



# **INTELLIGENT HOME ENERGY MANAGEMENT FOR POWER CONSUMPTION**

Final Year Project Report

## **Submitted by**

Taha Saeed (2133-2021)  
M. Khizer mallick (2240-2021)  
M. Shoaib Azam (2172-2021)

## **Supervisor**

Dr. Umer Farooq

## **Co-Supervisor**

Dr. Rashid Hussain

In partial fulfilment of the requirements for the degree of  
Bachelor of Science in Computer Science  
2021

## **Faculty of Engineering Sciences and Technology**

Hamdard Institute of Engineering and Technology

Hamdard University, Main Campus, Karachi, Pakistan

# Certificate of Approval



## Faculty of Engineering Sciences and Technology

Hamdard Institute of Engineering and Technology  
Hamdard University, Karachi, Pakistan

This project **“Intelligent Home Energy Management System For Power Consumption”** is presented by **Taha Saeed, M.Khizer Mallick, M.Shoaib Azam** under the supervision of their project advisor and approved by the project examination committee, and acknowledged by the Hamdard Institute of Engineering and Technology, in the fulfillment of the requirements for the Bachelor degree of Computer Science

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Dr. Umer Farooq  
(Project Supervisor)

---

In-charge FYP-Committee

---

Dr.Rashid Hussain  
(Project Co-Supervisor)

---

Chairman  
(Department of Computing)

---

(Dean, FEST)

## Authors' Declaration

We declare that this project report was carried out in accordance with the rules and regulations of Hamdard University. The work is original except where indicated by special references in the text and no part of the report has been submitted for any other degree. The report has not been presented to any other University for examination.

Dated:

Authors Signatures:



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Taha Saeed



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M. Khizer Mallick



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M. Shoaib Azam

## Plagiarism Undertaking

We, Taha Saeed, M.Khizer mallick and M.Shoaib Azam solemnly declare that the work presented in the Final Year Project Report titled **Intelligent Home Energy Management System for Power Consumption** has been carried out solely by ourselves with no significant help from any other person except few of those which are duly acknowledged. We confirm that no portion of our report has been plagiarized and any material used in the report from other sources is properly referenced.

Dated:

Authors Signatures:



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Taha Saeed



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M. Khizer Mallick



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M. Shoaib Azam

## **Acknowledgments**

In the name of Allah, Most Merciful, Most Generous. We had the courage to study and carry out this proposal within the allotted time thanks to all of His favors. In order to complete this job, we would like to appreciate and extend our sincere gratitude to our supervisors, Dr.Umer Farooq and Dr.Rashid Hussain We're grateful for your wise remarks and recommendations, which helped us through every stage of working on the project. We also want to thank our entire family for their continuous acceptance and support while we worked on your project and completed it. We've gotten this far thanks to their prayers for us.

## Document Information

Table 1: Document Information

Customer	
Project Title	Intelligent Home Energy Management System For Power Consumption
Document	Final Year Project Report
Document Version	1.0
Identifier	FYP-021/FL24 Final Report
Status	Final
Author(s)	M.Khizer, Taha Saeed, M.Shaoib
Approver(s)	Dr. Umer Farooq, Dr. Rashid Hussain
Issue Date	17-01-2025

## Definition of Terms, Acronyms, and Abbreviations

*This section should provide the definitions of all terms, acronyms, and abbreviations required to interpret the terms used in the document properly.*

Table 2: Definition of Terms, Acronyms, and Abbreviations


## Abstract

This project focuses on designing a Real-Time Smart Home Energy Monitoring and Management System aimed at optimizing residential electricity usage. The system features real-time monitoring, predictive analytics, and automated energy source switching to reduce electricity costs and improve efficiency. By integrating renewable energy sources like solar panels, it promotes sustainable energy consumption. The solution is tailored for homeowners, providing actionable insights and user-friendly customization through an intuitive interface.

### Keywords:

Smart Home

Energy Management System (EMS)

Real-Time Monitoring

Predictive Analytics

Renewable Energy

Automation

Sustainability

User-Friendly Interface

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# CHAPTER 1

## INTRODUCTION

### 1.1 Motivation

The increasing cost of electricity and environmental concerns have motivated homeowners to seek better ways of managing energy consumption. Real-time energy monitoring and switching to alternative sources, such as solar power, are vital in reducing electricity bills and strain on the power grid.

### 1.2 Problem Statement

Homeowners face difficulties in monitoring electricity consumption in real time. Current systems lack the capability to alert users before they exceed their desired energy usage limit, and they do not offer automated switching to alternative energy sources to optimize consumption. These limitations result in higher costs and inefficient energy usage.

### 1.3 Goals and Objectives

The primary goal is to develop a **Real-Time Smart Home Energy Monitoring and Management System**. The objectives include:

- Providing real-time insights into energy consumption.
- Alerting users when consumption approaches predefined thresholds.
- Integrating predictive analytics to forecast energy usage based on historical patterns.
- Automating the switch to alternative energy sources, such as solar panels or generators, to minimize grid dependency.

### 1.4 Project Scope

The project focuses on designing the front-end interface for the system during **FYP-1**, enabling user-friendly access to energy insights and management tools. The scope includes:

- Real-time consumption tracking.
- Notification and alert functionality.
- Initial integration of predictive analytics (limited to the front-end design phase).
- Compatibility with Android and iOS platforms.

## CHAPTER 2

### RELEVANT BACKGROUND & DEFINITIONS

Smart home energy management systems have emerged as a solution to address the growing demand for efficient energy usage. These systems integrate hardware and software components to monitor, analyze, and optimize electricity consumption in real-time.

**Energy Management Systems (EMS):** EMS refers to technologies that help monitor energy usage and provide actionable insights to improve efficiency. These systems are commonly used in industrial and commercial setups and are gradually gaining traction in residential spaces.

**Real-Time Monitoring:** This involves collecting and analyzing energy consumption data as it happens, enabling immediate feedback to users. Real-time monitoring is crucial for identifying excessive energy use and taking timely action.

**Predictive Analytics:** Predictive analytics uses historical data and AI algorithms to forecast future energy consumption. This helps homeowners anticipate usage patterns and make informed decisions.

**Renewable Energy Integration:** The shift toward renewable energy sources, such as rooftop solar panels, is a critical component of modern energy systems. These sources reduce dependency on the power grid and offer environmentally sustainable alternatives.

**Automation in Energy Management:** Automation allows systems to take proactive measures, such as switching to alternative energy sources or reducing the usage of non-essential appliances, without manual intervention.

## CHAPTER 3

### LITERATURE REVIEW & RELATED WORK

#### Literature Review

- The concept of energy management systems (EMS) has been extensively studied to address the rising demand for energy efficiency and sustainability. Research highlights the role of IoT-based solutions and AI-driven analytics in transforming energy consumption patterns. Studies such as those by Abdul-Rahman Al-Ali et al. (2017) and Heba Youssef et al. (2024) have demonstrated the effectiveness of smart home energy management systems in reducing energy waste through real-time monitoring and predictive modeling. However, most existing systems are either designed for industrial applications or lack customization for residential users. The integration of renewable energy sources, such as solar panels, has also gained attention for minimizing dependence on the power grid.

#### Related Work

- Several energy management solutions have been developed, such as Google Nest and Ecobee, which offer features like energy monitoring and automated appliance control. However, these systems often target high-end markets and lack comprehensive integration with renewable energy sources. IoT-based projects have explored using smart meters and sensors for energy tracking, but these solutions fail to provide predictive analytics or proactive alerts tailored to individual user preferences. Academic research has further investigated optimization techniques using AI algorithms to predict energy usage and suggest energy-saving measures, yet these approaches are rarely implemented in commercial residential systems.

#### Gap Analysis

- Despite advancements in energy management technology, significant gaps remain in addressing residential energy optimization. Current systems often focus on monitoring rather than proactive management, and they lack the ability to seamlessly switch between energy sources like solar or generators. Many solutions do not offer real-time alerts or predictive analytics specifically designed for household use. This project bridges these gaps by developing a system that integrates real-time monitoring, AI-driven analytics, and automation to provide homeowners with an affordable and user-friendly solution. The inclusion of renewable energy management further enhances its value by promoting sustainability and reducing grid dependency.

## **CHAPTER 4**

# **PROJECT DISCUSSION**

- 1. Software Engineering Methodology**
- 2. Project Methodology**
- 3. Phases of Project**
- 4. Software/Tools that Used in Project**
- 5. Hardware that Used in Project**

## **Chapter 5**

# **IMPLEMENTATION**

- 4.1 Proposed System Architecture/Design**
- 4.2 Functional Specifications**
- 4.3 Non-Functional Specifications**
- 4.4 Testing**
- 4.5 Purpose of Testing**
- 4.6 Test Cases**



## **Chapter 5**

### **EXPERIMENTAL EVALUATIONS & RESULTS**

#### **Evaluation Testbed**

#### **Results and Discussion**

## **CHAPTER 6**

### **CONCLUSION AND DISCUSSION**

- 7.1 Strength of this Project**
- 7.2 Limitations and Future Work**
- 7.3 Reasons for Failure – If Any**

## **REFERENCES**

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- A0. Copy of Project Registration Form
- A1a. Project Proposal and Vision Document
- A1b. Copy of Proposal Evaluation Comments by Jury
- A2. Requirement Specifications
- A3. Design Specifications
- A4. Other Technical Details
- Test cases
- UI/UX Details
- Coding Standards
- Project Policy
- A5. Flyer & Poster Design
- A6. Copy of Evaluation Comments
  - Copy of Evaluation Comments by Supervisor for Project – I Mid Semester Evaluation
  - Copy of Evaluation Comments by Jury for Project – I End Semester Evaluation
  - Copy of Evaluation Comments by Supervisor for Project – II Mid Semester Evaluation
  - Copy of Evaluation Comments by Jury for Project – II Mid Semester Evaluation
  - Copy of Evaluation Comments by Jury for Project – II End Semester Evaluation
- A7. Meetings' Minutes
- A8. Research Paper
- A10. Any other

## **A0. COPY OF PROJECT REGISTRATION FORM**

A Photostat or scanned copy should be placed when submitting a document to Project Coordinator. (**Note:** Please remove this line when attach copy that is required)

## **A1A. PROJECT PROPOSAL AND VISION DOCUMENT**

Any standard template may be used, as per project need approved by Project Coordinator & Supervisor. Following is a suggestive outline. **Also, the same outline should be used for Project Proposal Presentation.**

- 1 Introduction
- 1.1 Problem Statement
- 1.2 Project Motivation
- 1.3 Objectives
- 1.4 Literature Review
- 2 Project Vision
- 2.1 Business Case and SWOT Analysis
- 2.2 Background, Business Opportunity, and Customer Needs
- 2.3 Business Objectives and Success Criteria
- 2.4 Project Risks and Risk Mitigation Plan
- 2.5 Assumptions and Dependencies
- 3 Project Scope
- 3.1 In Scope
- 3.2 Out of Scope
- 4 Proposed Methodology
- 4.1 SDLC Approach (Waterfall/Agile/any model)
- 4.2 Team Role & responsibilities
- 4.3 Requirement Development
- 4.4 High-level Architecture / Design
- 4.6 Application (or Project) Testing
- 5 Project Planning
- 5.1 Gantt Chart
- 6 Project Requirements
- 6.1 Software tools requirements
- 6.2 Hardware requirements
- 7 Budget/Costing
- 7.1 Mention the budgeting cost of each item - required for this project
- 7.2 Estimated Budgeted Cost - of the Project
- 8 Project Deliverables
- 8.1 Phase I - Alpha Prototype
- 8.2 Phase II - Beta Prototype
- 8.3 Phase III - Release Candidate
- 8.4 Phase IV - Final Product
- 9 Proposed GUI (Disposable Prototype)
- 10 Meetings held with supervisor and/or client.
- 11 Reference

## **A1B. COPY OF PROPOSAL EVALUATION COMMENTS BY JURY**

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## **A2. REQUIREMENT SPECIFICATIONS**

Any standard template may be used, as per project need approved by Project Coordinator & Supervisor. Following is a suggestive outline.

1. Introduction
  - 1.1. Purpose of Document
  - 1.2. Intended Audience
  - 1.3. Abbreviations
2. Overall System Description
  - 2.1. Project Background
  - 2.2. Project Scope
  - 2.3. Not In Scope
  - 2.4. Project Objectives
  - 2.5. Stakeholders
  - 2.6. Operating Environment
  - 2.7. System Constraints
  - 2.8. Assumptions & Dependencies
3. External Interface Requirements
  - 3.1. Hardware Interfaces
  - 3.2. Software Interfaces
  - 3.3. Communications Interfaces
4. Functional Requirements
  - 4.1. Functional Hierarchy
  - 4.2. Use Cases
    - 4.2.1. [use case 1]
    - 4.2.2. [use case 2]
    - 4.2.n. [use case n]
5. Non-functional Requirements
  - 5.1. Performance Requirements
  - 5.2. Safety Requirements
  - 5.3. Security Requirements
  - 5.4. User Documentation
6. References



## **A3. DESIGN SPECIFICATIONS**

Any standard template may be used, as per project need approved by Project Coordinator & Supervisor. Following is a suggestive outline.

- 1 Introduction
  - 1.1 Purpose of Document
  - 1.2 Intended Audience
  - 1.3 Project Overview
  - 1.4 Scope
- 2 Design Considerations
  - 2.1 Assumptions and Dependencies
  - 2.2 Risks and Volatile Areas
- 3 System Architecture
  - 3.1 System Level Architecture
  - 3.2 Software Architecture
- 4 Design Strategy
- 5 Detailed System Design
  - 5.1 Database Design
    - 5.1.1 ER Diagram
    - 5.1.2 Data Dictionary
      - 5.1.2.1 Data 1
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- 6 References

## **A4. OTHER TECHNICAL DETAIL DOCUMENTS**

**Test Cases Document**

**UI/UX Detail Document**

**Coding Standards Document**

**Project Policy Document**

**User Manual Document**

## **A5. FLYER & POSTER DESIGN**

**A6. COPY OF EVALUATION COMMENTS**  
**COPY OF EVALUATION COMMENTS BY SUPERVISOR**  
**FOR PROJECT – I MID SEMESTER EVALUATION**

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## **COPY OF EVALUATION COMMENTS BY JURY FOR PROJECT – I END SEMESTER EVALUATION**

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## **COPY OF EVALUATION COMMENTS BY SUPERVISOR FOR PROJECT – II MID SEMESTER EVALUATION**

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## **A7. MEETINGS' MINUTES & Sign-Off Sheet**

Original Documents should be placed when submitting document to Project Coordinator.

Document should be signed by the supervisor and all other members present in the meeting (wherever possible). (**Note:** Please remove this line when attach copy that is required)

Weekly meetings' minutes are required (held with Supervisor and/or with client). Important group discussions can also be included here.

## A8. DOCUMENT CHANGE RECORD

Date	Version	Author	Change Details



## **A9. PROJECT PROGRESS**

Photostat of Incremental versions of Requirement Signoff sheet submitted to Project Coordinator. (**Note:** Please remove this line when attach copy that is required)

## **A10. RESEARCH PAPER**