

Domain: Sustainability and Green Economy

Problem Statement: Campus Energy & Renewables Management Platform

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PREFACE

With increasing energy demands and rising environmental concerns, campuses are required to adopt efficient energy management and sustainable practices. Educational institutions consist of multiple buildings with varied energy consumption patterns, making manual monitoring inefficient and inaccurate.

The Campus Energy & Renewables Management Platform is designed to provide a centralized system for monitoring electricity consumption, tracking renewable energy generation, and analyzing sustainability metrics. The platform supports data-driven decision-making, reduces energy wastage, and promotes alignment with green economy principles.

Introduction

2.1 Purpose and Need of System

The purpose of the Campus Energy & Renewables Management Platform is to enable effective monitoring and management of energy usage and renewable energy generation across a campus.

The need for this system arises due to:

- Lack of real-time visibility into campus energy consumption.
- Difficulty in identifying energy wastage and abnormal usage.
- Absence of a unified platform to track renewable energy generation.
- Increasing importance of carbon footprint measurement and sustainability reporting.

This system addresses these challenges by automating data collection, analysis, and reporting.

2.2 System Overview & Scope

The Campus Energy & Renewables Management Platform is a web-based application that collects and analyzes energy consumption data from campus buildings and meters. It also tracks renewable energy generation such as rooftop solar systems and calculates net energy usage.

The scope of the system includes:

- User authentication and role-based access
- Building and meter-level energy monitoring
- Renewable energy tracking
- Cost and carbon footprint estimation
- Anomaly detection and alerts
- Report generation and data visualization

User Requirements Definition

The system must satisfy the following user requirements:

- Users shall be able to securely log in based on assigned roles
- Administrators shall manage users, buildings, and meters
- Facility managers shall view detailed energy consumption dashboards
- Sustainability officers shall track renewable energy and emissions
- Department heads shall access department-level energy reports
- Users shall receive alerts for abnormal energy usage
- Users shall be able to generate and download energy and sustainability reports

System Requirements Specification

4.1 Functional Requirements

FR-01: User and Role Management

The system shall allow administrators to create, update, and manage user accounts and assign appropriate roles and permissions.

FR-02: Building and Meter Management

The system shall enable administrators to add, update, and manage campus buildings and associated energy meters.

FR-03: Energy Data Management

The system shall store, process, and manage energy consumption data collected from various meters.

FR-04: Energy Consumption Visualization

The system shall display energy consumption data through interactive charts, graphs, and dashboards.

FR-05: Renewable Energy Tracking

The system shall monitor renewable energy generation and calculate net energy consumption.

FR-06: Cost Calculation

The system shall calculate electricity costs based on recorded energy consumption data.

FR-07: Carbon Footprint Estimation

The system shall estimate carbon emissions associated with energy usage.

FR-08: Anomaly Detection

The system shall identify abnormal energy consumption patterns and notify authorized users.

FR-9: Report Generation

The system shall generate downloadable energy, cost, and sustainability reports for analysis and compliance.

4.2 Non-Functional Requirements

NFR-01: Usability

The system shall provide a user-friendly and intuitive interface suitable for all user roles.

NFR-02: Performance

The system shall respond to user requests within acceptable time limits under normal operating conditions.

NFR-03: Security

The system shall ensure secure authentication, authorization, and protection of user and energy data.

NFR-04: Reliability

The system shall operate consistently without unexpected failures or data loss.

NFR-05: Scalability

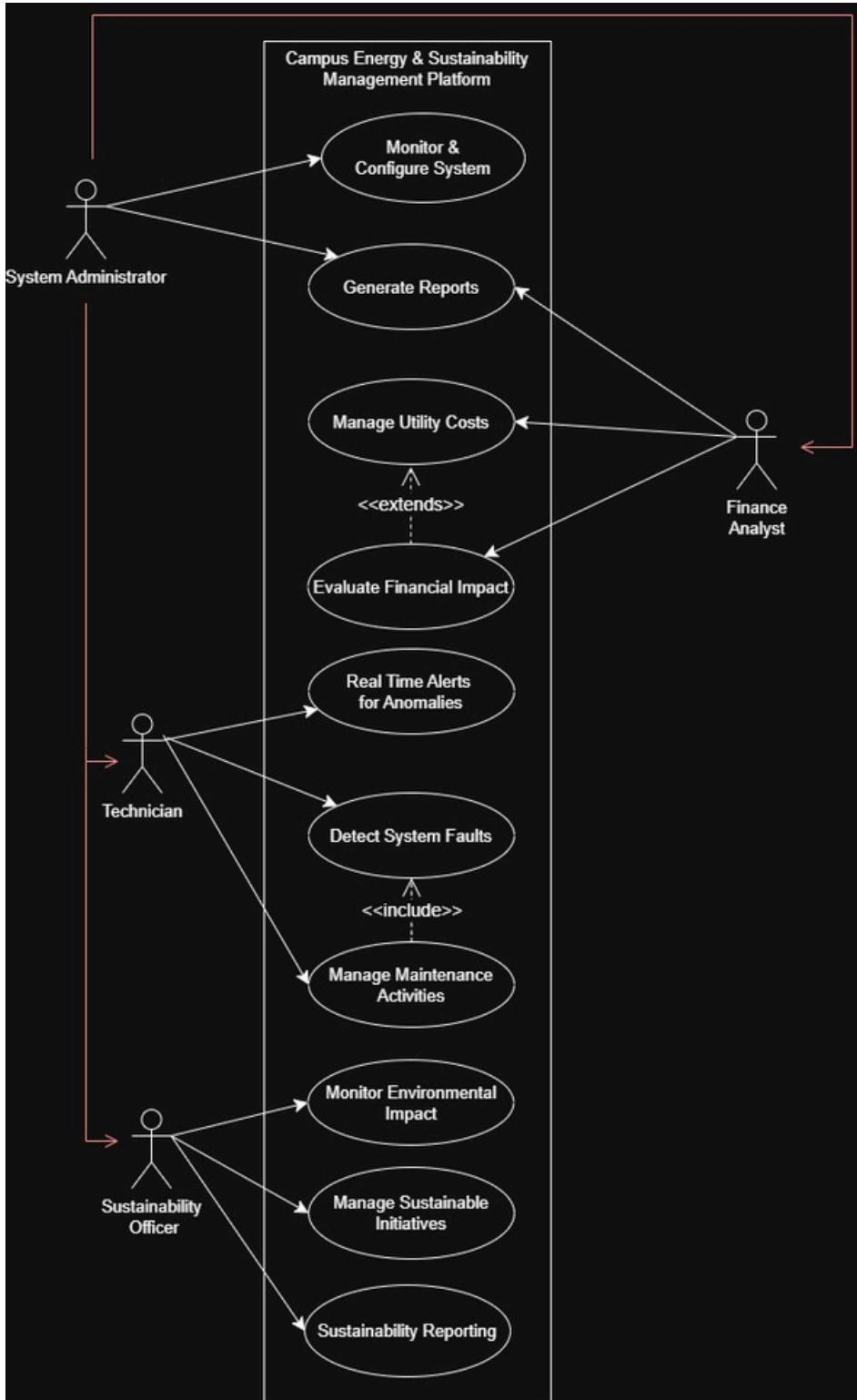
The system shall support future expansion of campus buildings, users, and energy meters without performance degradation.

NFR-06: Maintainability

The system shall be designed in a modular and well-documented manner to support easy maintenance and future enhancements.

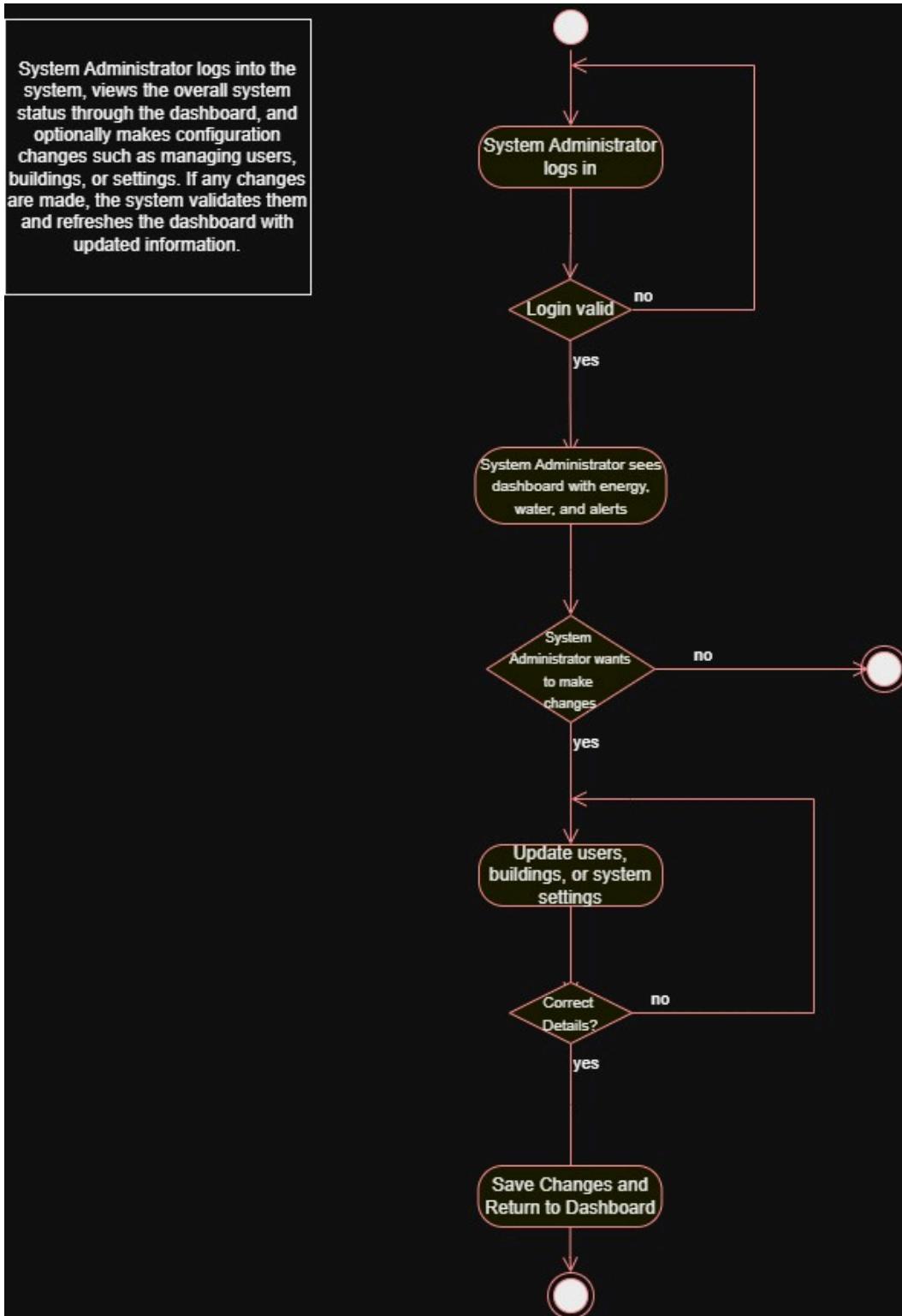
System Models

5.1 Use Case Diagram

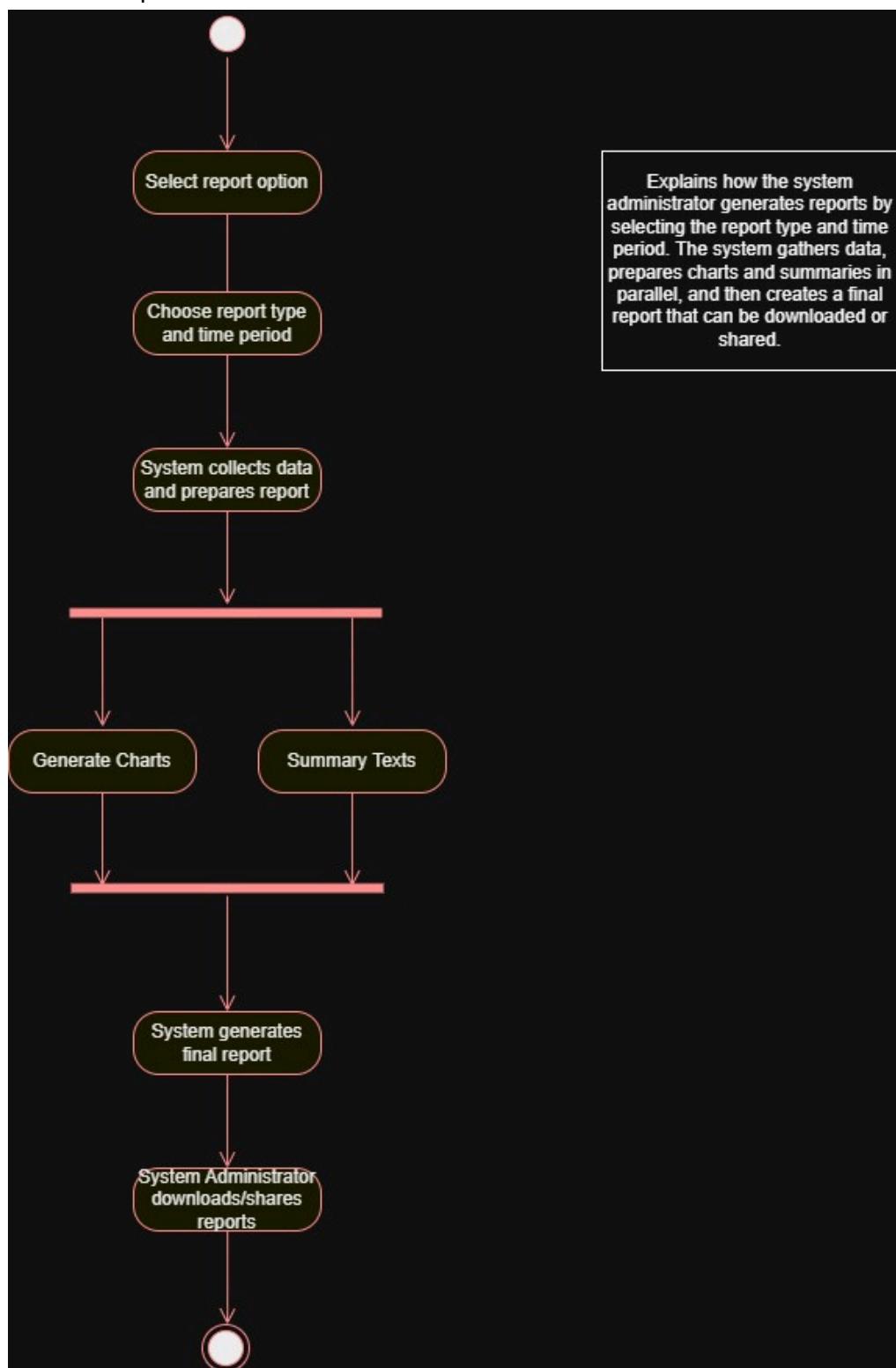


5.2 Activity Diagrams

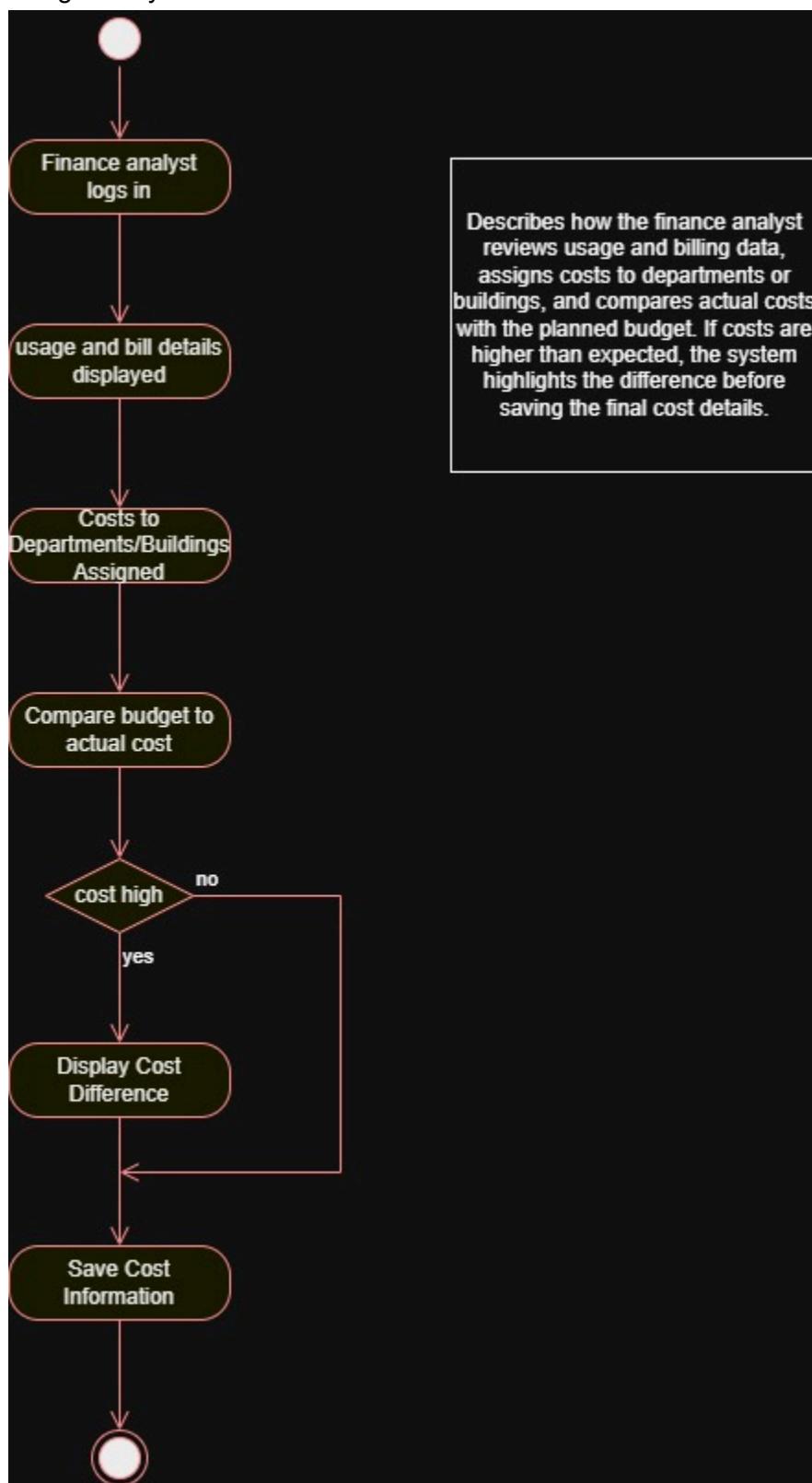
a) Monitor&ConfigureSystem



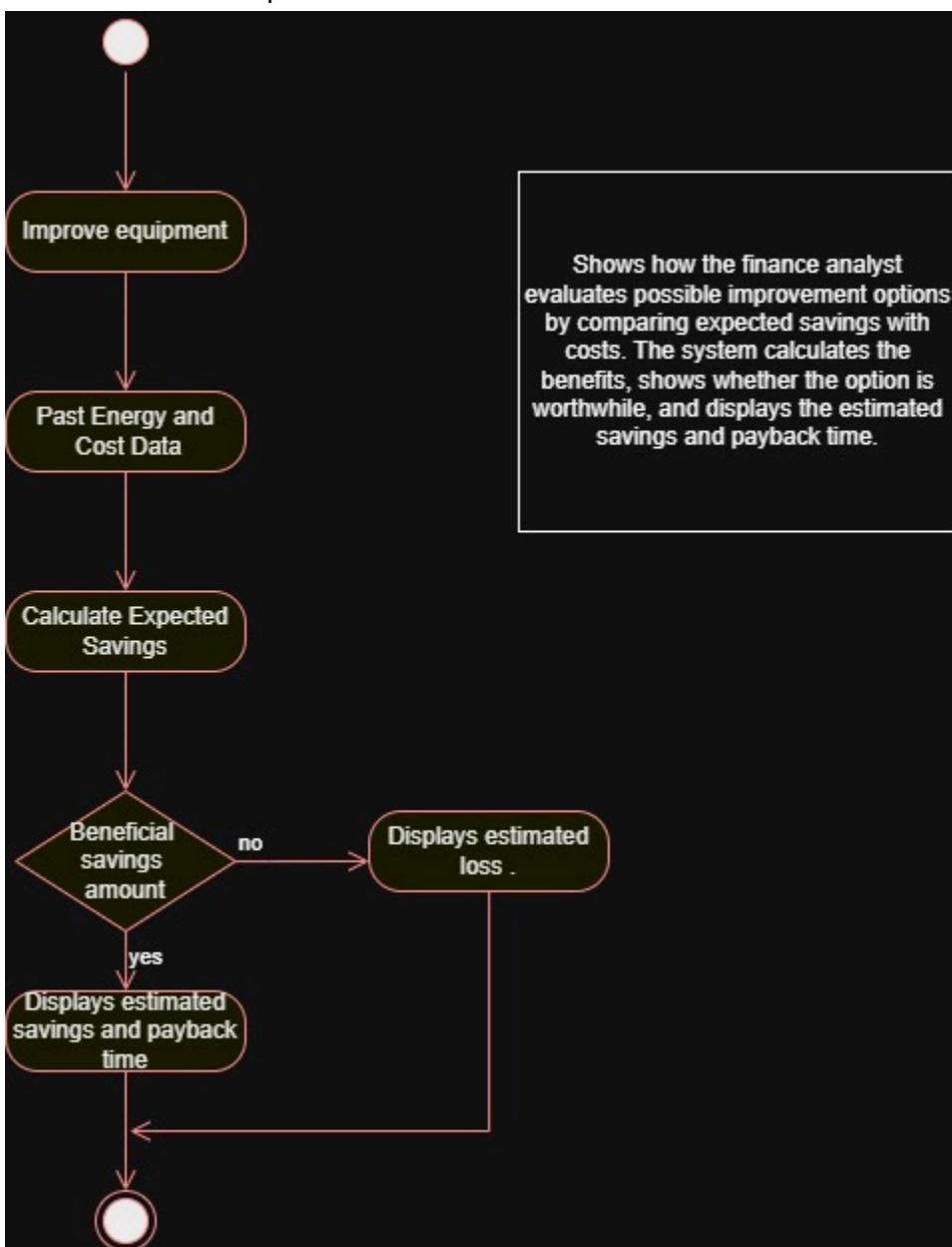
b) Generate Reports



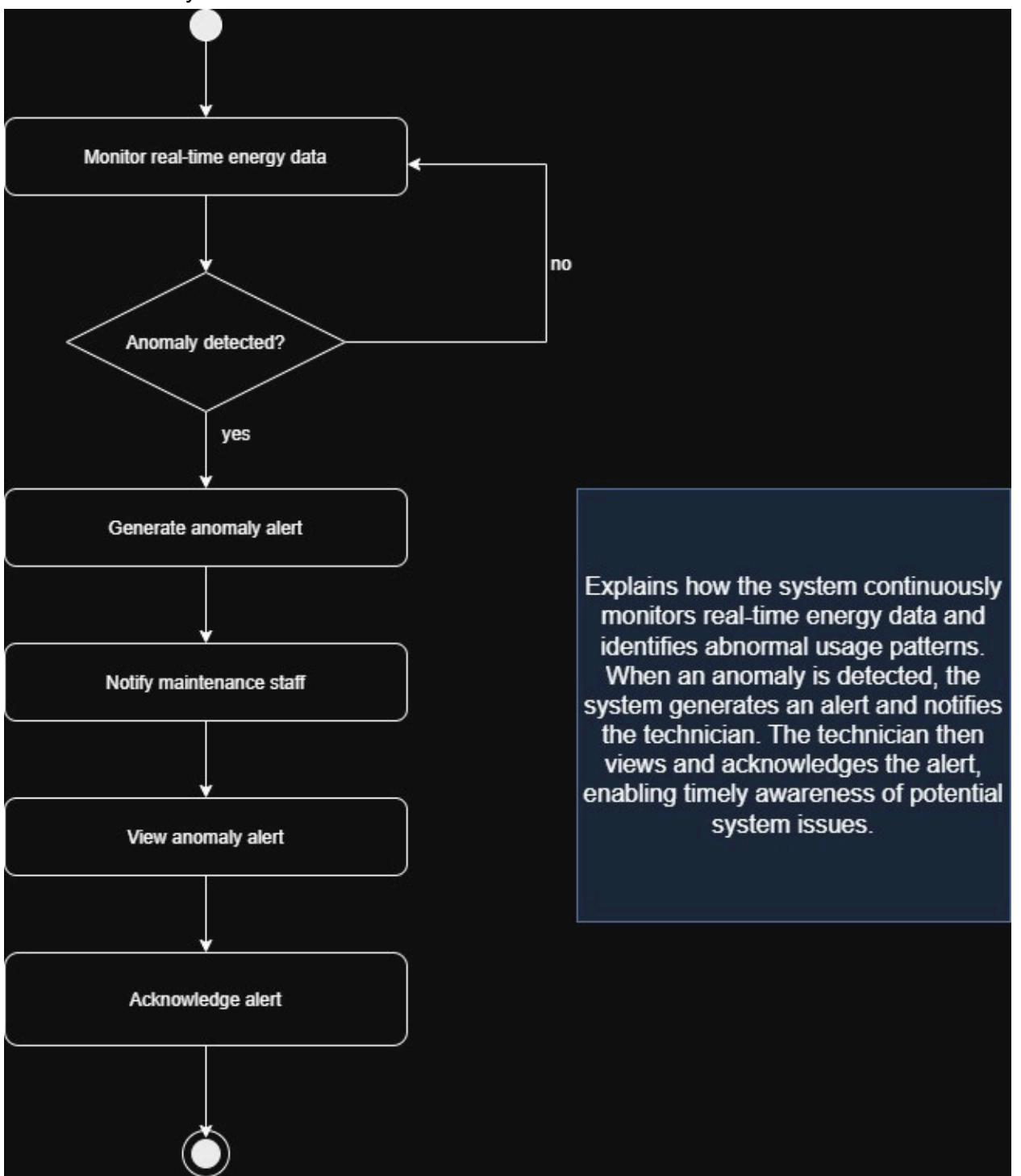
c) Manage Utility Costs



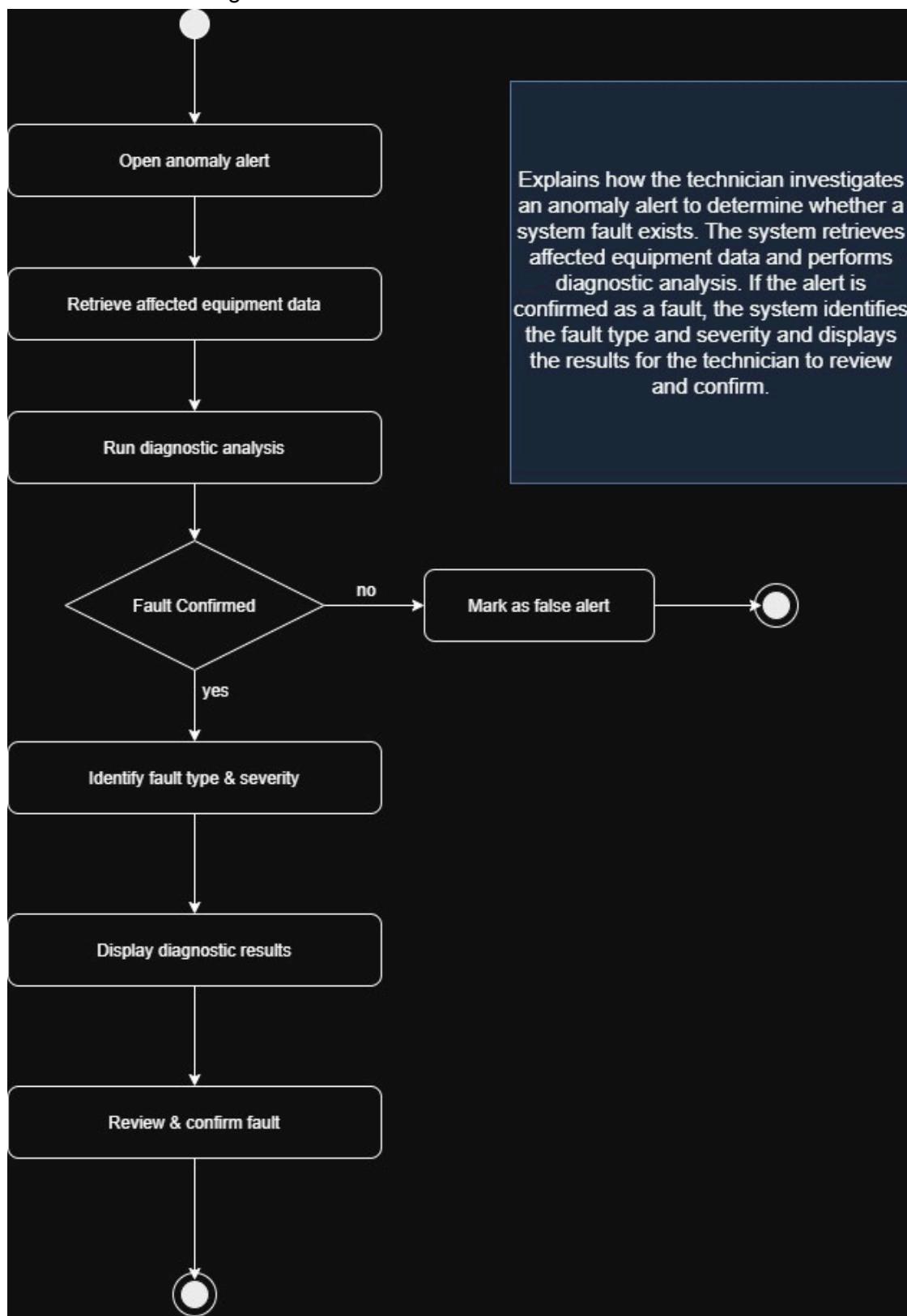
d) Evaluate Financial Impact



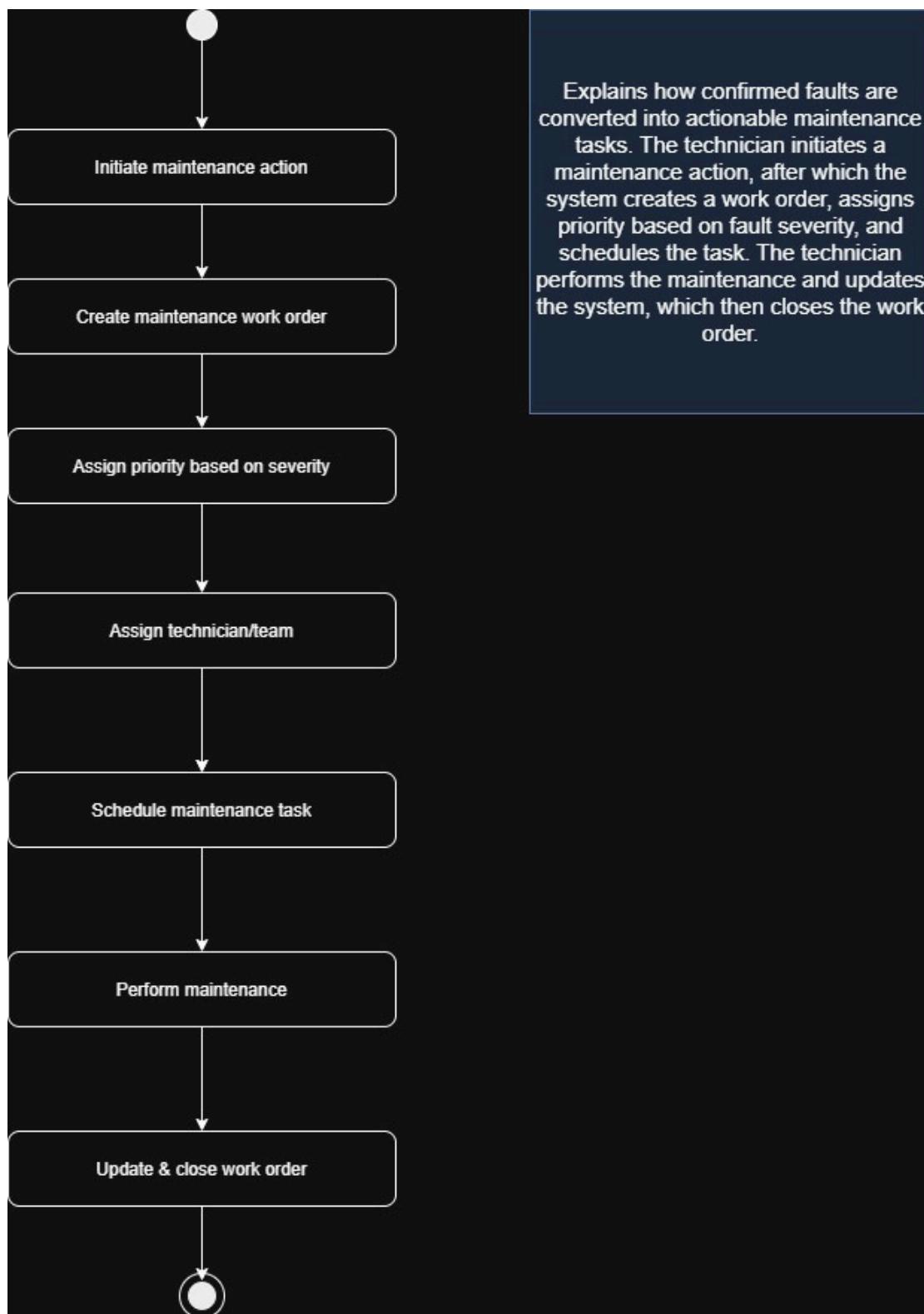
e) Real-Time Anomaly Alerts



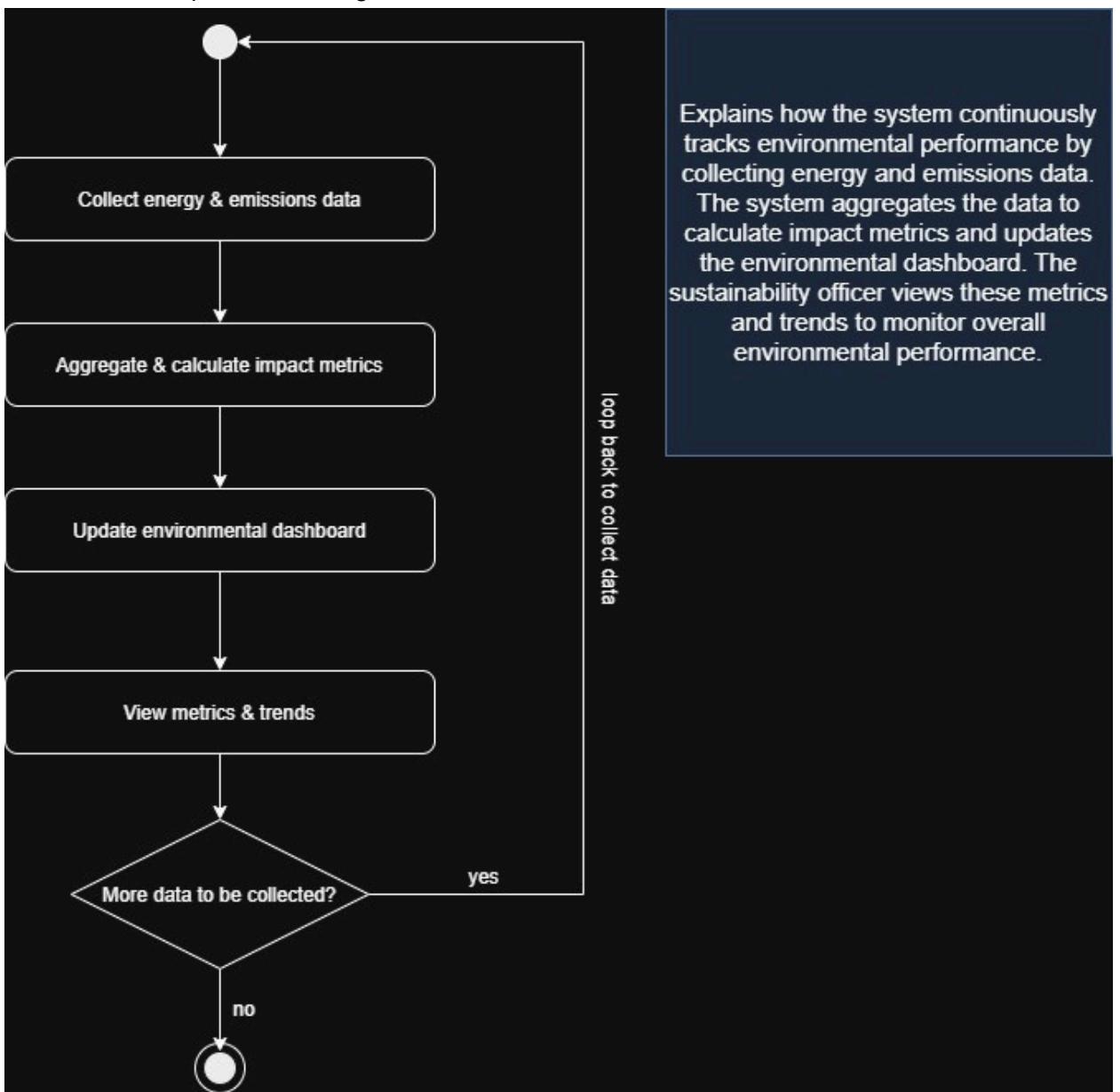
f) Fault Detection & Diagnostics



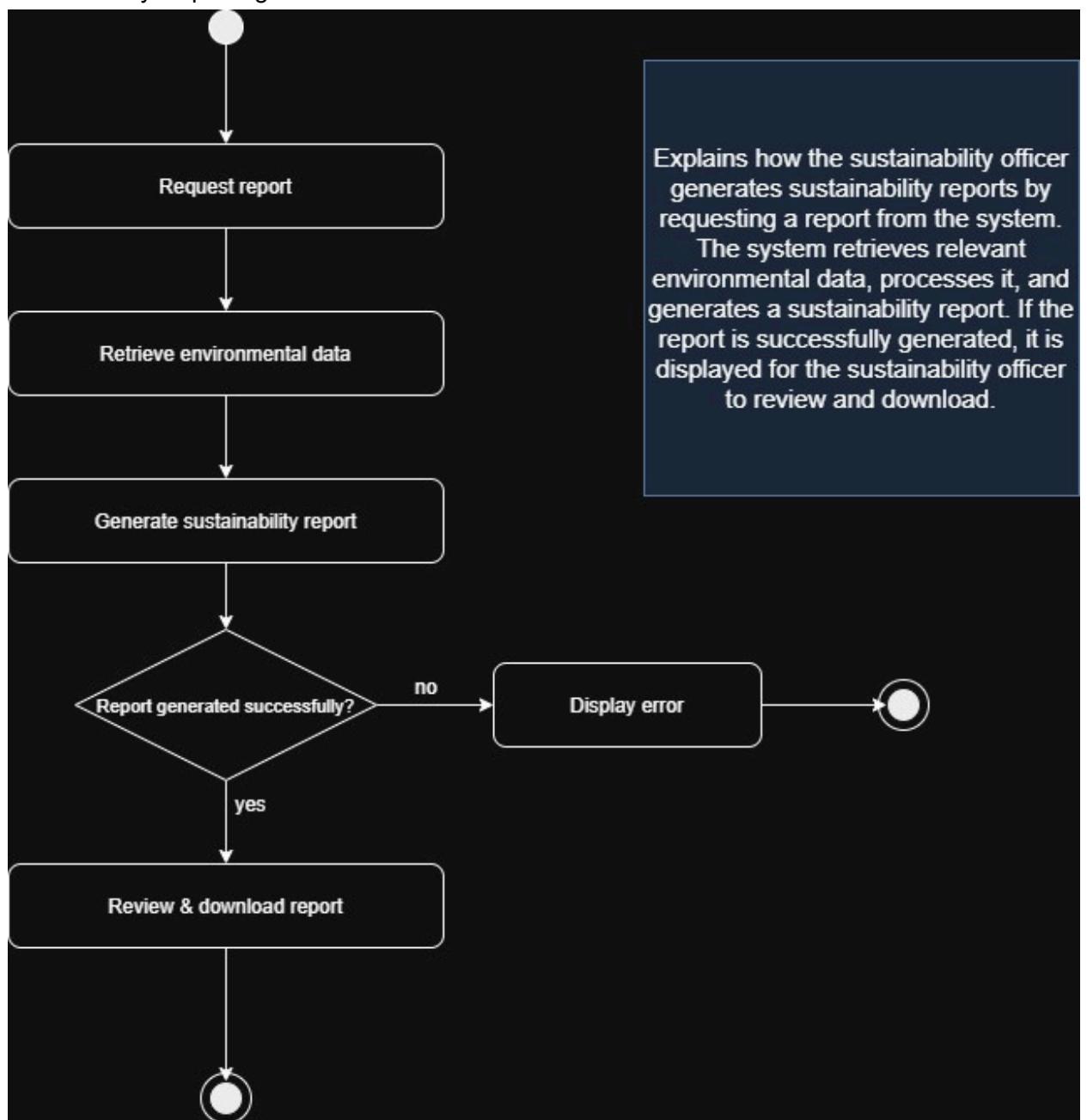
g) Maintenance Work Orders



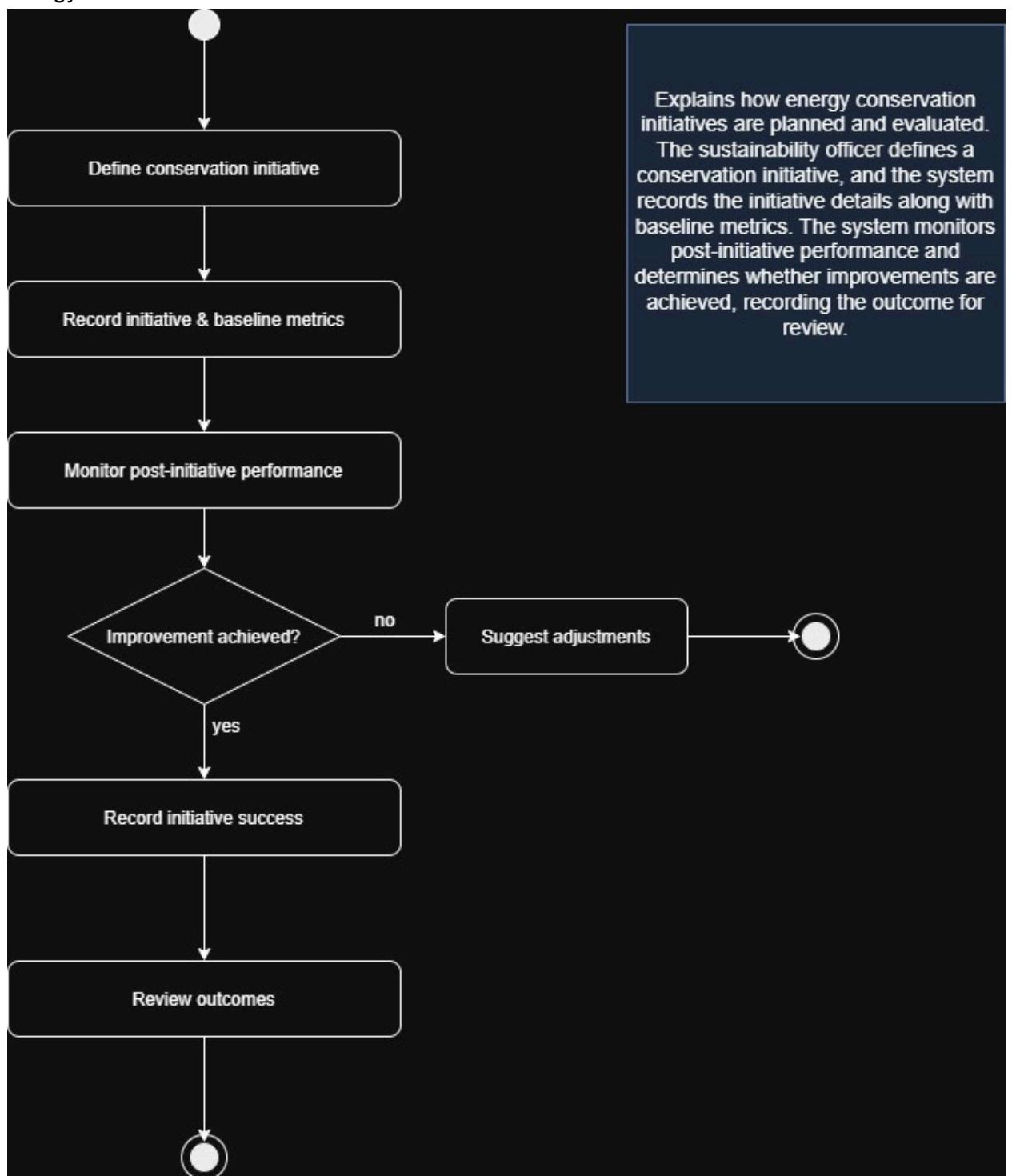
h) Environmental Impact Monitoring



i) Sustainability Reporting

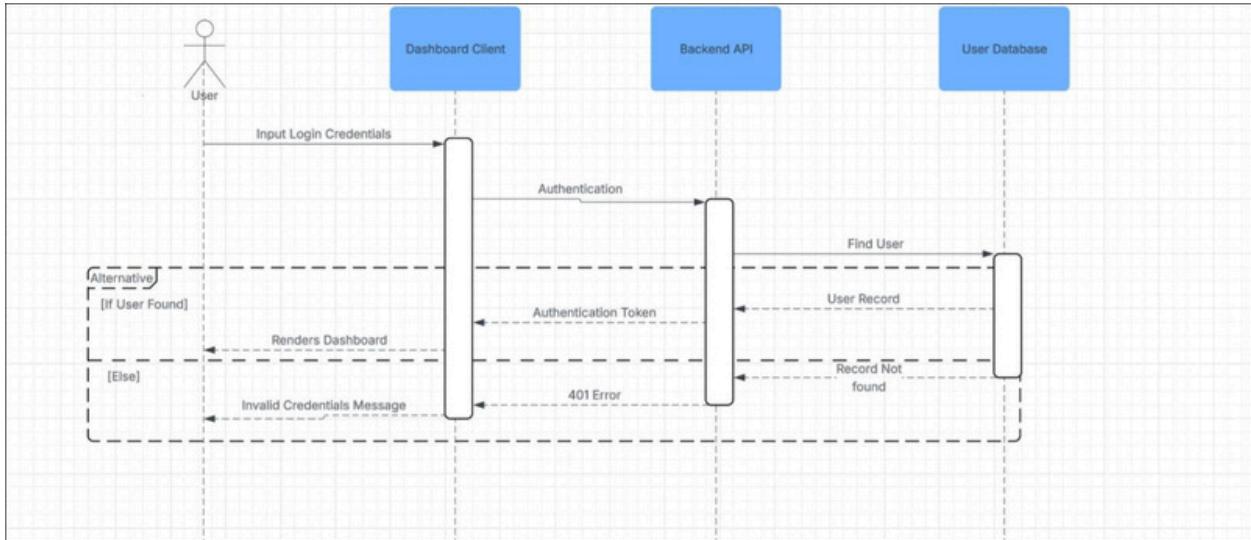


j) Energy Conservation Initiatives

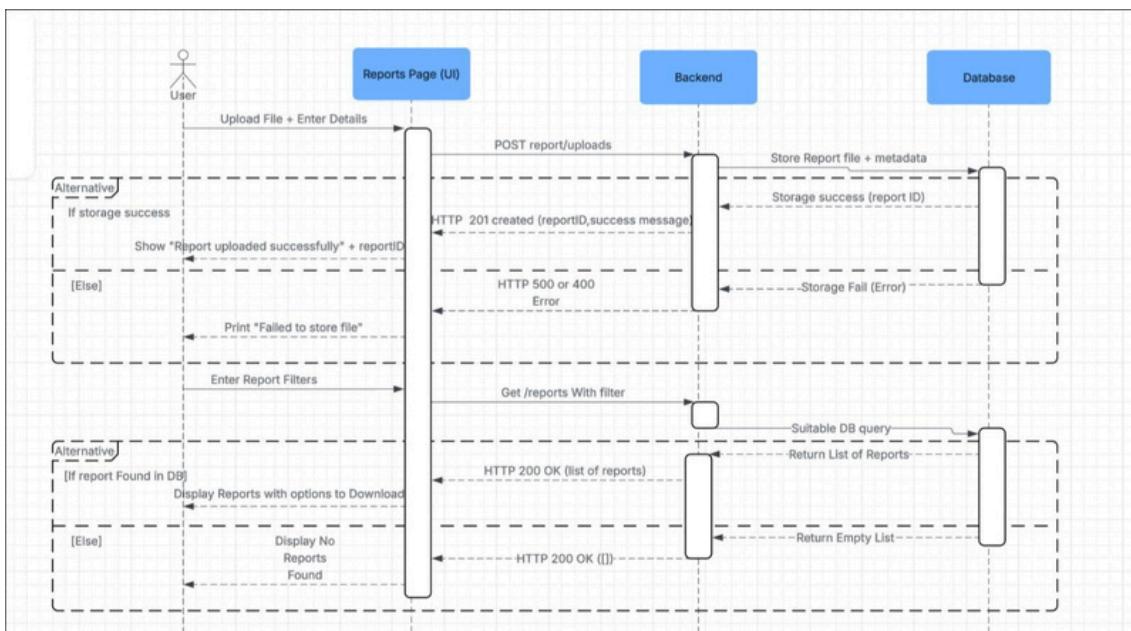


5.3 Sequence Diagram

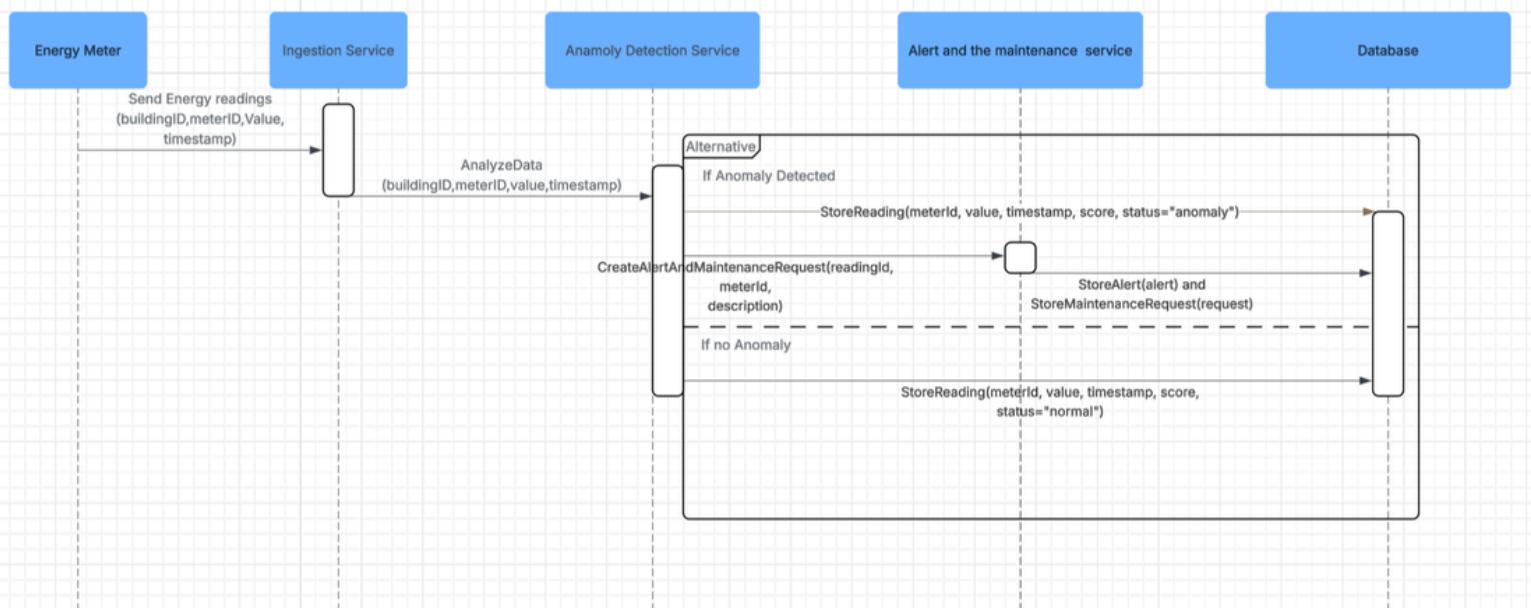
- a) The user enters login credentials in the Dashboard Client, which forwards the request to the Backend API for authentication by checking the User Database; if the user is validated, an authentication token is issued and the dashboard is displayed, otherwise a 401 error is returned and an invalid credentials message is shown.



- b) The user uploads a report and enters details on the Reports Page, which sends the data to the backend for storage in the database. If the storage is successful, a success message with a report ID is returned; otherwise, an error message is shown. The user can also apply filters to retrieve reports, where the backend queries the database and either displays the available reports or shows that no reports were found.



- c) This sequence diagram shows how incoming energy readings from IoT meters are processed in real time. The Data Ingestion Service forwards each reading to the Anomaly Detection Service, which calculates an anomaly score and stores the reading in the time-series database as either normal or anomalous. If the score exceeds a threshold, the service also triggers the Alert & Maintenance Service to create an alert and maintenance request, which are saved in the database for further action.



- d) This sequence diagram shows how maintenance staff handle energy-related alerts and work orders created by the system. The Maintenance Staff use the Dashboard Client to view open maintenance requests fetched from the Backend API, which queries the database. They then update the status of a selected request (for example, In Progress, On Hold, or Completed) with notes; the Backend API saves these changes in the database and the updated status is reflected back on the dashboard.

