators and users access to comprehensive financial information, the Statement Generation Module encourages openness and documentation.

I. Monthly reports that provide an overview of consumption trends and transactions.
II. A customizable time frame for producing thorough assertions.
III. For user convenience, export options are available in a variety of formats, including Excel and PDF.

3.3 Requirement Specification

Functional Requirements

User registration: Information about the users such as name, email address and phone number are to be collected.
Login and Authentication: Create credentials that were verified by the database to have secure user access.

Balance Inquiry: Read and display the current balance information in the digital meter.

Processing Recharges: Enable recharges both by automated and manual process by using connected payments.

Load and Cost Calculation: A real time charge and cost estimation of the electric appliances at the household.

Energy Uses and Monthly Billing: Using the load calculation, the system is able to store the daily uses and produce a monthly billing on the basis of the uses.

Service Notifications: Notify the customer of scheduled maintenance, and low balances.

Transaction History: Provide detailed description of all payments and utilization of data.

Non-Functional Requirements

Usability: Present an user-friendly interface applicable to both desktop and mobile.

Reliability: Ensure that there is always availability of the system with minimal downtimes.

Performance: Complete important duties, such as responding to recharge requests, and balance requests, within three to five seconds.

Security: The data of users should be encrypted and can be accessed only by authorized users.

3.4 Process Model

A process model is a framework that provides a more abstract look at the stages required in software creation. Several models can be used to direct the development process some of them include the incremental model, the spiral model, the iterative model and the waterfall model. Automation of class routines takes into consideration the following models:

The Waterfall Model

One of the methods to development is the Waterfall model which is a systematic linear method. It is suitable to the projects whose requirements are well outlined as every stage must be complete before commencing another [9]. Nevertheless, owing to the fact that instances of change are hard to undertake once the process has started, this paradigm is not flexible and it assumes a high risk.

Iterative Model

The iterative paradigm is based on creating a simple version of the system, then refining it with several iterations. The program gets more useful and improves with repetition. It is an effective strategy in case of the needs alteration or the necessity to be improved manageably [10].

The Spiral Model

Spiral approach puts focus on risk analysis, and this methodology integrates waterfall paradigm and iterating. Some of the phases of a development process, which are summarized by each cycle (or loop) of the spiral, include planning, risk assessment, and prototyping. The idea is ideal in the case of projects that have a considerable level of uncertainty since it repeatedly measures the risk and then aids avoidance [11].

Incremental Process Model

The project is divided into smaller, more manageable parts using the incremental technique. Planning, development, and testing are carried out for each increment as each component is created in a sequence of cycles. This guarantees that early in the development phase, a working system is produced, and later cycles add more functionality [12].

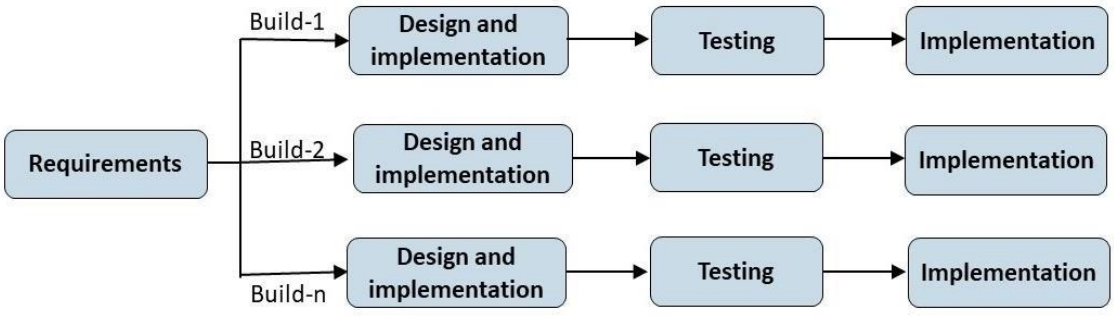

Figure 3.1: Process model of the project

Reason for Choosing the Incremental Process Model:

1. Phased implementation is made possible by modular development.
2. It is possible to give priority to essential functionality like user authentication and balance queries early on.
3. Improvements are made incrementally, such as reports and automatic recharges.
4. To ensure high-quality results, testing and feedback are included into every stage.

3.5 System Design

The system design consists of the following components:

1. **Use-Case Diagram:** Illustrates interactions between users (admins and customers) and the system

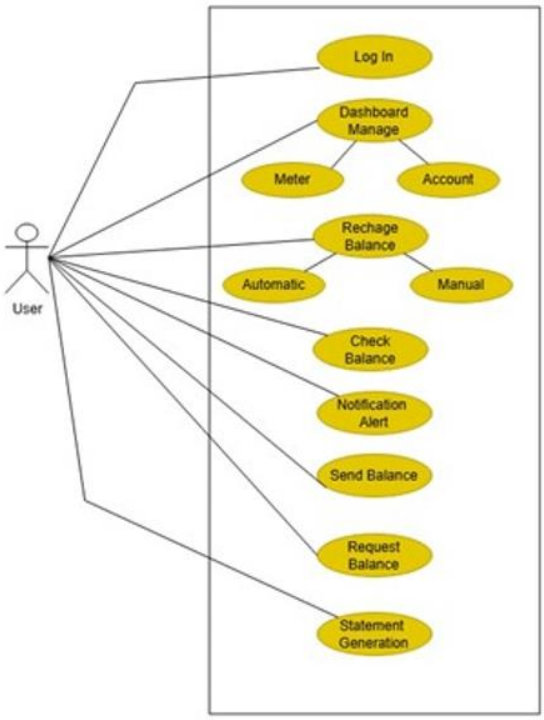

Figure 3.2: Use case diagram

2. **Entity-Relationship Diagram:** Maps relationships between key entities, such as users, meters, transactions, and notifications.

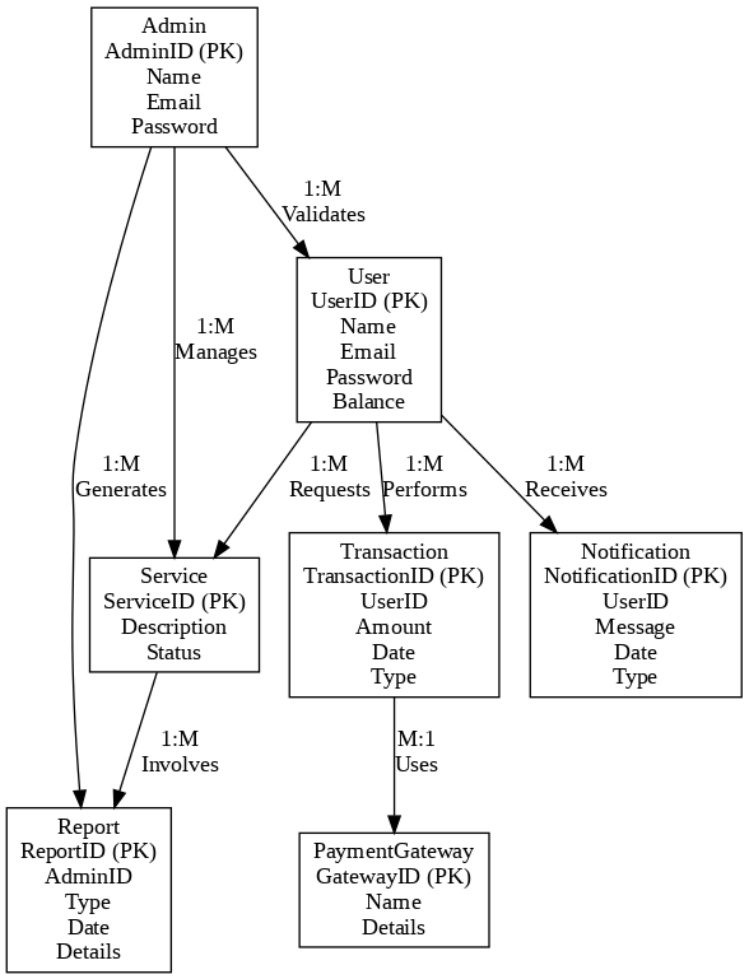

Figure 3.3: Entity relationship diagram

3. **Activity Flow Diagram:** Describes workflows for processes like login, balance checks, and recharges.

1. User Module:

I. **Activity 1**: Authentication and Login
   a. Input email and password credentials
   b. Validate credentials

II. **Activity 2**: Access Account Features
   a. View current balance, recharge history, and usage records

III. **Activity 3**: Recharge Management

a. Initiate recharge requests

b. Manage automated payments

IV. **Activity 4**: Issue Reporting

a. Submit a report for any issues or problems

b. Track report status

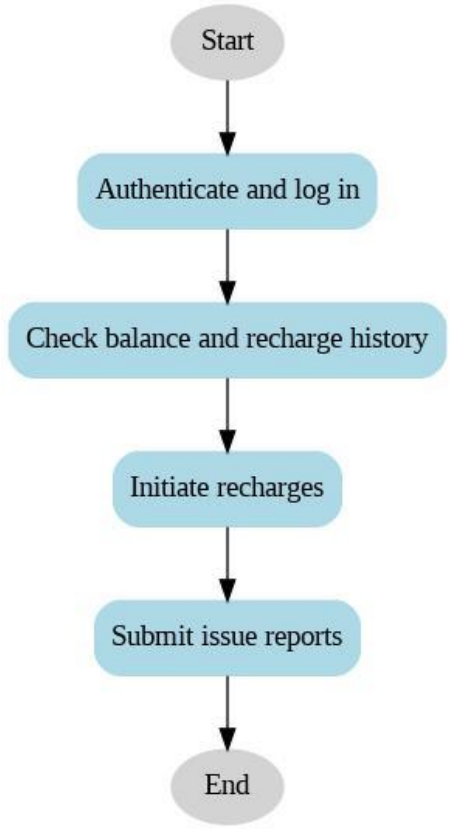

Figure 3.4: Activity of user module

2. Payment and Recharge Module:

I. **Activity 1**: Transaction Integration

a. Integrate with payment gateways for secure payments

II. **Activity 2**: Real-Time Recharge Processing

a. Process recharge requests in real time

III. **Activity 3**: Auto-Recharge

a. Enable auto-recharge based on user-defined limits

b. Trigger recharge when balance is below threshold

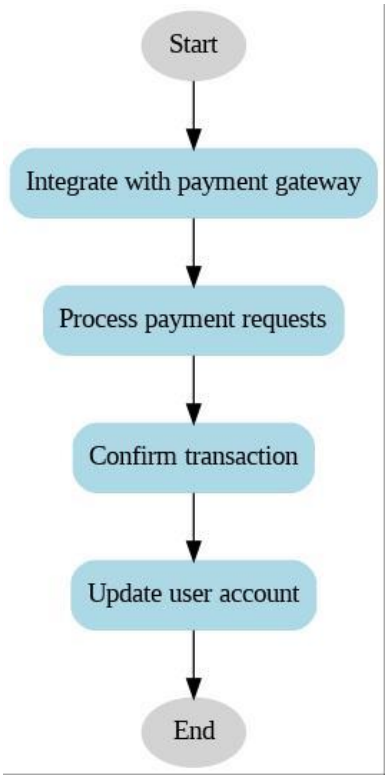

Figure 3.5: Activity of payment module

3. Notification and Communication Module:

I. **Activity 1**: Low Balance Alerts
   a. Send notifications for low balance

II. **Activity 2**: Service Update Alerts
   a. Notify users about scheduled maintenance and outages

III. **Activity 3**: Communication via Email/SMS
   a. Send alerts via email or SMS for various account updates

4. Send Money Module:

I. **Activity 1**: Transfer Funds
   a. Select recipient and transfer funds

II. **Activity 2**: Validate Recipient Details
   a. Check recipient information before processing the transfer

III. **Activity 3**: Secure Transaction Logs
   a. Maintain logs of all transactions for security and accountability

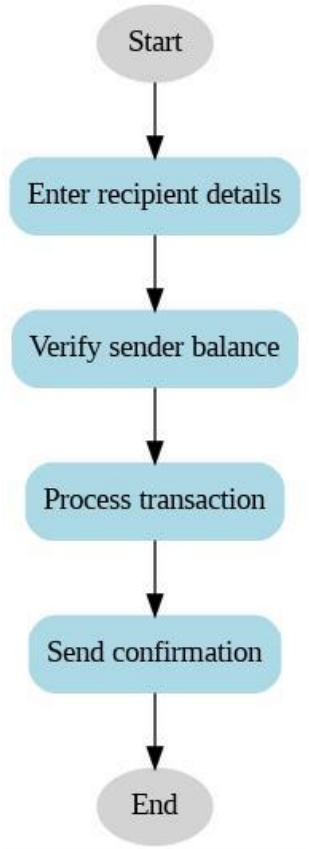

Figure 3.6: Activity of send money module

5. Balance Request Module:

I. **Activity 1**: Request Submission
   a. Submit request for balance correction or addition

II. **Activity 2**: Admin Review and Approval
   a. Admin reviews balance request and approves/rejects

III. **Activity 3**: Status Notification
   a. Notify the user about the request status

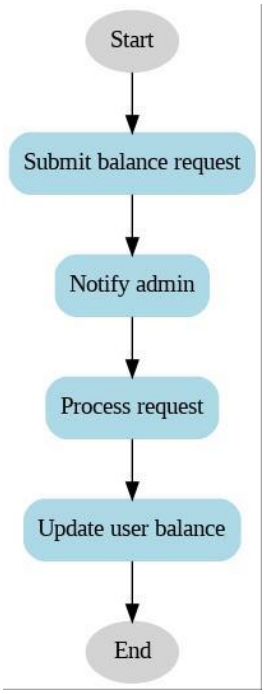

Figure 3.7: Activity of balance request module

6. Statement Generation Module:

I. **Activity 1**: Monthly Statement Generation
   a. Generate monthly transaction summaries

II. **Activity 2**: Customizable Date Range for Statements
   a. Allow users to generate statements for specific periods

III. **Activity 3**: Export Options
   a. Provide options to export statements in formats like PDF and Excel

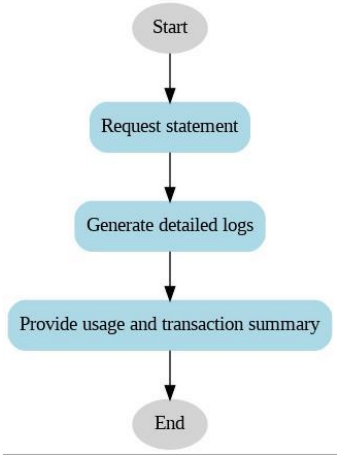

Figure 3.8: Activity of statement generation module

Chapter 4

SYSTEM IMPLEMENTAION

4.1 System Implementation

During this procedure, the information system's appearance, functionality, and compliance with quality requirements are all determined. It encompasses the system's construction, functionality, and quality assurance.

4.1.1 Software Requirements: The following software will be used to complete the project:

Table 3.1: Software Requirement of the system

Operating system	Windows XP or later
Browser	Google Chrome, Firefox
Editor	Notepad++, Visual Studio Code, Subline Text or any text editor.

4.1.2 Hardware Requirements: The following hardware will be used to complete the project:

Table 3.2: Hardware Requirements of the System

Processor	Standard Processor
RAM	2GB RAM or more
Hard Disk	50 GB or more
Monitor	Standard monitor
Keyboard	Standard keyboard
Mouse	Standard mouse

4.2 Technologies and Tools

This project will essentially use the MERN stack. Two types of tools are available for this project's creation in this client-server architecture. I will utilize the following technologies to construct my software project.

Technologies for Client-Side Scripting:

- HTML (Hypertext Markup Language)
- CSS (Cascading Style Sheets)
- Bootstrap (CSS Framework)
- Python
- Flask (Framework Library)

Technologies Server-Side Scripting:

- Python
- Flask (Framework Library)

Hosting and version control system:

- Heroku (for free hosting)
- GIT (for version control system)

Database Related Tools:

- MySQL (SQL Database)

(i) HTML: Hypertext Markup Language, or HTML, is the foundational element of the World Wide Web. Determining the significance and organization of internet material is its main duty. On the other hand, JavaScript improves the operation and behavior of web pages, while CSS handles their visual display [13]. Whether they are found on a single website or across several sites, the word "Hypertext" describes the linked linkages that link online pages. The internet would not function without these links. You are actively engaging with the huge world of the World Wide Web when you post stuff online and connect to other people's pages. [14].

(ii) CSS: A straightforward technique for enhancing the visual elements of online texts, including fonts, colors, and spacing, is CSS (Cascading Style Sheets) [15]. By defining how components should appear on displays, in print, on audio, and in other media, this stylesheet language helps determine the appearance of HTML or XML documents.

(iii) Bootstrap an open-source CSS framework called Bootstrap is used to create front-end web apps that are responsive and mobile-first. With the ability to use JavaScript, it offers CSS-based design templates for elements like buttons, forms, typography, navigation, and other interface components [16].

(iv) A well-liked option for web development, Python is a flexible, high-level programming language renowned for its readability and simplicity. Developers may create clear, maintainable code for backend processing because to its comprehensive library support and user-friendliness. Because of its adaptability, Python can be integrated with a wide range of systems and technologies, such as databases, APIs, and third-party services, and it offers strong capability for dynamic web applications [17].

(v) Python developers may create online applications more rapidly and effectively with Flask, a lightweight micro web framework. While being simple and impartial, Flask offers all the necessary tools and functionality for web development, such as routing, templating, and managing requests, allowing developers to select the components and tools they want. Small to medium-sized applications benefit greatly from its simplicity and usability, and third-party libraries may readily be added to offer more capabilities [18].

4.3 Testing and Maintenance

Finding mistakes is the main objective of testing. Testing entails making an effort to find every potential flaw in our creations. It's comparable to making sure software performs as intended and doesn't malfunction negatively. Software testing includes verification and validation. Software testing may be done in two ways.

i. Functionality testing, also known as Black Box testing: In this type of testing, testers make sure the program functions correctly on the surface but have no understanding how it is made within. It ultimately boils down to figuring out how the program works and acts.

ii. Implementation testing or White Box testing: White box testing, often referred to as structural testing, is used to assess the circulation, structure, and internal operations of the program. In order to verify that the programs' routes and logic flows satisfy the requirements, the tester develops test cases during this phase of testing.[19]

4.4 Challenges

The development and implementation of the proposed solution are likely to encounter several challenges:

I. **Technological Fences:** The implementation of safe payment gateways, and real time data synchronization might need specialized technical skills.
II. **User Adoption:** Convincing the users to move out of the traditional way of doing things to using a new digital way could be a difficult task especially among those that are not very tech-savvy.
III. **Infrastructural Constraints:** The current information technology infrastructure in some of the areas of development is likely not to allow the proposed entire system fully.

Chapter 5

RESULTS & DISCUSSION

5.1 Outlook of The System

The move towards digital utility service has become a major element in the present-day development of infrastructure. In this chapter we pay attention to the practical implementation and test of the digital energy meter service system that will be designed in this project. This will facilitate ease of tracking energy consumed, use of tokens to pre-pay bills and having the meter and its data on a web-based platform, which improves efficiency of operations as well as user comforts.

The implementation procedure consisted of some of the main stages called system design, backend as well as frontend development, the integration of real-time in terms of data handling and deployment of the secure transaction platforms adopting SSLCommerz as the system of digital payment. All the steps were well implemented so that they brought forth reliability, scalability, and user friendliness in the final product.

Homepage:

The Digital Energy Meter Service has a clean and convenient home screen office that presents the central functionality of the platform. It greets the users by a short explanation of the service and shows a new improved picture of digital meter to emphasize the possibility of adding operations balance check, fund management, history of energy bills use, monthly billing, and inform about national grid. The left sidebar provides a convenient navigation to such important functions as balance check, fund management, the history of energy usage, and billing. All-in-all, the home page is created to provide fast access to all the necessary services in the simple and understandable structure.

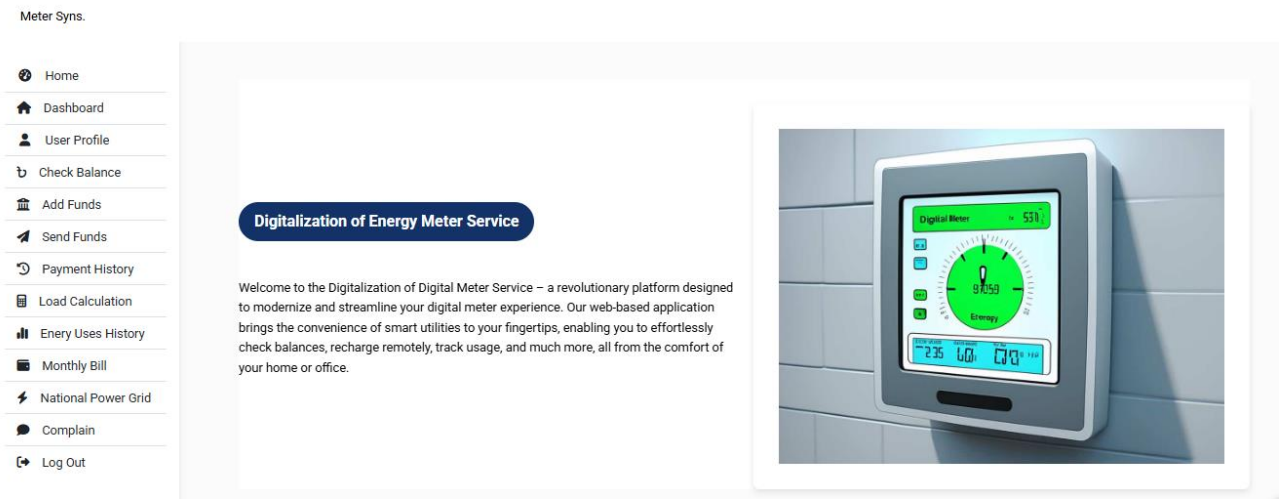

Figure 5.1: Homepage for Digitalization of Energy Meter Services

Dashboard:

Whether meter reader, consumer or contract holder, the Electricity Monitoring Dashboard gives the user a real time overview of their usage and account position and status. It has major parameters that include the current rate of electricity, total consumptions of kWh in a month, the total recharge value, the last recharge, unit remaining and the power consumption on a particular day. All sections are well shown and have visual signs (e.g., Low Balance, High Usage) to prompt the user to understand whether his or her energy is going well or not. This central aspect automatically makes it possible for the users to get a check on their consumption trends, recharging and updating themselves on their consumption levels easily and effectively.

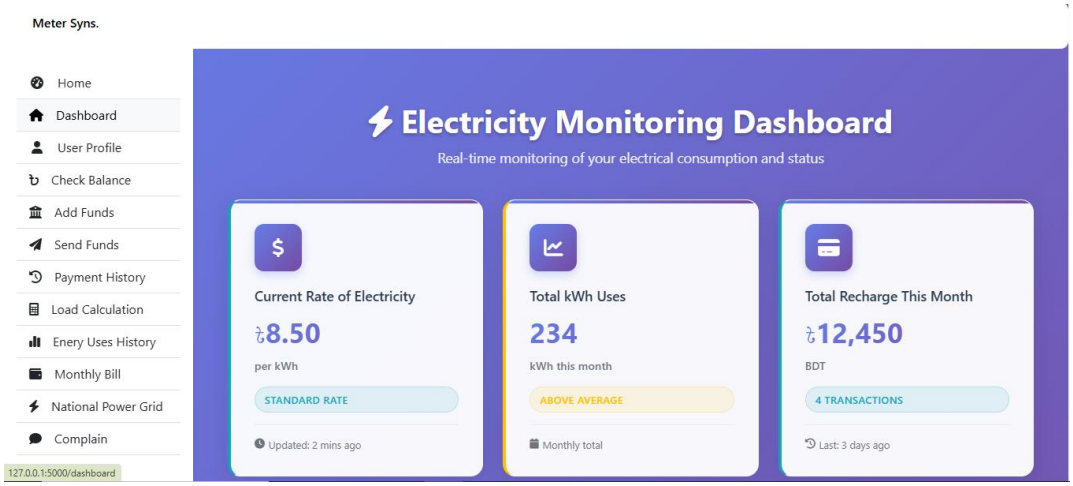

Figure 5.2: User Dashboard Page

User Profile:

All necessary information about the users is saved and presented on the User Profile page such as the name, contact information, address, and the meter data related to them. It is a personal dashboard used in identifying and verifying people with the system. The section manages to keep the user data stored safely and in an easily accessible format to carry out various activities relating to the service like charging, recharging, billing and support.

Other than an avenue where basic user information is stored, the User Profile page is also a central location to track the usage history and locating past transaction. The customers are able to see in-depth energy usage records, recharging transactions, and electricity bills in a neatly consolidated area. This aspect will assist the consumers to learn their usage behavior and make professional decisions that are related to their energy requirements. The system is capable of providing clear and transparent outlook, which builds user confidence and responsible management of utility use and efficiency.

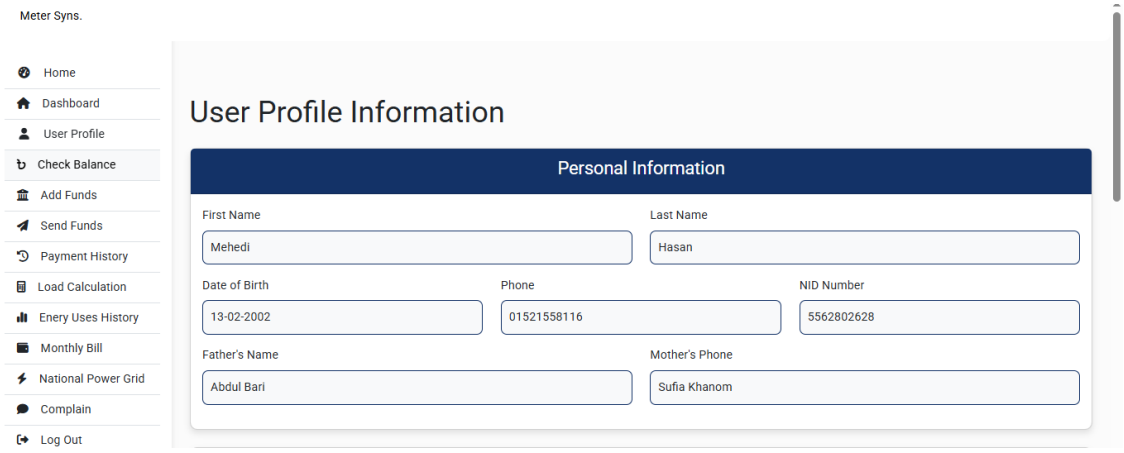

Figure 5.3: User Profile Information

Balance Checking Page:

The digitalized energy meter service offers a clear view of the current balance of any user on the Balance Check page, as well as the unique Meter ID together with the last time of update. Most importantly, it contains fields that list energy consumption and future payment plans, though there are none in the given picture; they indicate the purpose of the page to provide all-embracive financial and consumption-related information. We have also placed a large "Low Balance Alert" that acts as an anticipatory alert so the customers can top up and avoid running out of service an thus enable them to control their real time spending on energy consumption.

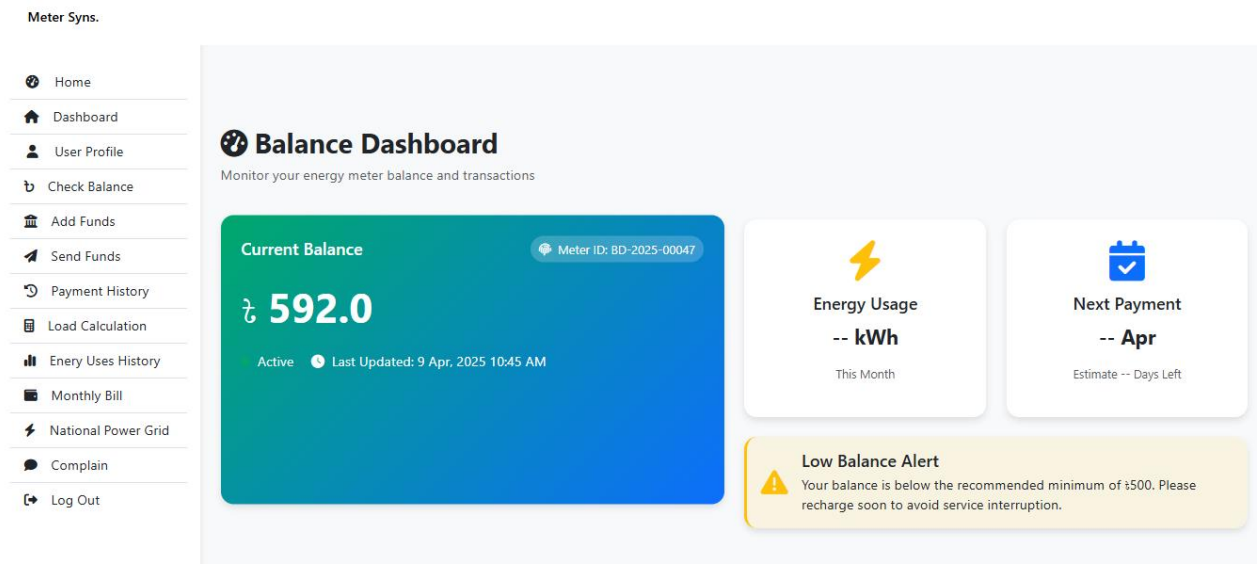

Figure 5.4: Balance Checking Page

Low Balance Alert:

To ensure a smooth and uninterrupted service experience, our system is designed to gently notify users when their balance runs low. Instead of facing unexpected disruptions, users will receive a friendly message alerting them in advance. This thoughtful feature gives you the time to recharge at your convenience, helping you stay connected and in control without worry. It's our way of adding a little more ease and care into your everyday utility experience.

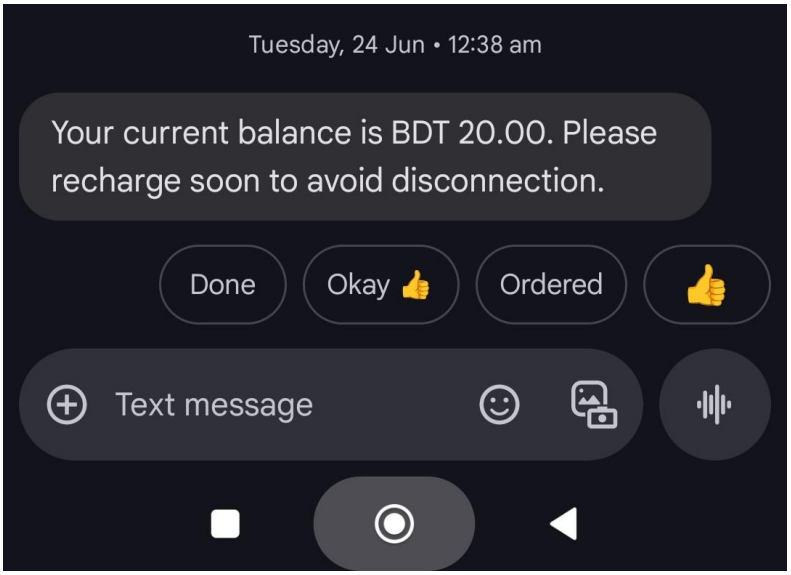

Figure 5.5: Notification in User Phone

Add Funds Via SSLCOMMERZ Gateway:

The direct interface is the Add Funds page, whose colors, design and text is aimed at reaffirming the "Meter Recharge" brand name. In this case, the users only enter their Meter ID and the amount of recharge they would want. When the user hits the button (RECHARGE), the system safely executes the payment, and most of the times, it is usually combined with an efficient payment gateway like SSLCOMMERZ.

The presence of this integration promises a range of payment options so that the user could secure a comfortable and secure funding procedure. The page notably carries on a message of the confidentiality of the wallet and money transfer process, a secure payment processing, wherein the status of having a good energy meter balance remains secure.

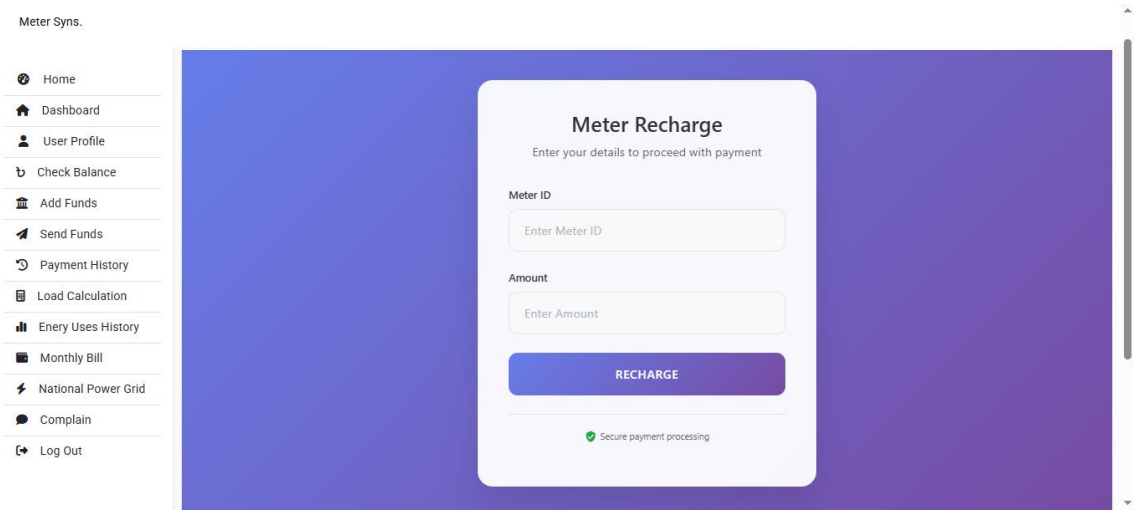

Figure 5.6: Payment Gateway Page

Send Funds to Other User:

The page is a very essential element named as the Send Funds that allows emergency transfer of credit among users in the system of digital energy meters. This page can be used in the event that the other user, who can be the neighbor or family member, has a critically low balance and is in danger of having his/her services turned off right away. One can send meter credit easily by just keying in the Identification number, the "Receiver Meter ID", of the needy person and the intended amount. This is a peer-to-peer transfer that serves as a life line, in cases when there is an urgent situation, there is no disconnection.

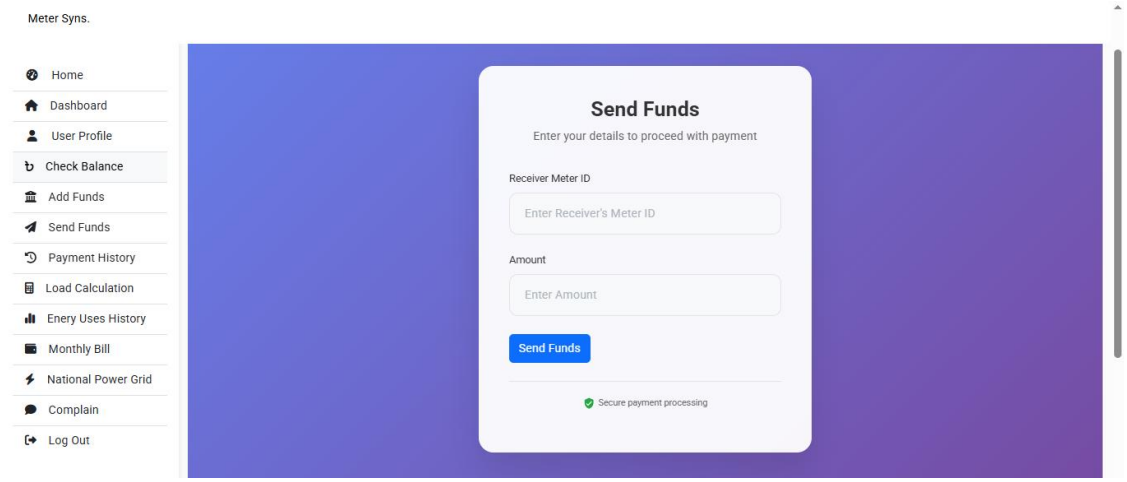

Figure 5.7: Send Funds to Oher User

Payment History:

The "Payment History" page is both an easy to navigate and an interactive financial ledger, which gives a user a detailed picture of all the transactions that relate to the energy meter. It systematically documents every activity with data expressed in a table format with columns of Date of transaction and Type of transaction (e.g. credit due to recharge and money sent to another user).

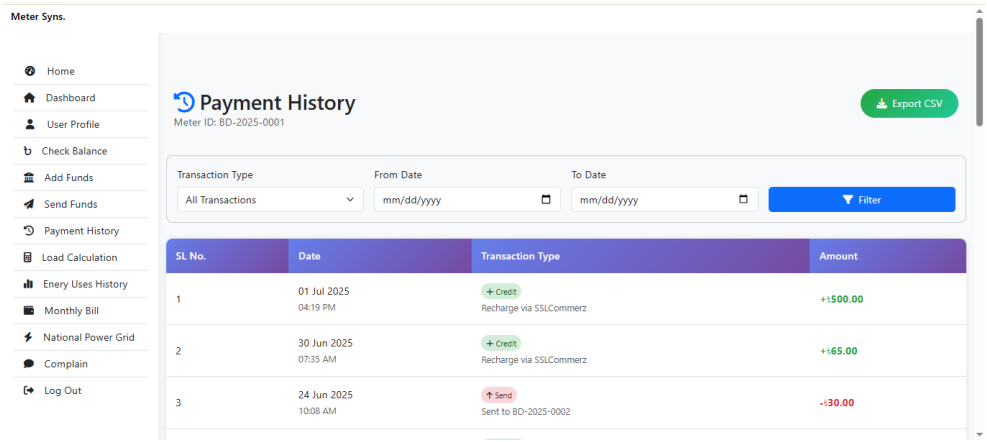

Figure 5.8: Payment History of The User

The page has heavy filing features to support information needs that are user-based. The user is given an opportunity to narrow down his/her scope by giving it a type of transaction (e.g., only recharges or only debits) or by setting specific "From Date" and "To Date". It enables detailed inquiry into certain periods of financial activity, i.e. seeing all top-ups that were made in the past quarter or the ability to select a certain transfer.

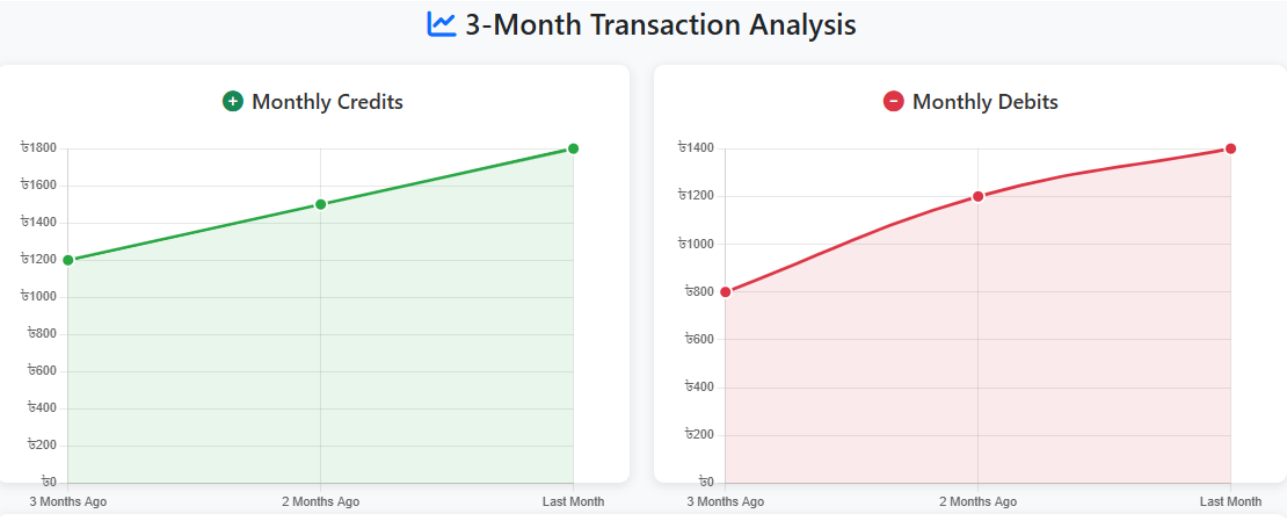

Figure 5.9: Transaction Analysis Graph

To facilitate further record-keeping and externally performed analysis, an easy exporting CSV option is made available, whereby a user may download all of his or her transaction history to use in spreadsheets or other financial management packages. In addition to simple data, the page incorporates compelling visual insights, such as: a 3-Month Transaction Analysis (indicating trends in the number of monthly credits and debits over time) and Combined Monthly Overview (bar charts comparison between the total number of credits and debits over the time). These visualizations help to digest transaction data and turn them into easily accessible information with the help of which a user can easily find their spending routine, timely control their financial flow and make more conscious choices regarding their financial consumption and budget.

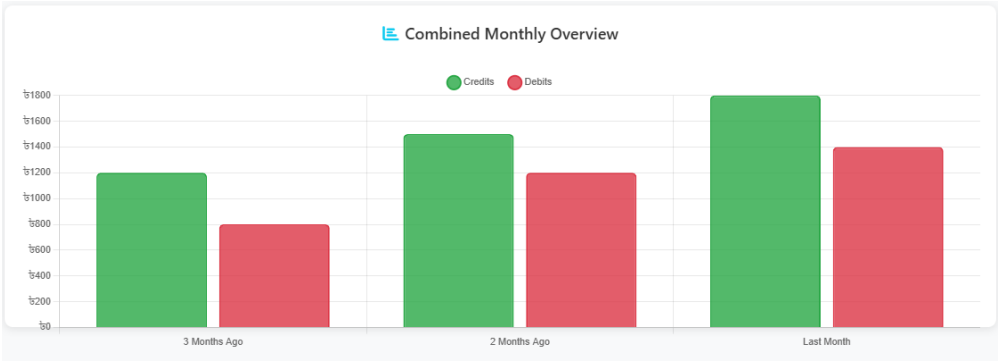

Figure 5.10: Combined Transaction Analysis Graph

Real Time Load Calculation:

The function of the Load Calculation page is to give the user detailed and up-to-date information on his or her use of energy and appliance management. On a higher level it also acts as a "Realtime Energy Dashboard" that shows its overall running power, running cost associated with this and how many appliances are running actively drawing power. This provides users with an instant overview of energy footprint of their household.

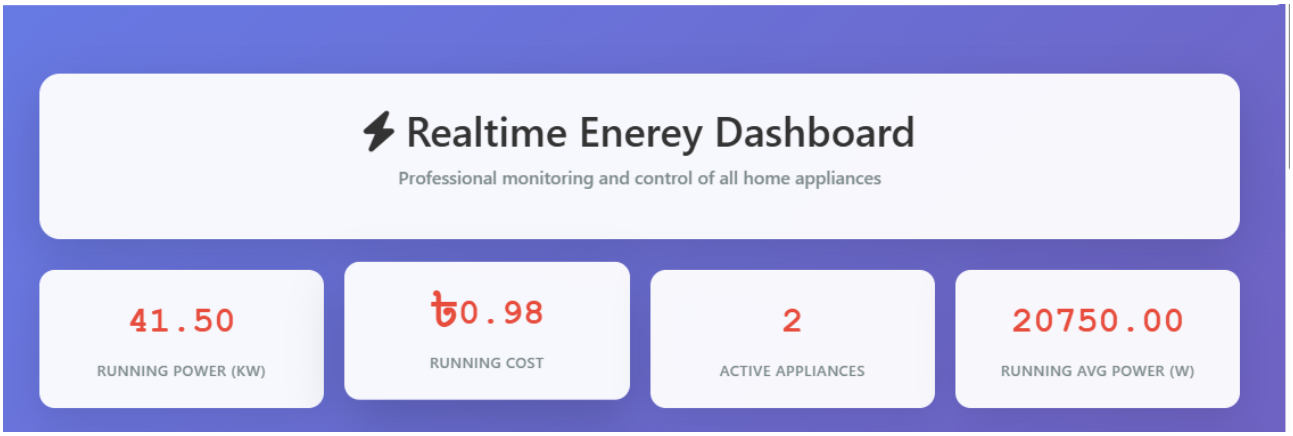

Figure 5.11: Overview of the Active Electric Appliances

In addition to the overall vision, the page becomes a Home Appliances Control Center. In this case, users get fine control and surveillance services of individual electric appliances. Under every appliance in the list, the best system gives specific details including power consumption, quantity, and the current status of that particular appliance. More importantly, it monitors the time spent by each appliance and the amount of specific energy used and the amount of money paid. Such detail gives users not only the option of monitoring, but even possible control (e.g., turn off/on) their devices in real-time and thus to be able to see which appliances use a lot of energy, learn their behaviors, and take action to be able to control the total energy usage of their household in order to lessen power expenses and to increase efficiency.

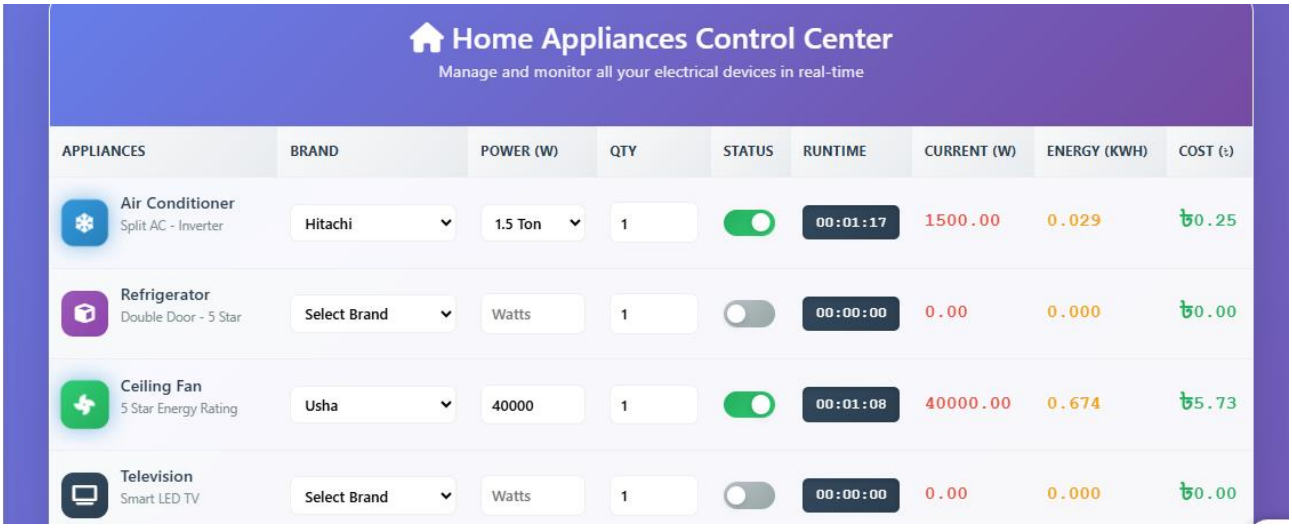

Figure 5.12: Realtime Load Calculation

Energy Uses History:

The Energy Uses History page represents a central element of the digitalized energy meter service, aiming to guide the user to gain compelling insight into his/her energy use, which can be easily used to modify the behavior. More than a data log, this is an interactive place where the user can carefully monitor, evaluate and finally enhance his or her energy footprint.

The page presents the trends of energy consumption in a clear form of graphs and visualizations and helps a person to compare the figures of consumption on various days, weeks, or months. It assists in individual feedback that enables users to know the times when they consume the most and the possible places of saving energy. The ability of the Energy Uses History page to convert raw numbers into comprehensible data enables the user to take proactive measures in their efforts to become more efficient and sustainable in their use of energy and makes energy management easy and fun.

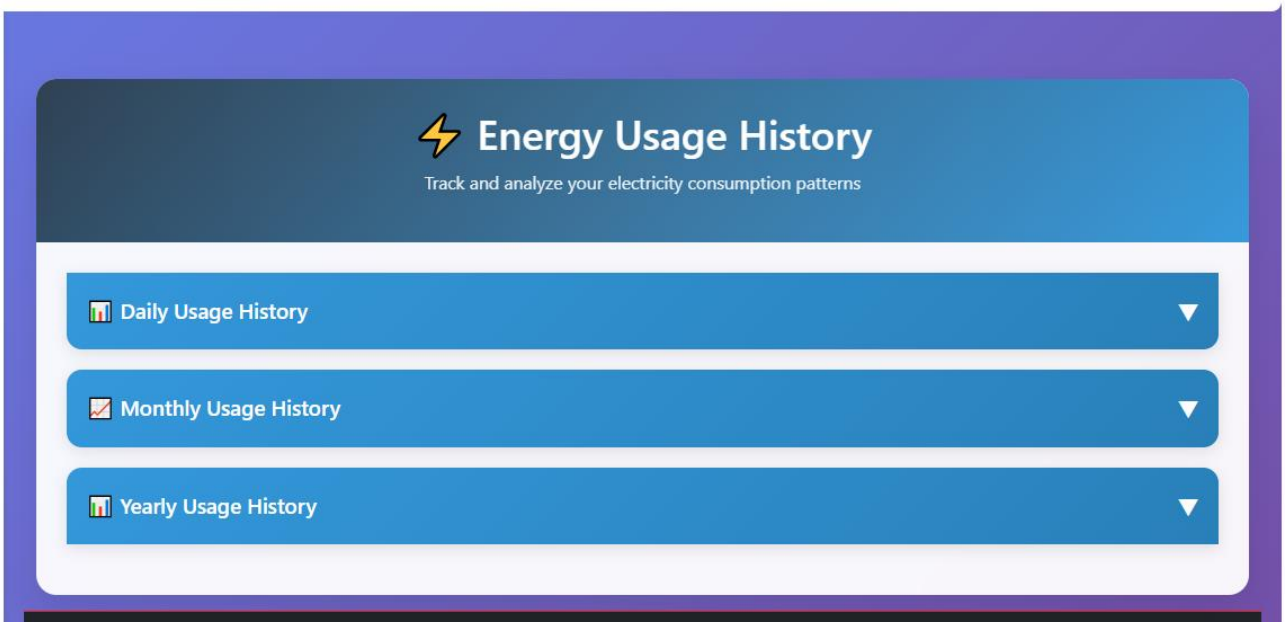

Figure 5.13: Energy Uses History

Its functionality is cleverly broken up into several historical granularities:

Daily Usage History: The given view features a detailed line graph depicting the consumption by the hour or by the day within the past thirty days. It is priceless in terms of identifying the particular consumption spikes, the presence of a given daily activity or an appliance use, and inefficiency periods. Users will be able to see the effect of their immediate actions as far as energy draw is concerned.

Monthly Usage History: With a more comprehensive view, this field reports on line graph demonstrating the usages of energy in a month over a year. This perspective is pivotal in the identification of seasonal consumption (e.g. using more when it is raining), differentiation of current month of usage and preceding years and the synchronicity of the consumption with billing periods

.

History by Year of Use: When one is undertaking a long-term strategic planning, the yearly view shows a bar chart of the past five years annual energy usage. This top-level summary allows a user to see how effective their energy-saving activities are in the long run, or discover key changes in total

consumption, or realize the effect of such big lifestyle changes, such as house repair, or new devices were installed.

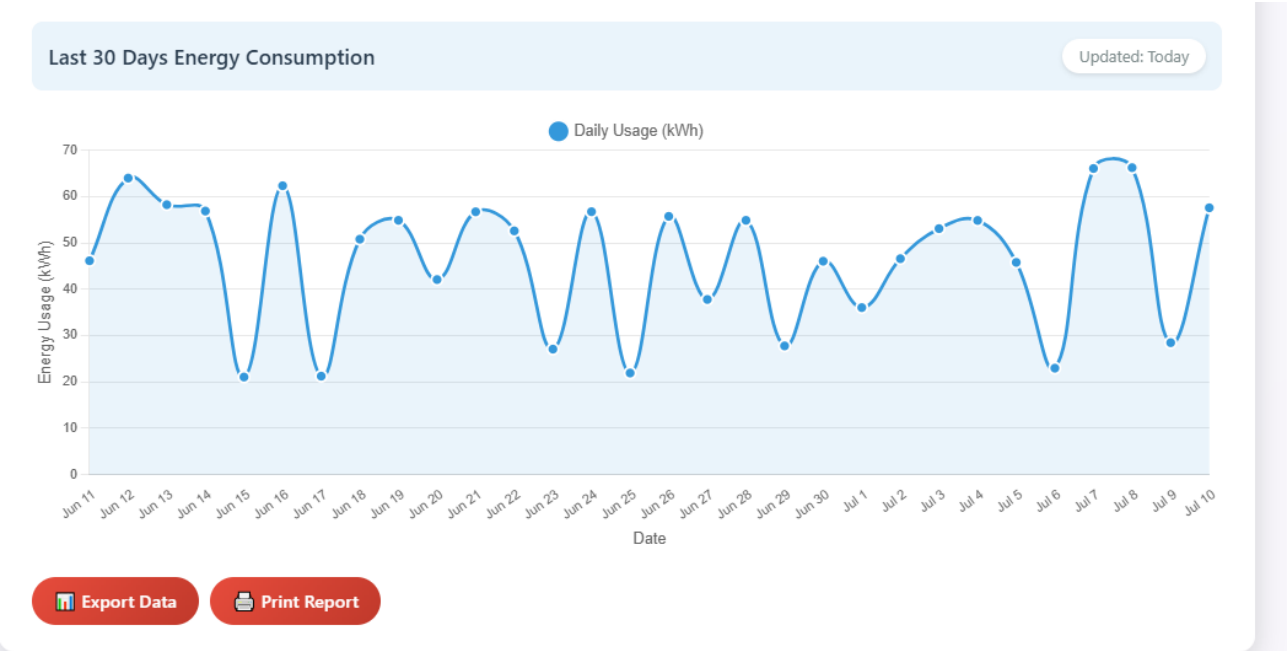

Figure 5.14: Daily Energy Uses (KWh) History

In all these historical visualizations, the power of data management tools available to users is great. Export Data option is available which will conveniently save un-collated consumption data into a CSV file that can be further detailed analyzed by an individual user, interfaced with budgeting software or reconciliations. Also, the print report feature helps in creation of hard copy version of such intuitive graphs and summary data to keep as a record or to share with other users.

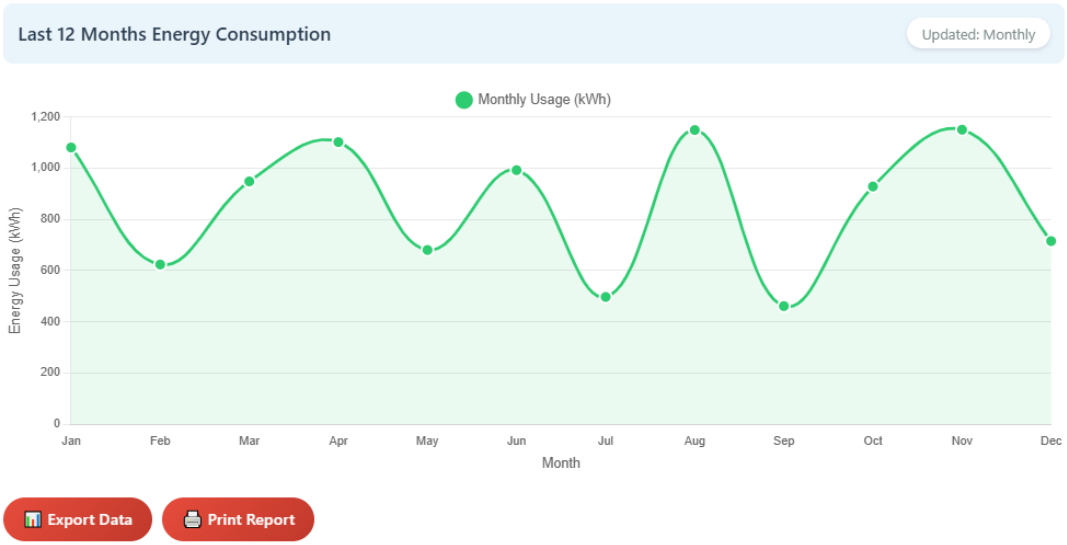

Figure 5.15: Monthly Energy Uses (KWh) History

Altogether, the Energy Uses History page makes abstract data on consumption turn into practical and comprehensible information. It prepares its users in selecting the direction of their energy behavior, taking a proactive approach to cost management, finding a way to consume energy efficiently, and favoring a more sustainable mode of consumption in the digitized energy environment.

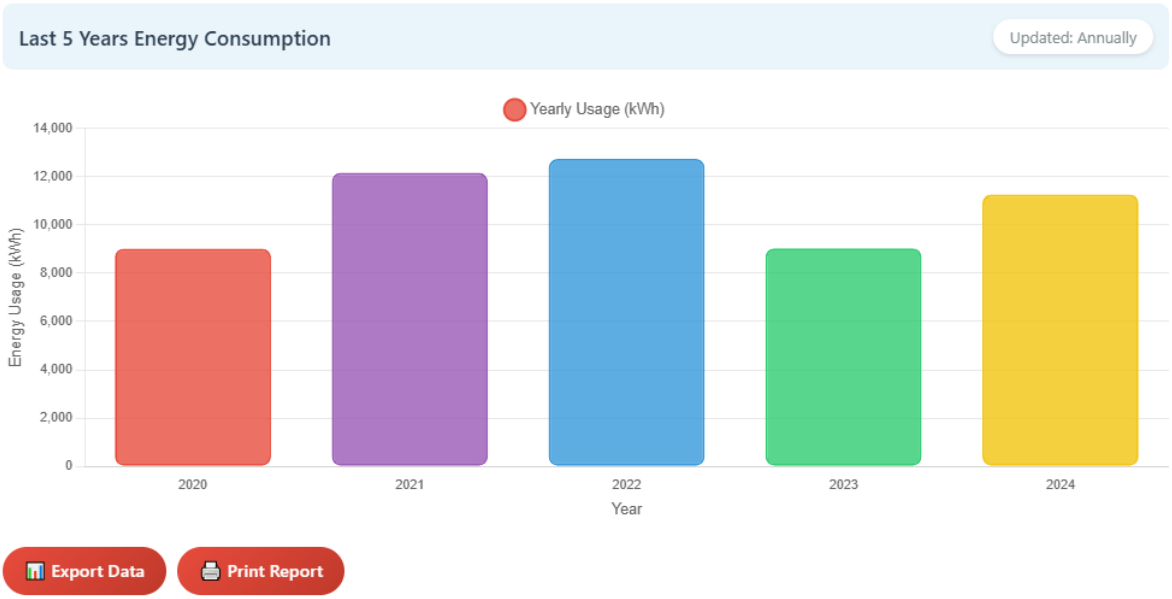

Figure 5.16: Yearly Energy Uses (KWh) History

Monthly Billing:

The Bill lesson, called the Monthly Bill is the scanned copy of an electricity bill of one of the consumers of Bangladesh Power Development Board, and acts as an actual direct CONSUMER COPY. This page categorically shows the information on three key areas which are the consumer, bill and meter and tariff information in 3 tabs i.e., consumer information which authenticates consumer information like the consumer number, location and bill information which gives specific details on the bill like the month, bill number, issue date and last payment date and the third information called meter and tariff information which lists the technical information like meter number, tariff type and sanctioned load. Such an extensive mono is transparent, and the consumer easily finds all the appertaining billing and technical parameters.

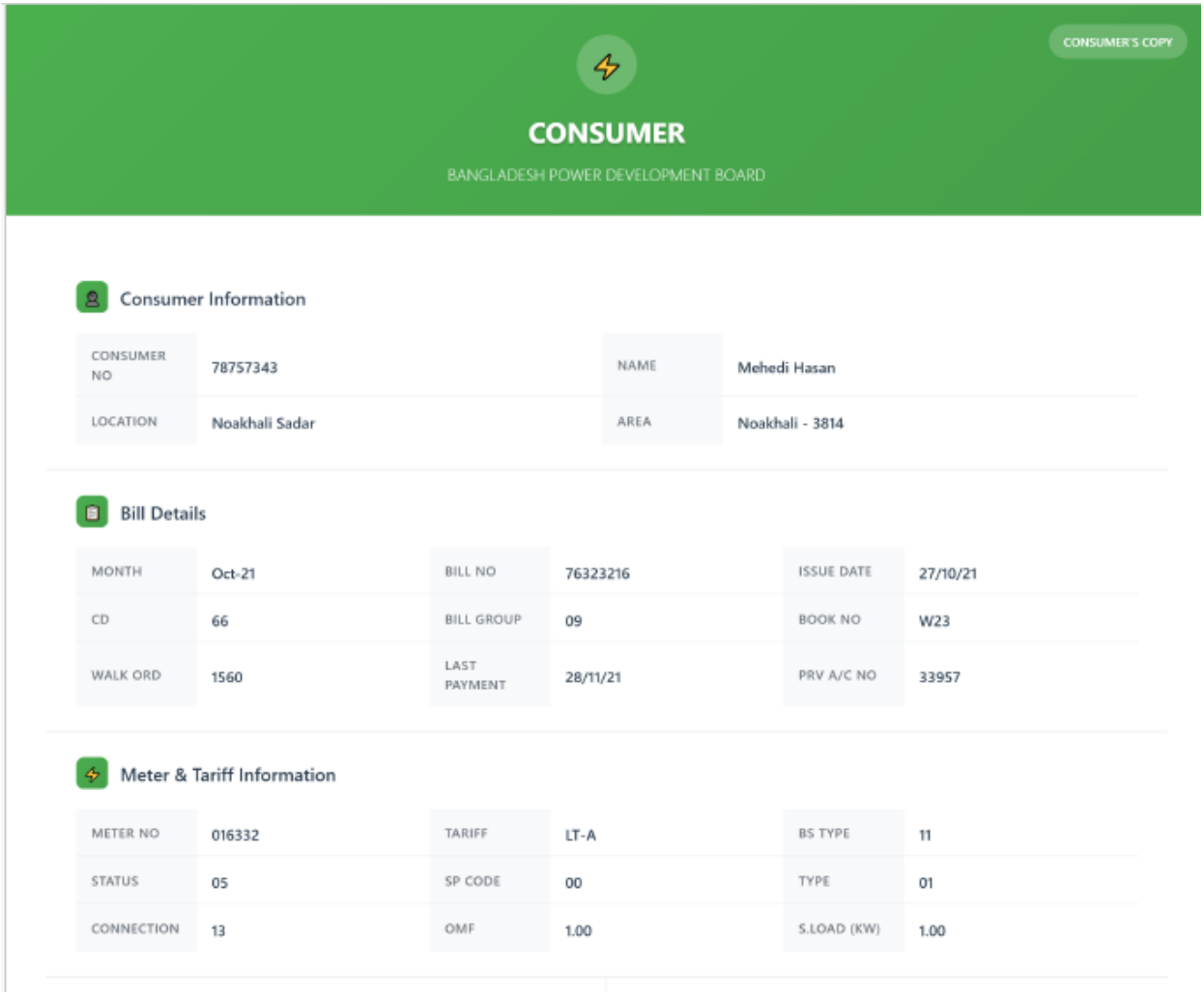

Figure 5.17: Monthly Bill Copy of The User

In accompaniment to this, the average bill calculator page is also an interactive page which aims at proactive energy calculations and cost estimation. It enables the user to enter his or her specific tariffs rates, the rate per kWh, fixed charges, and VAT percentage rates all of which ensures correct calculations. The major characteristic of the calculator is a section called the "Home Appliances Control Center", where individuals can add to the list the appliances they have in the house, the quantities involved and most importantly the average number of hours used each day in the home appliances. Using such inputs, the calculator dynamically gives a calculation of the TOTAL MONTHLY CONSUMPTION in kWh and estimation of monthly bill (with VAT) including a Generate Report option. Users of this tool can predict future costs, learn about the effects of using appliances, and make better decisions to ensure that they use energy well and take care of their budget.

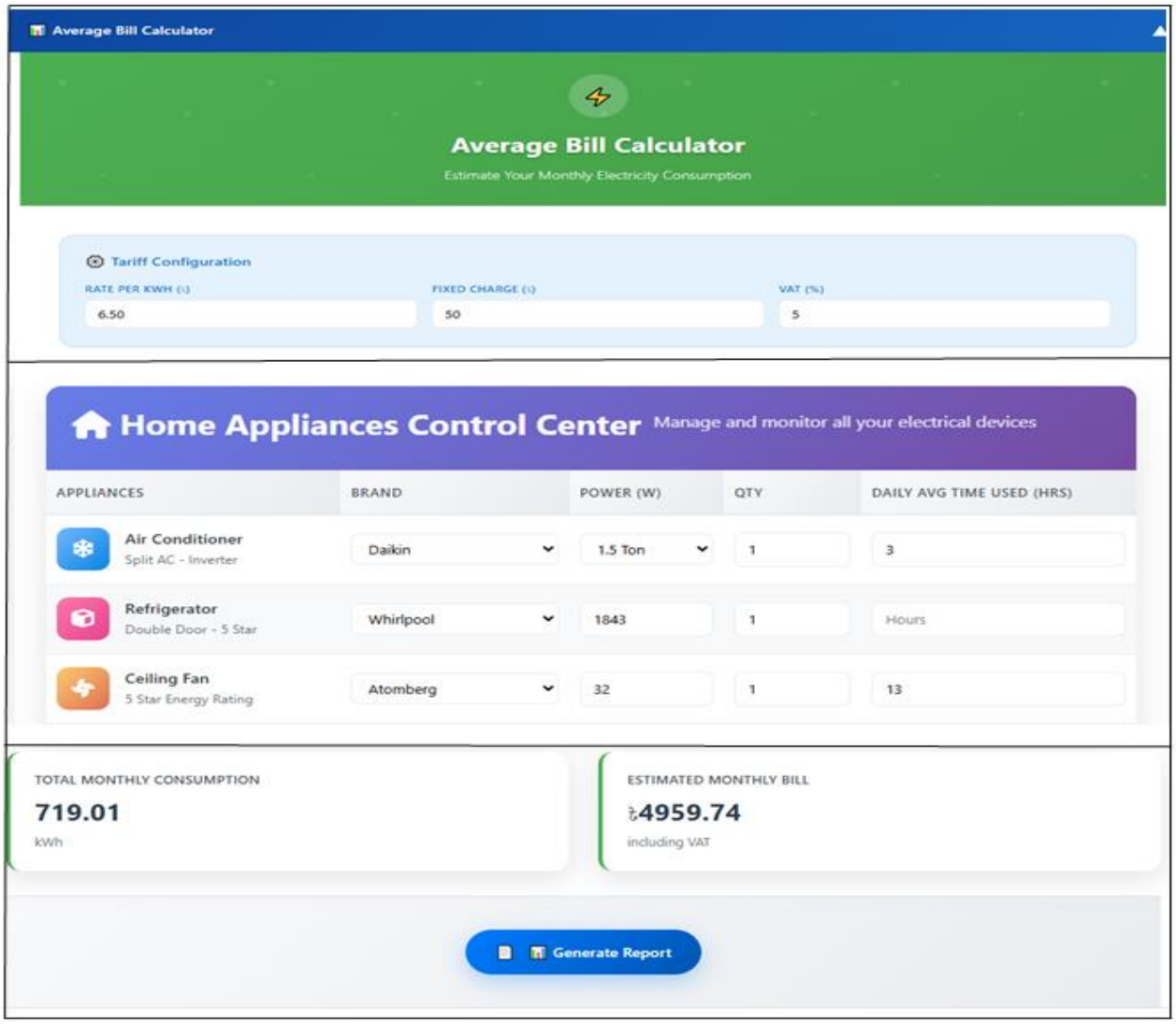

Figure 5.18: Monthly Average Bill Calculation

Power Grid:

The section dealing with Power Grid provides the reader with a larger picture of the process of dispensing and controlling the system through electricity. It offers real-time information about what is happening on the grid such as availability of power, what is being worked on and also any interruptions to the service. This section takes on the form of a glass open door to the engine room of energy transmission so that users are better aware of the performance of the whole network. The Power Grid section helps users to trust and be aware by giving them a broader perspective of the power infrastructure and promoting the more purposeful use of energy in harmony with the grid performance.

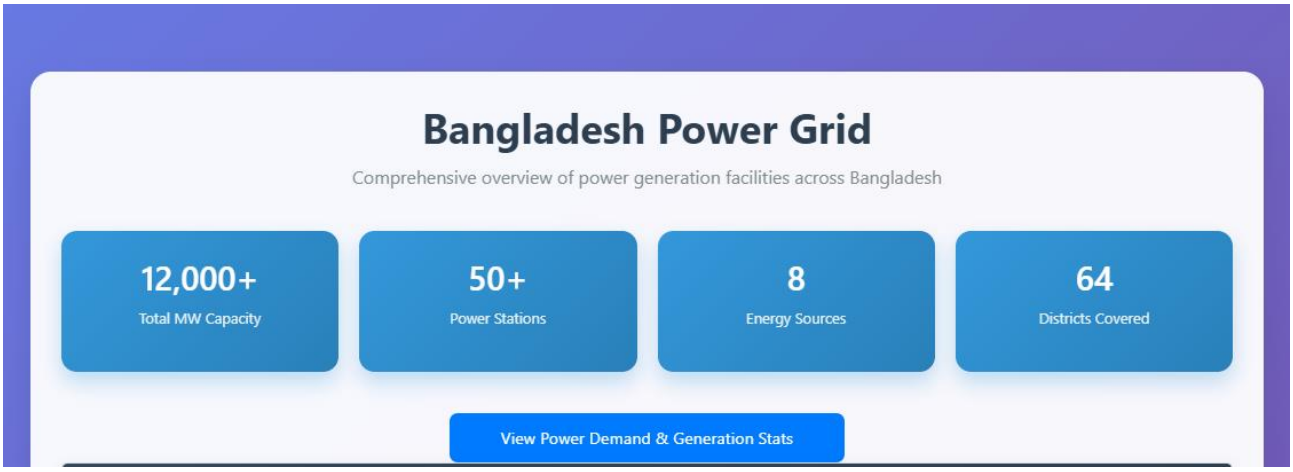

Figure 5.19: Power Grid

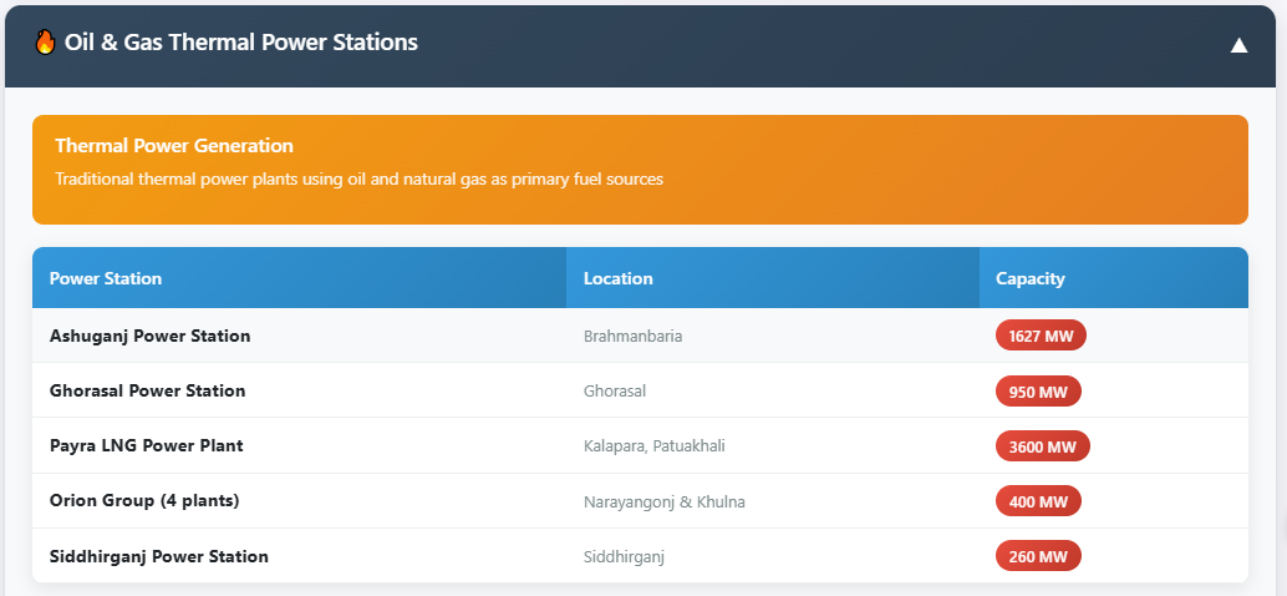

Figure 5.20: Capacity of Oil and Gas Power Station

Complain From:

The complaint form that is available on the page of Complain has a well-organized and effective approach that enables the users to officially post a problem or feedback to their energy meter service. It will take all the needed information to solve the problem effectively. The most important ones are a mandatory field called Complaint Title where one can provide a brief summary of the problem and a Description text box where the user needs to write more information in a minimum of 20 characters. The form also provides an option to attach a picture (optional), JPG, PNG, and GIF files of up to 5MB, which is also priceless when it comes to supplying evidence of the problem visually. To communicate, an obligatory email address should be entered and an optional phone number field is present. After feeding in all the necessary information, a user can tap the button that reads; SUBMIT COMPLAINT to officially present his/her grievance to the service provider who will be expected to review and address the issue.

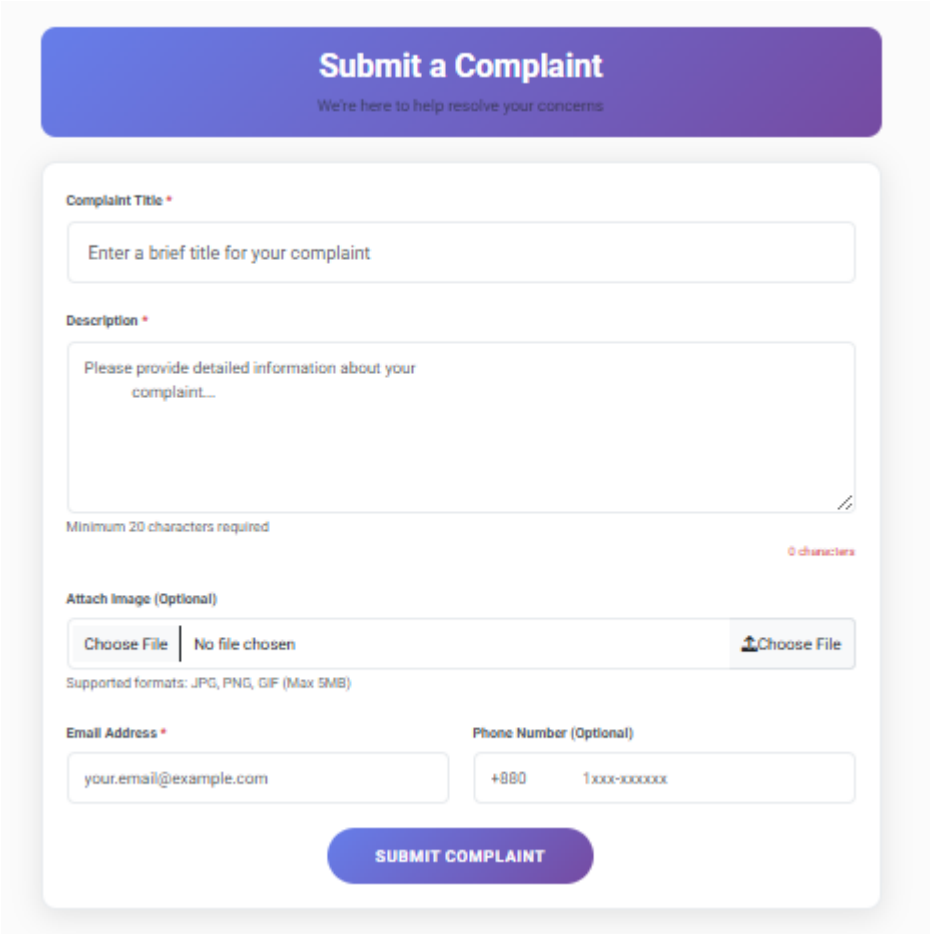

Figure 5.21: User Complain Form

Chapter 6

CONCLUSION AND FUTURE SCOPE

6.1 Conclusions

Living in the age of a blistering digital shift, the effectiveness and promptness of the service delivery in public utilities is the key signifier of national development. Bangladesh has seen huge incremental progress in digital carrier and smart-tech application. There is however a significant discontinuity between the current power of digital electricity meters and the outdated manual system in which services are being carried out. The gap in the access to the benefit that digital meters pose weigh down on efficiency of implementation of the benefit and leads to decreased customer satisfaction, service economies, and operational expenses by service providers.

This research is also conducted with an aim of closing this gap in technological advancements and delivery of services. The project is about the design and development of a web-based program that can make the service of digital electricity meters accessible to more people, useable, and efficient in Bangladesh. This platform will assist users to check on the energy uses, recharges records, transaction reports and the real-time billing at any given time and anywhere.

Digitization and automation of utility service must focus on making the process efficient thus overall intentions of proposing a system will be to facilitate the overall user-experience and to standardize its operations by the service providers. It also favors the wider government agenda of Digital Bangladesh which focuses on transparency, empowering the user as well as sustainable development of technology in the public sectors.

Although issues like Infrastructure shortcomings, gaps in digital literacy, and the complexity of system integration occur, the suggested model is meant to be scable, low-cost, and efficient. Its block structure enables it to be incorporated with other smart city project and technological advancements in the future. Moreover, the system is constructed in an inclusive way by attempting to incorporate both the urban and rural user thus increasing access to the system.

In the end, the study also provides a vision of the utility management that will respond to the international requirements and rapidly changing customer demands. It is the precedent towards the improvement of the traditional service delivery by introduction of a seamless and digital service delivery, which would encourage efficiency and sustainability and also be user based in terms of service.

6.2 Future Works

This project lays the foundation of a modernized utility system of management. The future research can be addressed to the following points:

Integration with IoT Device: supporting direct communication on real-time update between the digital meters and the application.

Advanced Analytics: The application of data analytics technologies as a means of enhancing the utilization of resources and providing consumption patterns insights.

Machine Learning: Making a forecast and optimal recommender on consumer recharge on the basis of predictive algorithms

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