

BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF COMPUTER SCIENCE



FUEL COUPON MANAGEMENT WITH AI INFERENCE.

CASE STUDY OF PETROTRADE.

BY

CHIEDZA KAGANDE (B211136B)

**A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE
REQUIREMENTS FOR A BACHELOR OF SOFTWARE ENGINEERING HONOURS
DEGREE AT BINDURA UNIVERSITY OF SCIENCE EDUCATION. FACULTY OF
SCIENCE AND ENGINEERING**

Approval Form

The undersigned certify that they have supervised the student Chiedza Kagande's dissertation entitled, "Fuel Coupon Management with AI inference", submitted in partial fulfillment of the requirements for a Bachelor of Software Engineering Honors Degree at Bindura University of Science Education.

STUDENT:

DATE:

...Chiedza Kagande.....

12/08/2025



SUPERVISOR:

DATE:

...G. MHLANGA.....

12/08/2025



CHAIRPERSON:

DATE:

..Mr P Chaka.....

13/08/2025



Dedication

I dedicate this project to my mother.

Thank you mum, for every prayer, every sacrifice you made, believing in me and cheering me to keep going.

To my family members, thank you for understanding, patience and words of advice. Those words kept me going through the difficult times. Your efforts did not go unnoticed.

Thank you for being my biggest cheerleaders. This accomplishment is a reflection of your love and support.

Acknowledgements

Completing this project has been a roller coaster journey and I want to take a moment to express my gratitude to every individual who made the journey much easier.

I would like to thank my supervisors Mr Mhlanga and Dr Kanyongo. Your guidance and feedback have been a compass throughout the process. From the project proposals up to the final submission you were mentoring me, I appreciate your patience and encouragement.

I am grateful to Bindura University of Science Education for creating an environment, resources and infrastructure necessary for this research.

A special thank you to my friends Glennis Vimbiso Mtisi, Polite Tanyanyiwa, Tawanda (Jotach) Chisero, Timothy Chitakashira, and Tanaka Dube for their support throughout the research. It was not an easy journey but you made it endurable through your support and words of encouragements. I did not give up because of your support, you were there when I needed you.

Abstract

This research demonstrates the design and implementation of a Fuel Coupon Management System with AI Inference, PetroTrade as a case study. Traditional methods are often prone to inadequacies, fraud, poor decision making and they do not promote real-time monitoring. To address these challenges, the propose system made use of artificial intelligence to validate and enhance fuel distribution. The integration of the Random Forest model has made the decision making process easier to the admins due to its simplicity. The system consists of a web-based interface for administrators and a mobile application for customers. Through iterative development and stakeholder involvement, the system was tested against real-world expectations, demonstrating significant improvements in data accuracy and efficiency. This study signifies the importance of AI-powered systems not only to PetroTrade but other sectors that will be facing the same challenges.

Table of Contents

Approval Form	ii
Dedication.....	iii
Acknowledgements.....	iv
Abstract.....	v
Abbreviation	1
Chapter 1: Problem Identification	2
1.1 Introduction	2
1.2 Background of the study	3
1.3 Statement of the Problem	5
1.4 Research Objectives	5
1.5 Research Questions	6
1.6 Research Hypothesis	6
1.7 Significance of the study	6
1.7.1 Significance to Customers	6
1.7.2 Significance to the Filling Station	7
1.8 Assumption	8
1.9 Limitations	8
1.10 Scope	9
1.11 Definition of Terms	9
Chapter 2: Literature Review	10
2.0 Introduction	10
2.1 Fuel Management System	11
2.1.0 Empirical Study	12
2.1.1 Gaps in Related System	13
2.2 Role of AI in Fuel Management System	14
2.2.0 AI Techniques	15
2.2.1 Random Forest Algorithm	17
2.3 Gaps in the Current Systems	17
2.4 Future Trends	18
2.5 Summary	19
CHAPTER 3: Research Methodologies	19
3.0 Introduction	19

3.1	Research Design	20
3.1.0	Qualitative Research.....	20
3.1.1	Quantitative Research	20
3.2	Requirements Analysis	21
3.2.0	Functional Requirements	22
3.2.1	Non-functional Requirements.....	23
3.2.2	Software Requirements	23
3.2.3	Hardware Requirements	24
3.3	System Flowchart.....	24
3.4	System Development	25
3.4.0	Prototype.....	28
3.5	Data Collection Methods	30
3.5.0	Questionnaires.....	30
3.6	System Development Tools.....	32
3.7	Validation and Verification	33
3.8	Limitation of Methodology.....	33
3.9	Summary.....	34
Chapter 4: Data Presentation, Analysis, and Interpretation.		35
4.0	Introduction.....	35
4.1	Validation and Verification.....	35
4.1.0	Validation	35
4.1.2	Verification	37
4.2	System Testing Overview	38
4.3	Real-time Coupon Issuance Performance.....	41
4.4	Evaluation of the Analytic Dashboard.....	43
4.5	AI model evaluation.....	45
4.6	Summary.....	47
Chapter 5: Conclusions and Recommendations		47
5.0	Introduction.....	48
5.1	Aim and Objective Realization	48
5.2	Challenges Faced.....	48
5.3	Recommendations	49
5.4	Conclusion	50

Works Cited	51
-------------------	----

LIST OF FIGURES

FIGURE 1: "SYSTEM FLOWCHART"	24
FIGURE 2: "WATERFALL MODEL"	25
FIGURE 3 "PROTOTYPE"	29
FIGURE 4 "QUESTIONNAIRE 1"	31
FIGURE 5 "QUESTIONNAIRE 2"	31
FIGURE 6 "QUESTIONNAIRE 3"	32
FIGURE 7 "ACCOUNT VALIDATION"	36
FIGURE 8 "COUPON VALIDATION"	36
FIGURE 9 "ACCOUNT CREATION"	37
FIGURE 10 "LOGIN FORM"	38
FIGURE 11 "COUPON GENERATION"	39
FIGURE 12 "FAILED LOGIN"	40
FIGURE 13 "STAFF LOGIN"	40
FIGURE 14 "WELCOME PAGE"	41
FIGURE 15 FUEL CONSUMPTION"	43
FIGURE 16 "REDEEMED COUPON GRAPH"	44
FIGURE 17 "PREDICTIONS"	45

Abbreviation

AI – Artificial Intelligence

ML – Machine Learning

IoT – Internet of Things

KPIs – Key Performance Indicators

Chapter 1: Problem Identification.

1.1 Introduction.

The main objective for a successful business is to maximize operational efficiencies, especially in sectors that deal with fuel. Mostly inefficiency in the fuel sector can result in increase in operational costs and financial losses unlike ineffective which causes errors, fraud and lack of transparency. The use of traditional methods that are based on paperwork for data storing results in losses. (Balla, 2024). The use of these traditional methods are time consuming and they rely much on human judgement. However, human judgement varies due to different cases such as level of qualification and experience. This can lead to inaccuracy and inconsistency which makes it difficult to optimize fuel usage.

The author aims to address these challenges by introducing a Fuel Coupon Management System powered by AI inference. The system focuses on fuel coupon issuance in real-time to Petrotrade customers, improved human errors in the organization and a real-time monitoring dashboard for fuel tracking. Real-time fuel coupon issuance improve efficiency and eliminate constraints that are associated with manual fuel coupon distribution. A real-time monitoring dashboard helps to identify fuel trends and it makes data-driven decisions easier to optimize fuel utilization (Navleb, 2024). To add on the above information, the system will also reduce data entry errors as data will be captured automatically and already validated. This will ensure data accuracy and reliability.

Artificial Intelligence (AI) has become a game changer in the day-to-day running of businesses as it enhances accuracy and reliability, increased efficiencies and AI helps to forecast consumptions in real-time which helps to make data-driven decisions. This will help businesses to attain their objectives thereby improving how they operate. The use of a real-time monitoring dashboard combined with human intelligence, businesses can forecast fuel consumption ahead of time.

In summary, this research highlights the significance of adopting a Fuel Coupon Management System with AI inference to PetroTrade. By addressing operational inefficiencies that comes with the use of paper work, the system gives a better solution that increases operational efficiencies,

improve transparency and accuracy. With the use of an AI-powered system, PetroTrade will be able manage resource allocation thereby gaining a competitive advantage.

1.2 Background of the study

The demand for fuel around the world has increased with an estimated value of 4.9 billion liters of gasoline and diesel each day (Kalghati, 2019). Fuel is said to be the one with the largest operational cost in the day to day running of the business. Despite this, some of the businesses do not see the need of better way to manage their operational costs (Balla, 2024). Around the world, businesses are taking the advantage of new technologies being introduced each day, some of their processes are now automated, but the energy sector is being left out due to the use of traditional methods, it is hard to make data-driven decisions and to estimate future trends. (Takyar, 2024).

Fuel car systems were introduced in the early 1980 such as Comdata, which was launched in 1981. When the system was introduced, fuel customers were mesmerized such that it was easy for them to adapt to this new system. Customers were now able to manage how they consume fuel. Although this was good to fuel users, it was difficult for managers who were recording the transactions as the process was paper-based. Before fuel cards were introduced, fuel customers were using credit cards to purchase fuel, then master cards came later on as a new way of purchasing fuel(Suizo, 2013).

In the early days, fuel management was based on paperwork and guesswork. There was too much use of paper work and human labor which often cause errors. Managers moved from the use of logbooks to enter data when distributing and using fuel and analyze the data manually to draw conclusions and check for future trends. This process was vulnerable to fraud and errors caused by humans, therefore it was difficult to make correct conclusions and forecast future trends due to missing data. The use of these methods had caused many business to close up due to too much losses as a result of biased information (Nollora, 2025)

In Australia, Banlaw System is being used to manage fuel, this system is being used in Europe as well as Cameroon. The system was developed to enhance accuracy, security and accountability in fuel management. Banlaw tackles different issues such as fuel theft, human error due to traditional methods of record keeping and data inaccuracies. The automation of fuel tracking and fuel

management, enhances accuracy when monitoring fuel usage and consumption for businesses like mining, farming and fishing which are commonly in Cameroon. By using of Banlaw system, businesses can manage their operations more effective and efficient. The system also help to improve employee's accountability, thereby making the business more productive (Banlaw, 2025).

In 1993, Czech Republic established the Gasnet system which is an automated system that helps to manage fuel consumption. The system's primary aim is to monitor fuel related transaction and manage fuel stations as well and the system enables real-time remote fuel control. The system was launched in Nigeria in 2017. Due to the system's automated functionalities, it has transformed fuel consumption for the better. According to GasNet (2021), the system has reduced fuel theft by worker with then an estimated percent at 87%, operational expenses were reduced with 58%, and sales has increased with 68% as a result of customer satisfaction. These percentages show how Gasnet has enhanced transparency, reduce loss and boost profit in the fuel sector of Nigeria.

The Chronicle (2021) highlights the greater changes in the availability of diesel and petrol around Zimbabwe in 2021. Long queues that were once caused by fuel shortages has ended. Despite the increased supply of fuel in filling stations, not everyone benefited from it as filling stations were now selling fuel in foreign currency leaving those without foreign currency out. To address this problem, the Zimbabwean government ended up giving some of the service stations funds so that they could sell fuel in local currency, their goal was to make fuel more accessible to everyone. However, the solution introduced another challenge, some individuals started buying fuel using local currency then sale in the black market, charging foreign currency. This affected the intended benefits of selling fuel at filling stations with local currency. The writer emphasized that fuel stations are supposed to make use of the National Fuel Management System. The system can help filling stations to regulate fuel distribution, prevent unfairness and ensure that everyone get access to fuel with the intended price and currency.

In 2020, fuel stations failed to deliver what they had promised to their customers that had purchased fuel coupons. Due to high levels of inflation rates, prices were changing each and every day. As a result, customers were issued half the expected amount of fuel they expected that is to say for a 20l fuel coupon customers were redeeming on 10l. "The situation ended up appearing as a take it or leave it type of a situation" (The Herald, 2020). Customer ended up agreeing to what the filling stations were saying as they needed the fuel for their businesses (The Herald, 2020).

In summary, the adoption of a Fuel Coupon Management with AI inference comes with many perks to PetroTrade filling stations. Besides cost saving through printing hard copy fuel coupons, the system helps to forecast future fuel trends based on the Fuel Attendant's location considering how much fuel has been consumed in the last month. This system will also help to avoid situation like the one that occurred in 2020 as customers will be able to purchase coupon whenever they want to use them.

1.3 Statement of the Problem

Due to PetroTrade's reliance on traditional methods such as paper based methods to track and record fuel transactions has resulted in operational inefficiencies, poor decision and difficulties in monitoring fuel usages in real time. It is difficult to navigate through piles of paper to write reports and draw decisions due to how tiring the process is. To make data-driven decisions, the use of clean data is very important, which means it must be meaningful without any missing information. However, with the use of paper based system, one can forget to enter the accurate date on which the coupon was issued. Lack of accurate data results in the unreliability of data which might result in poor decision making. The analysis of paper based data is very tiring and time consuming, this will cause some of the information to be left out as individual will be tired to navigate through all the papers to compile reports. This will result in biased conclusions because they will be drawn from incomplete information. On the other hand, by adopting Fuel Coupon Management System with AI inference, PetroTrade can easily see future fuel trends based on the amount of fuel that consumers have consumed the month before. Embracing this system will help PetroTrade to gain competitive advantage and increase customer satisfaction.

1.4 Research Objectives

1. To develop a fuel management system that enhances fuel coupon issuance in real-time based on the customer's account balance.
2. To implement an analytics dashboard that provides real-time reporting of fuel coupon usage.

3. To develop an AI-driven fuel demand forecasting system that analyzes historical usage patterns to accurately predict future fuel coupon requirements based on fuel attendant location.

1.5 Research Questions

1. To what extent does an automated real-time coupon issuance system reduce manual data entry errors compared to traditional methods manual methods, and what are the key factors influencing its effectiveness? For example, user training.
2. How can an AI-powered analytics dashboard be designed to provide real-time reporting of fuel coupon usage?
3. How can AI-driven forecasting system leverage historical fuel usage patterns to accurately predict future fuel demand?

1.6 Research Hypothesis

H₀: There is a greater significance with the use of a fuel management system with AI inference to PetroTrade.

H₁: There is no significance with the use fuel management system with AI inference to Petrotrade.

1.7 Significance of the study

1.7.1 Significance to Customers

In an age of rapid technological advancement, relying on outdated methods for fuel coupon acquisition creates significant inefficiencies and discomfort. For PetroTrade customers, the process of physical visitation to a filling station to get fuel coupons is not only time consuming but also disadvantage individuals that are trying to utilize the little time that they per day. So visiting

a filling station to request for fuel coupons will then become inconvenient. The use of a Fuel Coupon Management System holds great value to customers, as it allows them to purchase fuel coupons online, substituting the need for physical visits, especially for customers in remote areas where physical coupon availability is limited. With a real-time system in place, customers can easily plan and budget their fuel expenses by paying in advance, ensuring they always have access to fuel when needed. However, not everyone will immediately recognize the benefits of such a system. Some individuals might find it hard to adopt the concept of paying for fuel in advance, which might affect them when they attempt to request coupons without sufficient funds. Despite this, the overall advantages of a fuel management system are convenience, accessibility and improved budgeting making it a crucial step forward in meeting the needs of modern customers.

1.7.2 Significance to the Filling Station

Maximizing profits is a universal goal for every organization, and for PetroTrade filling station, the implementation of a Fuel Coupon Management System represents a transformative step toward achieving this objective. The Fuel Coupon Management System acts as a game changer, boosting operational efficiency, elevating customer satisfaction and empowering data-driven decision-making. These errors often lead to inaccuracies in data recording, creating information gaps that can have far-reaching consequences. For instance, important data may be omitted or incorrectly recorded, such as the date of coupon issuance or the quantity of fuel sold. These inaccuracies not only disturb the auditing process but also affect managers' ability to make informed decisions. When data is incomplete or unreliable, managers are forced to base their decisions on partial information, which can lead to unfavorable outcomes.

In this era, customers value usability, speed and reliability. The traditional process of visiting a filling station to purchase fuel coupons is time-consuming and often inconvenient, particularly for customers in remote areas where access to physical coupons may be limited. By transitioning to an automated system, PetroTrade can offer customers the ability to purchase fuel coupons online, eliminating the need for physical visits. This not only saves customers time but also ensures that they have access to fuel coupons whenever they need it, regardless of their location.

Another significant benefit of a Fuel Coupon Management System is its ability to enhance decision-making through data-driven insights. In a manual system, managers often rely on incomplete or outdated information, which can lead to poor decisions and missed opportunities.

In summary, the implementation of a Fuel Coupon Management System is a strategic investment that offers numerous benefits for PetroTrade filling stations. By eliminating human errors, improving accuracy and providing real-time data and insights, the system enhances operational efficiency, customer satisfaction and decision-making processes.

1.8 Assumption

1. The study assumes that both users and the filling station are willing to migrate from the use of hard-copy fuel coupons to the use of online fuel coupons.
2. The researcher assumes that the AI model will be able to give accurate data trends and patterns despite the amount of data provided.
3. The study assumes that the system will be able to respond in real-time in terms of fuel coupon issuances as well as analyzing fuel usage trends.

1.9 Limitations

1. The study might be affected with time. Due to the complexity of implementing AI models in a system. The given time might affect the system's quality.
2. The study might be affected by the amount of data. AI models require vast data for proper data-driven decision-making.
3. Human judgment might be neglected and then end up focusing on the decisions or predictions made by AI models.
4. Users might neglect the use of the system due to fear of the unknown or some might be afraid of job loss.

1.10 Scope

The Fuel Coupon Management System with AI inference includes the development and implementation of a comprehensive solution designed to enhance fuel coupon issuance and provide advanced data analytics capabilities. The system will be focusing on automating the entire process of fuel coupon management, from issuance to redemption, eliminating the inefficiency and errors associated with traditional methods. It will include a user-friendly interface for administration department to see fuel consumption trends and search users when they have purchased coupons. PetroTrade customers will use a mobile application to purchase their fuel coupons whereas PetroTrade managers will be using a desktop web application. The system will also feature a secure and centralized database to store all transaction details, including coupon issuance dates and customer information, enabling seamless tracking and auditing. Additionally, the scope includes the implementation of a reliable data analytics dashboard that provides real-time insights into fuel coupon usage and trends. The analytics component will also incorporate predictive capabilities, leveraging AI to forecast future demand and optimize inventory management.

1.11 Definition of Terms

1. Fuel management: refers to the process of monitoring and controlling fuel consumption through the use of different systems with the aim of usage optimization (Galooli, 2022)
2. Artificial intelligence (AI): refers to a technology that enables computers to carry out tasks imitating human intelligence. For example decision-making (Stryker & Kavlakoglu, 2024).
3. Inference: refers to the process of using an AI model to analyze and generate predictions or perform specific tasks (IBM, 2023).

4. Key performance indicators (KPI): refer to measurable metrics used to evaluate an organization's long-term performance and success (Twin, 2025)
5. Data: consists of raw, unprocessed elements or facts, which can include numerical values, symbolic representation, textual content, and visual (Jain, 2025)
6. AI model: refers to a computer program that employs algorithms to analyze new data and make decisions or predictions (Glover, 2024).
7. Technology: refers to the practical application of scientific knowledge to solve real-world problems and improve human welfare, with the aim of achieving industrial goals (Luenendok, 2023).

Chapter 2: Literature Review

2.0 Introduction

The development of a Fuel Coupon Management with AI Inference helps organization or business that deals with fuel. The system will help to address problems that comes as a result of using manual methods when monitoring and managing fuel consumption at PetroTrade. The fuel industry deals with large datasets, navigating through the data on paper is very tiring and time consuming and this call for an automated system to help with such tasks. Usually traditional methods result in inefficiencies due to human error when storing data. An online system that show fuel trends will help to quickly compile reports as well as a dashboard that forecast future trends reduces human labor in the organization.

This chapter addresses and analyzes already existing systems that are being used in the fuel industry. The research focuses on how the systems enhances decision-making, reducing operational costs and analyze fuel trends. The chapter will also address the evolution of AI in fuel management and AI in general, how it has helped users to migrate from traditional methods to automated systems. This analysis will help to find the gaps in the existing systems and how can the system address those gaps.

2.1 Fuel Management System

Uffizio (2025), defined Fuel Management System as a system that helps businesses to control, manage and monitor fuel consumption in real-time. The Fuel Management System helps to track fuel usages in real-time so as to improve efficiency due reduced human error by automating some of the functions. Since, the system will enable organization to have results in real-time, they can manage their cost because of transparency in fuel consumption (Crivva, 2024). According to Samsara (2025), a Fuel Management System is a system that helps to provide visibility of fuel consumption trends that will help to control fuel economy and overall spending of fuel (Samsara, 2025). The researcher then defines a Fuel Management System as a system that helps managers and fuel customer by providing online services that reduces the need for too much labor.

2.1.0 Empirical Study

(Anayo, et al., 2016), conducted a study based on the “*critical review of Petrol Station Management System with emphasis on the advantage of digitalized in Nigeria*”. The study was focused on fraud, missing documents and time wastage due to the traditional methods in Petrol Station management. Traditional methods come with inaccuracy, vulnerabilities and limited space to keep the documents that stores data when recording fuel transactions. The researcher, proposed a system that would monitor staff activities, track sales and manage inventory efficiently. The system was designed to process data from station managers and produce a report for the day. This was done to reduce time that managers would take to analyze all the transactions and also to reduce inaccuracy when entering data. The system was a Web-based application developed with PHP/MYSQL, Java and HTML languages. The researcher concluded that it was high time for Nigeria to migrate from the use of manual methods to use automated online systems (Anayo, et al., 2016). Despite the fact that the system was able to track staff activities, it was not able to monitor fuel consumption in real time and forecast for the future.

(Zangana, 2018), conducted a research based on how management information systems can address data redundancy, failure of addressing daily sales and inventory supply and time management due to the use of manual methods. The system was introduced to reduce data redundancy, thereby helping in analyzing vast amount of data which would then result in better decision making. The system made the recording and search of transactions for managers a lot easier. The researcher concluded that the implementation of a management information system for Petron gas was a game changer as it would help to save time due to elimination of manual methods and the system was helping in decision making. However, the author did not clarify how much time it would take for managers to enter transaction and making decisions with manual methods. Also the research methodologies that were used to carry out the research were not outlined.

(Mugalla, 2022), carried out a research on the impact of using a filling station system at the filling station in Nairobi Kenya. Due to many traditional methods that are paper-based records each and every day, managers were failing to compile reports on time. Since these transactions were paper-based, they would rely on who is at the station to get reports on how much fuel has been consumed. The author’s objective was to develop a system that would avoid such cases when managing Filling

Stations. The system was going to save time spent at filling station by each customer, thereby the aim was to enhance customer satisfaction. To make the development system a success the researcher made use of journal and past record as well as questionnaires and interview as research methodology. Although the system was designed with a user-friendly interface, some of the filling stations were not willing to migrate from old methods to the use of computerized systems. The researcher did not specify the metrics of system, such as response time and the overall performance of the system.

Hamed (2021) and his team carried out a research focusing on vehicle fuel consumption prediction model using machine learning. The aim was to analyze how fuel consumption predictions can be enhanced through machine learning algorithms such as the Support Vector Machine Learning model. Which is a supervised machine learning model. The consumption analysis was evaluated with the R-squared (R^2) and Root Mean Square Error (RMSE). These models predict the future based past datasets. According to the results, the R^2 was the one with the most accurate results (Hamed, et al., 2021).

The increase in fuel consumption due to increase in its demand, show that there is a need for an efficient way of managing fuel consumption. Predictive analytics is very important in the fuel sector as it is one of the industry that deals with large amount of data (Manjunath & Kumar, 2024). The research was focusing on comparing the linear regression model and the Support Vector Regression when making predictions. Due to linear regression simplicity and effectiveness, it was said to be the most suitable model between it and the Support Vector Regression. Linear-regression offers results in real-time as compare to support vector (Manjunath & Kumar, 2024). A linear regression is an algorithm that provides the linear relationship between an independent and dependent variable to predict future outcomes (Kanage, 2023).

2.1.1 Gaps in Related System

The related researches have shown their advantages and limitations when managing and monitoring fuel consumptions. How best can an organization monitor and manage fuel consumptions and what can be done to do this effectively. However, some of these systems, did not make use of AI. They did not take into consideration the use of different model to predict future

fuel demands and also making the system more accessible to customers as well but, they were more focusing on the management side. They did not promote the use of mobile devices to consumers to increase fuel demands due to automated functions. These limitations show the need of an AI-powered system that benefits both customers and managers when dealing with fuel. The implementation of a Fuel Coupon Management System with AI Inference will address these limitations.

2.2 Role of AI in Fuel Management System

Artificial Intelligence (AI) refers to a technology that enables computers and softwares to mimic human intelligence when carrying out tasks. AI is subdivided into narrow AI and general AI. Narrow AI is also known as weak AI which is a system designed to perform a specific task. For example, Siri for Apple devices. General AI is also known as strong AI. It is designed to perform tasks that humans can perform also (The Investopedia team, 2025). Fuel is said to be the one with the largest operational expenses within the business. Industries are evolving to the use AI so as to reduce operational expenses, enhanced decision making and remaining competitive in the industry. making when managing fuel consumption (Balla, 2024).

Fuel management using traditional methods such as the use of paperwork is very difficult to navigate through with the aim of making predictions based on the given data. With the adoption of AI, the managing of fuel consumption is becoming easier and the fuel industry's future looks brighter. AI enables users to forecast trends based on historical data this helps in decision-making as compared to traditional methods (apw, 2024).

AI enhances fuel consumption management through predictive analysis. AI-powered systems have the capability of using large amount of past data to analyzes trends and gains insights of the given data and forecast fuel consumption. AI promotes real-time monitoring as unlike manual methods. For example, the use of machine learning algorithms can analyze past data and forecast.

AI helps fuel management through predictive fuel consumption analysis. AI-powered fuel management systems have the ability to analyze all types of data and give insights to its users. For example, based on the fuel that had been consumed in the past. More so, AI enhances real-time

monitoring of fuel consumption. With the use of AI tools such as ML, they can predict data patterns and trends based on the raw data provided. Real-time monitoring helps managers to plan ahead. Since AI models can analyze large data amounts, they can assist managers in decision-making through the data available (Sharma, 2024).

2.2.0 AI Techniques.

1. Machine learning

AnalytixLabs explained machine learning (ML) as a data analytic tool that identifies patterns and predictions automatically. It allows real-time data analysis no matter the amount of data being analyzed. Machine learning helps data analytics tools to continuously learn from the given data which will increase accuracy in decision making over time (AnalyticLabs, 2024). ML can be defined as the use of algorithms that can predict or make decisions based on the given data (Nollora, 2023). “ML is a subset of AI that allow computers to learn from data and make decisions or predictions without being explicitly programmed to do so”, said Crabtree. ML is all about having an automated algorithm that can learn from the given data set, unlike traditional methods where computers were commanded to perform data analysis processes. This is what differentiates ML from other AI tools which makes it powerful. ML is divided into supervised and unsupervised machine learning (Crabtree, 2024).

Supervised learning

Supervised learning is an ML technique that identifies trends and relationships between input and output using labeled datasets to train the AI algorithm model. Supervised machine learning is more effective when you understand the type of data you are using. This data must be clean without any bias and complexity for accurate results. Data will then be trained, validated and tested, this will help to choose the suitable ML algorithm that will give accurate results (Belcic & Stryker, 2024). Supervised learning can make use of linear regression, which is used to understand the relationship between two different variables (Belcic & Stryker, 2024).

Predictive Analytics

Predictive analytics is an advanced analytics tool that makes predictions based on historical data, it involves data mining and machine learning. Predictive analytics can be used in supervised groups of data where data will be categorized based on history and it can give insights based on the relationship of the given data, or, unsupervised data where data is basically grouped according to similarity (IBM, 2024).

Unsupervised Learning

Unsupervised learning is an unsupervised machine learning algorithm that is used to analyze unlabeled dataset. It discovers hidden patterns or relationships within the given dataset. However, this learning model requires much time to train it, there is high risk of inaccurate results due to unlabeled dataset and it requires too much human intervention to validate output variables (IBM, 2021).

2. Deep Learning

Deep learning involves the use of neural networks to read data patterns of the given dataset. It has the ability of analyzing large amount of data in real-time which will give proper insights based on the data thereby improving predictive analysis that can be used for decision making (AnalyticLabs, 2024).

Every organization is trying to remain functional in the industry, despite increased competition they are looking for strategies to fight over competition this is where data analytics for decision-making comes in. The significance of data analytics in an organization cannot be ignored as data amounts increase daily (Tiwari, 2024). As the population is increasing, the amount of data to be processed daily is increasing as well (Crabtree, 2024).

Neural Network

A neural network is a models that imitate the human brain structure and functionality. It consists of interconnected layers of nodes that work together to process and analyze complex data (Stryker & Kavlakoglu, 2024).

2.2.1 Random Forest Algorithm

Random Forest Algorithm is a supervised machine learning algorithm that builds many trees and lets them work together to produce a more accurate and stable prediction. It helps minimizing overfitting and enhance prediction accuracy. Random forest algorithm works by constructing multiple decision tree during training and outputting the mode or mean of the predictions of individual trees (Great Learning Editorial Team, 20205).

The implementation of Random Forest algorithm is of great use as it can model complex and nonlinear relationships in data. Filling stations deal with large datasets which requires the use of a Random Forest algorithm to analyze future prediction. According to Hamed (2021), “Random Forest is more effective when making predictions as compared to other algorithms when forecasting energy consumption patterns”.

2.3 Gaps in the Current Systems

The current systems in the fuel industry lack real-time monitoring and tracking. Due to the use of traditional methods, many systems do not have a model that provides real-time tracking of fuel usage and coupon redemption. The lack of such models often causendelays when complying reports.

More so, current systems cannot detect future demands. Predictive analytics helps to forecast demands. This helps to meet customer demands and avoid over-issuance or under-issuance of fuel coupons which may lead to wastages or shortages.

Furthermore, current systems do not allow users to get coupons in real-time. For example, if someone want to purchase a coupon but cannot get to the filling station on that time. This reduces the convenience for users especially those in remote areas. The use of a mobile app is very convenient as users can easily get coupons when in need.

2.4 Future Trends

With the way new technologies are emerging, the future of fuel management is filled with many potentials. The introduction of the Internet of Things to fuel management systems can greatly improve how fuels will be managed in the future. It will help to improve the accuracy of real-time monitoring and tracking of fuel consumption. AI and ML give fuel management systems the capability of learning and intelligence. Combining these technologies with fuel management systems will improve data accuracy thereby assisting managers with decision-making strategies (Nollora, 2023). Nollora goes on to say that if these fuel management systems are not accurately monitored it might result in fraud, which will result in losses to the organization.

Furthermore, ML and AI continuously learn and predict data patterns from large data amounts, this will help managers when fuel demand starts changing. Also taking into consideration data security (Nollora, 2023).

However, as much as AI comes with many benefits, we have to take into consideration data privacy when using a fuel management system. In the long-run, it can become costly to maintain an update the management system(apw, 2024).

The future of fuel management system lies within integrating of AI, Internet of Things (IoT), and mobile platforms to easily monitor all fuel activities to continuously reduce theft, fraud, and enhance real-time monitoring. However, they are limited with infrastructure and high implementation costs. With the government's willingness to improve on resource management on systems that offer real-time analytics and transparency, they will be more of the system that offers results in real-time in the region. Future development may also include Hybrid models that helps with more accurate demand forecast.

With all that being said and done, the future of fuel management systems looks brighter.

2.5 Summary

The research highlighted that it is very significant for PetroTrade to have a Fuel Coupon Management System with AI Inference. This system will help them to issue coupons in real-time and have a dashboard for real-time monitoring and tracking of fuel usage. This will not only help to reduce cost but they will be able to forecast fuel demands based on the coupons issued.

CHAPTER 3: Research Methodologies

3.0 Introduction

The design and implementation of a Fuel Management System is a critical attempt for organizations seeking to manage fuel usage, reducing operational costs and improving decision-making processes. This chapter highlights the research's methodology that the author employed to achieve the research objectives of this study, which focus on the development of a real-time fuel coupon issuance system, the implementation of an analytics dashboard and the evaluation of the system's effectiveness in reducing manual data entry errors. The research methodology is designed to provide a well-structured approach in achieving the research objectives, using both qualitative and quantitative research methods to provide a comprehensive understanding of the problem and validate the proposed solutions.

3.1 Research Design

The research design serves as the foundation for the entire study, providing a structured framework for achieving the research objectives. For this study, a mixed-methods research design was adopted, combining both qualitative and quantitative approaches. This design was chosen to ensure an overall understanding of the problem and to validate the findings through multiple perspectives. The qualitative phase of the research is focused on understanding stakeholders' requirements, identifying challenges in the existing management processes and gathering insights into user expectations.

Qualitative Research

Qualitative research is a research methodology that enables researchers to understand complex factors by examining people's experiences, behaviors, attitudes and interactions in their natural context. It emphasizes the use of non-numerical data such as words and objects, to gain in-depth insights into the subject matter (Lim, 2024). This phase involved conducting interviews, observations and focus groups.

3.1.0 Quantitative Research

A quantitative research method is a systematic fact-based investigation which uses numerical values and statistical methods to analyze test hypothesis and identify patterns or relationships (Sreekumar, 2023). Unlike qualitative research, which focuses on understanding the depth and complexity of human experiences, quantitative research emphasizes measurements and objectivity. This phase includes surveys, questionnaires and system testing. The quantitative data offers clear, measurable proof of the system's performance, which is crucial for confirming its effectiveness.

The researcher will use both qualitative and quantitative research to develop the system. This is due to the fact that each research method has got its own advantages and disadvantages. Qualitative research is very flexible as it includes methods such as focus groups and open ended surveys, this helps to get information based on user's experiences and emotions. However, it limits data sample because it is time consuming to use qualitative research. It is also hard to interpret as it is mostly expressed in words and emotions than numbers. With quantitative research, the research can have more data as it included the use of close-ended questions. This method is to interpret its results and it is less time consuming. However, it is limited to human emotions and it can be biased as the intended respondent can give someone else to answer the questions.

3.2 Requirements Analysis

Requirements analysis refers to the process of analyzing user's expectations based on the system that is to be developed. It is based on understanding what is that the user expects the system to look like and the expected functions to be in the system. The requirements analysis consists of functional and non-functional requirements.

Requirements analysis is very important as it helps to have a clear vision of what the system's stakeholders are looking for. These stakeholders consist of users, programmers and others. Requirements analysis helps to improve efficiency and effectiveness in the development.

Usually, high-quality requirements are documented, actionable, measurable and traceable and are defined to facilitate the system design. These requirements are documented in different formats such as user stories and natural-language documents. This will help when assessing if the system was designed according to the stakeholder's expectations.

A project will succeed if a proper requirement analysis has been carried out properly. A poor requirement analysis will result in a project failure. As requirements analysis helps to remove complexity in the requirements (Redtest, 2018).

3.2.0 Functional Requirements

Functional requirements refer to what the system should do in terms of features, functionalities and behaviors. In general, they give guidance on what the system is supposed to perform when certain conditions are met. For example, reporting and analytics (Grow Solutions, 2023).

Functional requirements need to be documented so the stakeholders will have a single source of truth. This will reduce confusion among stakeholders as they will be on the same page. Also, it enhances effectiveness in the design process, there will be no need for constant meetings as all the requirements will be documented where they can be easily referenced. More so, documented functional requirements help to identify problems sooner before it is too late. For example, in my area of study, the system must send a QR code when a coupon has been issued to the user which is a functional requirement (Nuclino, 2025).

Based on the research, below are the functional requirements of the system:

1. User authentication: the system will allow users to create accounts and login based on roles, either customer or admin.
2. Fuel coupon issuance: the system will allow users to purchase fuel coupons based on their account balance. The system will generate a unique QR code for every fuel coupon.
3. Coupon redemption: the system will allow the fuel attendant to scan and redeem QR codes at the filling station. The system will validate if the coupon has not been redeemed yet.
4. Account balance: the system will deduct fuel coupon value from the customer's account balance.
5. Real-time dashboard: the system will show fuel consumption in real-time. Every time a coupon is redeemed it will update the level of consumption.
6. AI-based predictions: the system will predict future demands based on the last month consumption using Random Forest model.

3.2.1 Non-functional Requirements

Non-functional requirements refer to the specifications that describe the system's operation capabilities and constraints. These are basic requirements based on security, reliability and speed. They give quality to the system. Users when using a system, consider how responsive the system is and if their data is protected such that no one can access their data.

Based on the study, below are the non-functional requirements of the system:

1. Performance: under normal load, the system should issue a fuel coupon within 10s. After a fuel coupon has been redeemed, the dashboard must update in real-time.
2. Scalability: the system shall be able to handle multiple users at the same time without degrading its performance.
3. Usability: the system will have a user-friendly interface for both mobile and desktop users which will require less to no user training.
4. Availability: the system shall be available 99% of the time.
5. Compatibility: for admin the system will work on a web browser for customer, they can use both web browser and mobile application

3.2.2 Software Requirements

1. Android or better operating system.
2. Windows 10 (operating system)
3. MySQL
4. Laravel Framework
5. Visual Studio
6. Python
7. PHP

3.2.3 Hardware Requirements

1. Laptop corei5 processor or better
2. 8 gig ram

3.3 System Flowchart

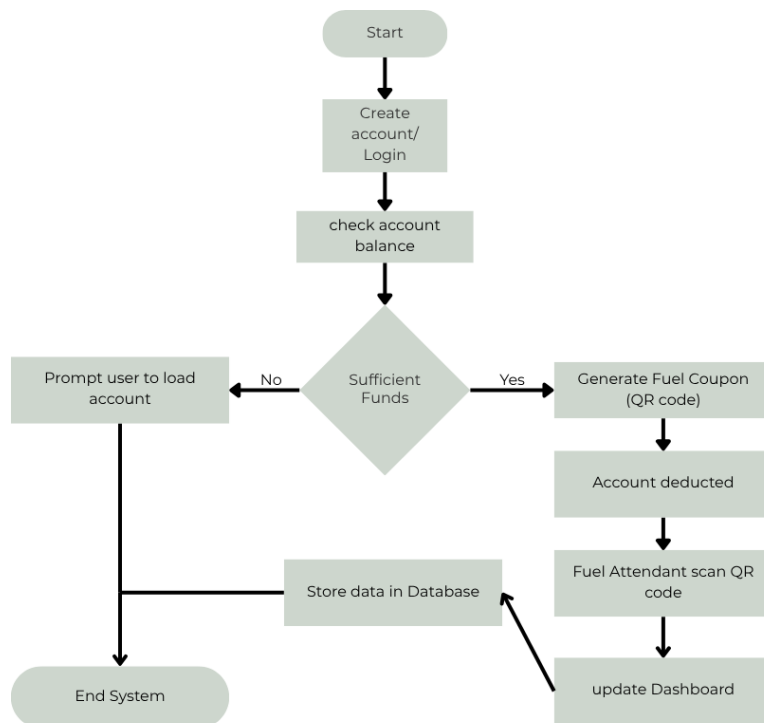


Figure 1: “System Flowchart”

Figure 1 above show the flowchart of the Fuel Coupon Management System with AI inference. After accessing the system whether on a browser or application customers start by creating an account or login to their account. After this they can check their account balance, if they have sufficient fund then can purchase a fuel, however, if they have insufficient funds, they can load their accounts then purchase fuel coupons. A coupon with a unique will then be generated were customer can take that and go to the filling station. The Fuel Attendant can scan the QR code and issue fuel if the coupon has not been redeemed yet. As soon as the coupon has been redeemed, the graph will change its position. This information is stored in a database for future references.

3.4 System Development

System development refers to the structured process of designing, creating and deploying a software or hardware system to address specific user needs or solve particular problems. It involves a structured and iterative process to design, build, and deploy a solution that optimizes fuel coupon issuance, reduces errors and enhances operational efficiency. The waterfall model uses iterative development, where you cannot move to the next stage before finishing the first stage. The development cycle is as follows:

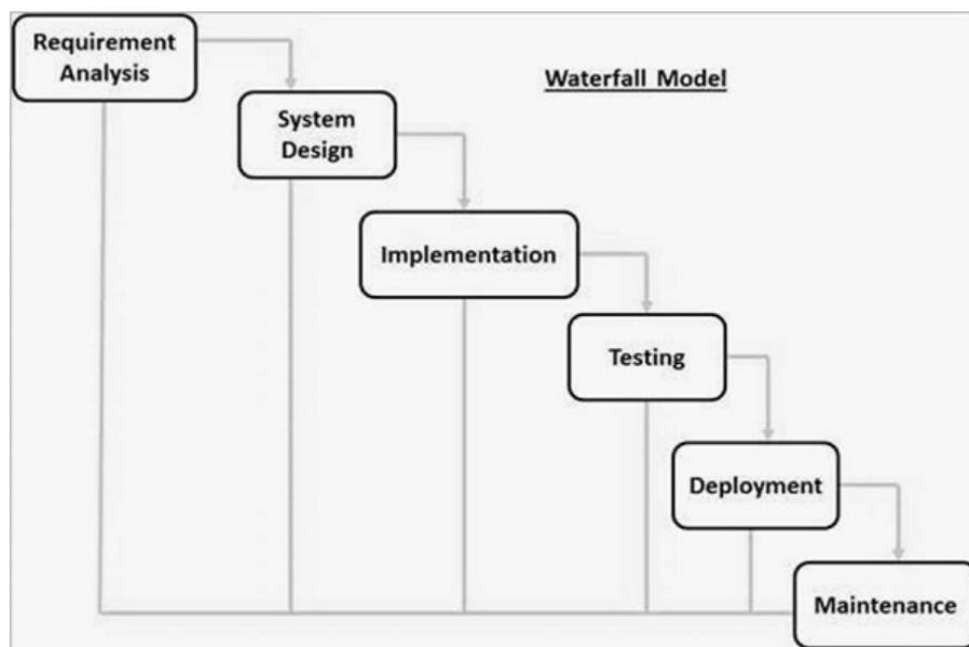


Figure 2: “Waterfall Model”

Requirements analysis

Requirements analysis is the foundational phase of system development, where the needs, expectations and constraints of stakeholders are identified, documented and analyzed to define the system’s objectives and functionalities. It ensures the final system aligns with user needs and delivers value, as it provides a clear roadmap for development and minimizes the risk of misunderstanding or misaligned expectations. Without thorough requirements analysis, systems

risk being inefficient, irrelevant, or failing to address the core problems they were designed to solve.

System design

System design is a critical phase in the system development process where the architecture, components, and workflows of the system are planned and defined in detail. It works as a guideline ensuring that all requirements gathered during the analysis phase are translated into feasible and scalable solutions. For a Fuel Management System, system design would include defining how fuel coupons will be issued, how fuel data is collected, processed, and stored, how users interact with the system through interface, and how real-time analytics are generated. This phase also addresses non-functional requirements, such as scalability, security, and performance, ensuring the system can handle growing data volumes and user demands while protecting sensitive information. The system was developed using Laravel for backend and Python for training the AI model.

Implementation

The implementation state is where all the planning and design finally come together, turning ideas into real working system. For a Fuel Management system, this means developers start write the actual code-building the backend to handle fuel data and creating user-friendly interface for tasks like issuing fuel coupons in real-time. The implementation stage also includes databases set up to keep track of transactions and configure APIs so as to enhance communication within the system. By the end of this stage, the system will be running

Testing

The testing stage is a crucial phase in the system development lifecycle where the developed system is carefully evaluated to ensure it meets the specified requirements, functions as intended and is free of defects. This stage involves a series of systematic tests designed to identify and fix bugs, validate functionality and assess performance, security and usability. Testing is typically divided into several levels, including unit testing (testing individual components or modules), integration testing (ensuring different modules work together seamlessly), system testing (evaluating the complete system against requirements) and user acceptance testing (UAT) (confirming the system meets end-user needs). For a Fuel Management System, testing might

involve verifying the accuracy of fuel data collection from sensors, ensuring the AI-powered analytics dashboard generates correct reports in real time, and validating that user authentication and access controls function securely. Automated testing tools and manual testing methods are often combined to achieve comprehensive coverage. The testing stage not only ensures the system is reliable and efficient but also builds confidence among stakeholders that the final product will perform as expected in real-world scenarios. Any issues identified during testing are documented, prioritized, and resolved before the system moves to the deployment phase.

Deployment

The deployment stage is the phase in the system development lifecycle where the completed and tested system is released and made operational for end-users. This stage involves transferring the system from the development environment to the production environment, where it will be used in real-world scenarios. Deployment begins with preparation, including setting up servers, configuring hardware and ensuring all dependencies are installed. For a Fuel Management System, this might include configuring databases. Next, the system is installed and configured in the target environment and final checks are performed to ensure compatibility and functionality. Once the system is live, user training is conducted to familiarize stakeholders, such as fuel station operators and fleet managers, with the system's features and workflows.

Maintenance

This is the final ongoing phase of the system development lifecycle, where the deployed system is monitored, updated and improved to ensure it continues to function effectively and meet user needs. This phase is critical for addressing issues that arise after deployment, such as bugs, performance bottlenecks, or security vulnerabilities and for adapting the system to changing requirements or technological advancements. Maintenance can be corrective maintenance, which involves fixing defects or errors; adaptive maintenance, which ensures the system remains compatible with evolving hardware, software, or regulatory environments; perfective maintenance, which focuses on enhancing system performance, usability, or functionality based on user feedback and preventive maintenance, which aims to proactively identify and resolve potential issues before they impact the system. For a Fuel Management System, maintenance might

include updating the system to support new fuel types, improving the AI-powered analytics dashboard, or patching security vulnerabilities to protect sensitive data. Regular maintenance ensures the system remains reliable, efficient and aligned with stakeholder needs, extending its lifespan and maximizing its value. Without proper maintenance, systems can become outdated, inefficient, or prone to failure, ultimately undermining their purpose and effectiveness.

3.4.0 Prototype

A prototype refers to a sample that gets deployed before the final project is deployed. Prototype helps to get early feedback from stakeholders. By presenting a working model, developers can identify potential issues, gaps and misunderstandings in the requirements before investing significant time and resources. The use of a feedback system helps to have a final project that will align with the user's requirements.

Also, the use of prototyping helps to avoid scope creep. It helps to clarify user requirements. A prototype provides a tangible representation that will help stakeholders to have a visualized final system. Through this, they can openly talk about what they need to be added and removed from the system before wasting resources.

Last but not least, prototyping reduces development risks. Risks can be detected in the early stages of development. It allows developers to test concepts, validate assumptions and get possible solutions to possible risk that might arise. Early risk detection helps to find the most possible solution and apply the solution before the risk arises.

In summary, prototyping helps to enhance user satisfaction. Since prototyping involves understanding user requirements, developers can develop a system that will align with the requirements. As soon as the developer manages to understand the user requirements, it is guaranteed that the user will get a good quality system.

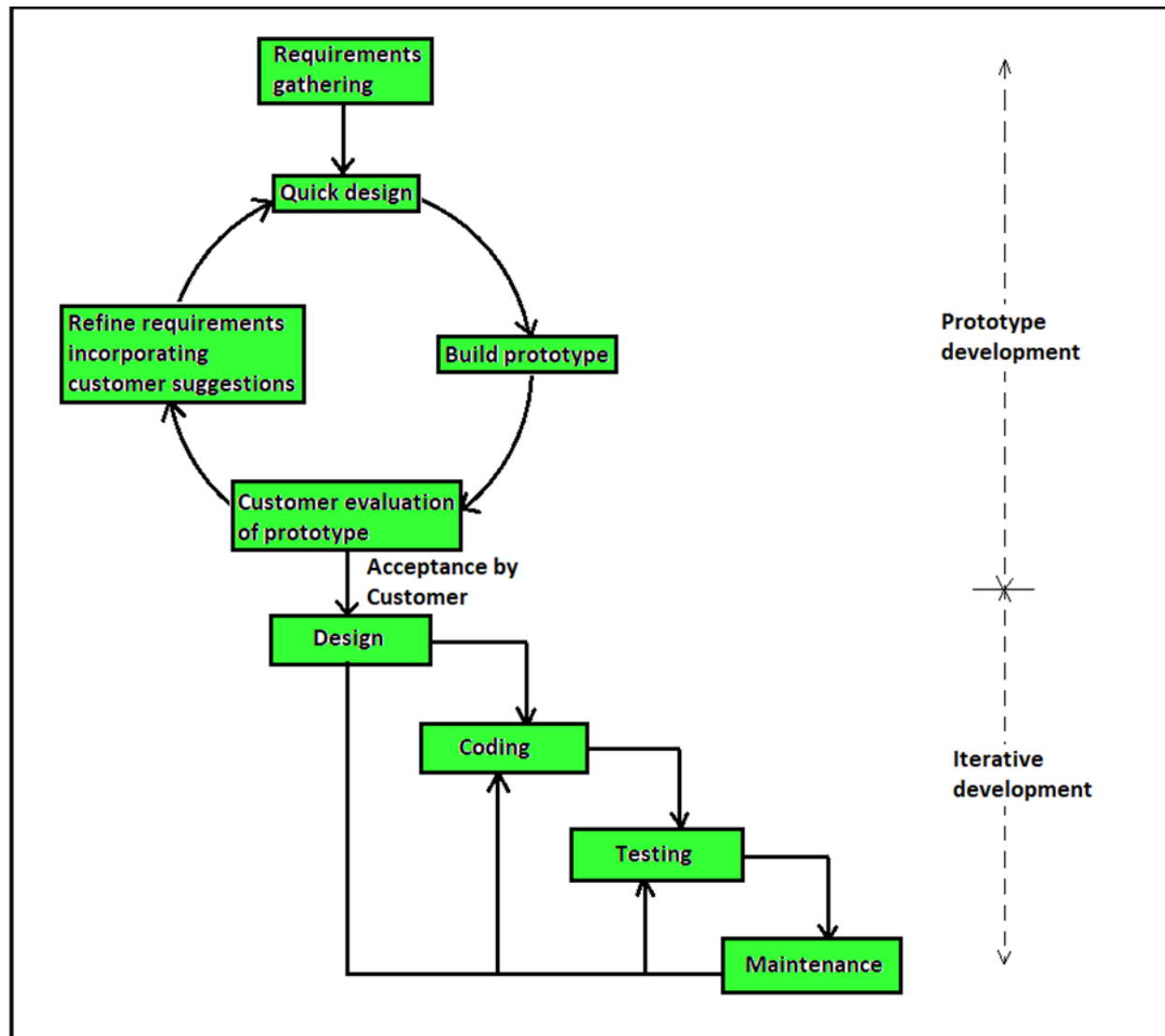


Figure 3 “Prototype”

Figure 3 above show the steps that are followed when developing a prototype. The process start by gathering stakeholder requirements. Then it moves on a quick design with an aim of understanding the expectations, then a prototype will be developed. Stakeholders will evaluate the prototype to determine if an additions or changes will be required.

A prototype can be paper based, wireframes, storyboards, flowcharts and mockups. Each one of them has got its advantages and disadvantage. They become effective when the audience

understands what will be presented to them. After the prototype has passed the test, developers will now start developing the actual system using iterative development.

3.5 Data Collection Methods

3.5.0 Questionnaires

A questionnaire refers to a research instrument that consists series of questions with the purpose of gathering information from respondents (McLeod, 2023). Questionnaires help to gather more data from a wide range of people as it does not require physical interaction like interviews. More so, questionnaires offer confidentiality. Respondents can say whatever they feel like because it is an online process their identity will be protected. However, with the use of questionnaires, the intended might assign someone to answer the questions. This will lead to biased information as the respondent will answer questions just to show that he or she has participated (Lindeman, 2023). Below are the questions that the researcher has used to understand how respondents feel about going to the filling station to get fuel coupons and the use of an online system. Below is the link for the questionnaire that the researcher used:

[https://docs.google.com/forms/d/e/1FAIpQLSdWXs303oB2SGd3tmTbWUuEyYPjd8KR49Cd2Q9omi0gqCP -A/viewform?usp=header](https://docs.google.com/forms/d/e/1FAIpQLSdWXs303oB2SGd3tmTbWUuEyYPjd8KR49Cd2Q9omi0gqCP-A/viewform?usp=header)

According to the questionnaires that PetroTrade customers and potential customers have respondent, below are some of the responses that contributed to the development of the system:

2. How often do you use fuel coupons?

 Copy chart

20 responses

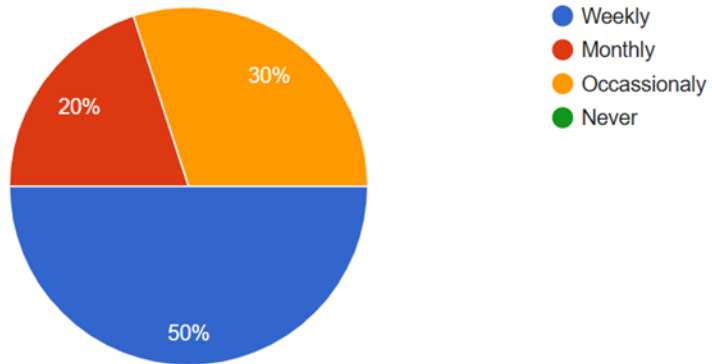


Figure 4 "Questionnaire 1"

Section 2: Challenges with current system

 Copy chart
3. What challenges do you face when collecting coupons at filling stations?
(Select all that apply)

20 responses

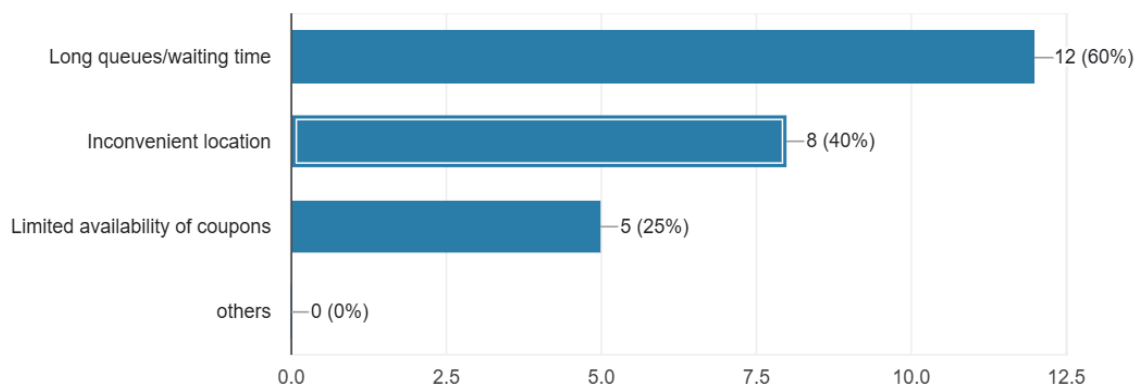


Figure 5 "Questionnaire 2"

5. Would you prefer a digital system over physical coupon?

 [Copy chart](#)

20 responses

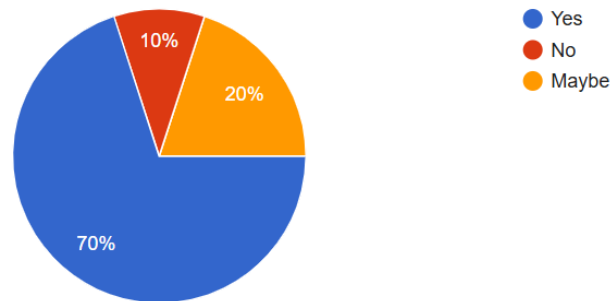


Figure 6 "Questionnaire 3"

From the images above, most PetroTrade customers make use of coupons every week. This shows that there is a great demand of fuel coupons at PetroTrade which shows the importance of having an efficient distribution system. Among these customers, some suffer from long queues when they want to purchase fuel coupons. Some of them get affected by location and some unavailability of coupons. This will reduce customer satisfaction, which can lead to loss of customers. Most of the customers opted that it would be a great idea to have a digital system rather than the use of physical coupons.

3.6 System Development Tools

Python

Python programming language is a high-level, interpreted, general purpose programming language which is known for its simplicity, readability and wide range of applications. The researcher will make use of Python programming language to train the machine learning algorithm. This is due to the programming language's simplicity, flexibilities and wide range of machine learning libraries.

Laravel Framework

Laravel is a free, open-source PHP web application framework designed for building modern, secure and scalable web application. The researcher decided to use Laravel as the primary backend

framework for the project because of its well structured syntax, robust features and efficiency in developing scalable web application.

3.7 Validation and Verification

validation refers to the process of checking the accuracy or validity of data and verification is the process of insuring that the user has provided accurate information before proceeding in the system. To ensure the system's accuracy and reliability, both validation and verification techniques will be implemented during the development. Input validation was set at the backend and frontend levels in Laravel using the built in rules to ensure required fields data types and formats are correct before processing. For a Fuel Coupon Management System, this includes checking the customer's account balance before fuel coupon issuance. The system was verified against user requirements through different testing methods. Such as unit testing and user acceptance testing, just to mention a few.

3.8 Limitation of Methodology

The research methodology chosen by the researcher to carry out the study, provided a valuable insight and a functional system prototype, the researcher faced many challenges. To start with sample size, the sample size for interview was limited, the research only manages to interview few managers due to limited time and some individuals did not feel safe to participate due to personal reasons. To address this, for the future expanding the interview sample size will be required. This affected the quality of data based on what managers think about adopting a system that helps them to predict future trends. Also, the AI model was trained with limited dataset, this might affect the model's ability to accurately predict in real world deployment. More data will increase the accuracy prediction of a model. In the future, the model needs need to be continuously trained to be able to accommodate all the dataset. The integration between Laravel and Python was challenging which can affect the development speed.

3.9 Summary

In the summary, the research has outlined the methods that will be used in the development and evaluation of a Fuel Coupon Management System with AI Inference for PetroTrade. The research utilized many research methodologies so as to get as much information as possible. Despite the limitations based on the dataset size and time, the methodology supported the development of a functional system. This chapter is a foundation of understanding how research methods guide the development of the system. Data used was collected through questionnaires, interview, and system testing.

Chapter 4: Data Presentation, Analysis, and Interpretation.

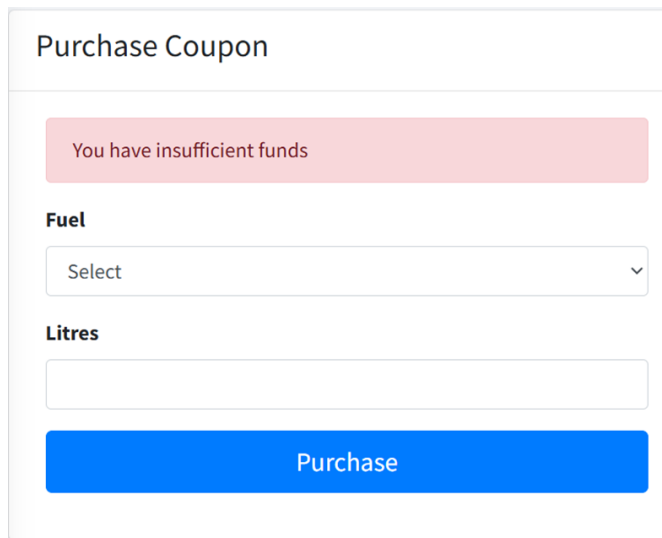
4.0 Introduction

The foundation of this research was based on addressing the inefficiencies due to the use of traditional methods when managing and issuing coupons at PetroTrade. This chapter presents, analyze and interpret the findings after implementing the Fuel Coupon Management System with AI Inference. The chapter aims to show how the objectives were met after the system was implemented and give insights on how research problems were minimized. The results are based on user feedback after interacting with the system through answering questionnaires, system testing and AI model predictions using a dataset.

4.1 Validation and Verification

4.1.0 Validation

Validation refers to the process of checking the accuracy or validity of data. The system must be able to validate the customer's account balance before issuing a fuel coupon as well as notify that the fuel coupon has already been redeem. The validation process was done through user testing with the help of PetroTrade customers and potential customers. This was achieved through answering questionnaires after interacting with the system. The aim was to test the system against user expectations.



Purchase Coupon

You have insufficient funds

Fuel

Select

Litres

Purchase

Figure 7 "Account Validation"



Figure 8 "Coupon Validation"

From Figure 7 and 8 above, it shows that the system is behaving as expected. This shows that the system was properly validated to avoid losses of issuing a fuel coupon without any payment as well as issuing a fuel coupon twice.

4.1.2 Verification

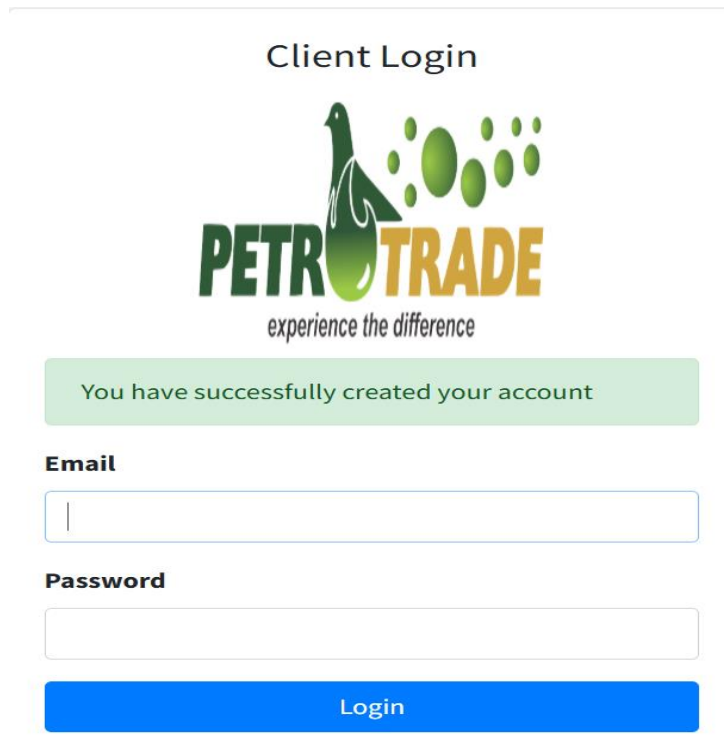
Verification is the process of ensuring that the user has provided accurate information before proceeding in the system. Within the system, users must be able to create an account with the expected input. After creating an account with valid inputs, the user will be directed to the login form. The system was verified through unit testing. Unit testing was conducted to verify the functionality of the system's components individually. It involved testing functions such as fuel coupon generation and user authentication. For example, users must not mix characters and numbers in the name and surname label.

The screenshot shows an account creation form titled "experience the difference". The form contains several input fields with associated labels and error messages:

- Name:** Input field contains "chiedza70". Error message: "The name format is invalid." (in red).
- Surname:** Input field contains "kagande76". Error message: "The surname format is invalid." (in red).
- Email:** Input field contains "chiedzakagande864@gmail.com".
- National ID (Format 12127453B12):** Input field contains "1607463A48".
- Date of Birth:** Input field contains "03/03/2012". Error message: "The dob must be a date before or equal to 2009-05-28." (in red).
- Gender:** Dropdown menu with "Female" selected.
- Phone:** Input field contains "023478765". Error message: "The phone format is invalid." (in red).
- Address:** Input field contains "654 zimre".
- Password:** Input field is empty. Error message: "The password must be at least 8" (in red).
- Confirm Password:** Input field is empty.

Figure 9 "Account Creation"

Figure 9 is showing the fields that a customer is supposed to pay attention to. Insert the expected characters before proceeding to the next function. This is shown by the red text highlighting that the user has to pay more attention to those fields. Some of the system users would require training to save time when navigating within the system. Training will also help to avoid such errors when creating an account.



Client Login



PETROTRADE

experience the difference

You have successfully created your account

Email

Password

Login

Figure 10 "Login Form"

Figure 10 is showing a login form, after using the correct formats when creating an account, the user will then be directed to the login page as shown above. Customer will then login using their Emails and Passwords. The interface is very user friendly.

4.2 System Testing Overview

System testing is based on the functional and non-functional requirements of a Fuel Coupon Management System with AI inference.

Functional Testing

Module	Test Description	Expected Outcome	Result
Coupon Issuance	Issue coupon with valid inputs	QR code generated/ Balance deducted	Pass

Redemption Module	Redeem valid QR code	Coupon marked as redeem	Pass
Invalid Redemption	Redeem same coupon twice	Error: “coupon already redeemed”	Pass
Account Login	Invalid login credentials	Error: “incorrect credential”	Pass
Admin Panel Access	Attempt access by unauthorized user	Access denied	Pass

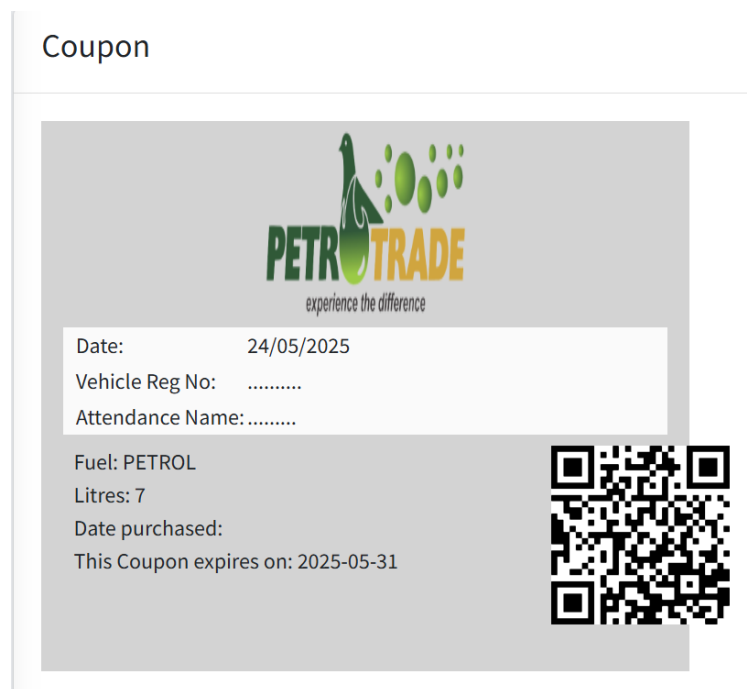


Figure 11 "Coupon Generation"

Figure 11 above shows a fuel coupon that has been generated after a customer purchased it. The fuel coupon comes with a unique QR code. Once the QR code has been scanned it cannot be scanned again; that is to say, once a fuel coupon has been redeemed, it cannot be redeemed again. The system passed the test of issuing a fuel coupon to the customer. The fuel coupon shows the day on which it was purchased and the expiring date as well as the amount of liters purchased.

Client Login



Invalid Login Details

Email

Password

Login

Figure 12 "Failed Login"

Staff Login



Invalid Login Details

Email

Password

Login

Figure 13 "Staff Login"

Figure 12 and 13 above shows that a user cannot login without the correct credentials in the system. If the customer's Email is not in the database or the password, customer cannot proceed within the system. This also applies to the admin where you cannot login with the correct information.

Non-functional Testing

Non-functional requirements were tested by users to make sure that the Fuel Coupon Management System with AI inference for PetroTrade is secure, reliable and user-friendly. Every system's top priority is to ensure that the users feel safe when using the system which is based on access control, authentication and data encryption. This ensures that data will be accessible to authorized users when needed. Under normal load, the system's response time was optimized to be below 10s. The system is very scalable that it can handle multiple users at the same time, it also has an intuitive interface that ensure that the users does not necessarily requires user training.

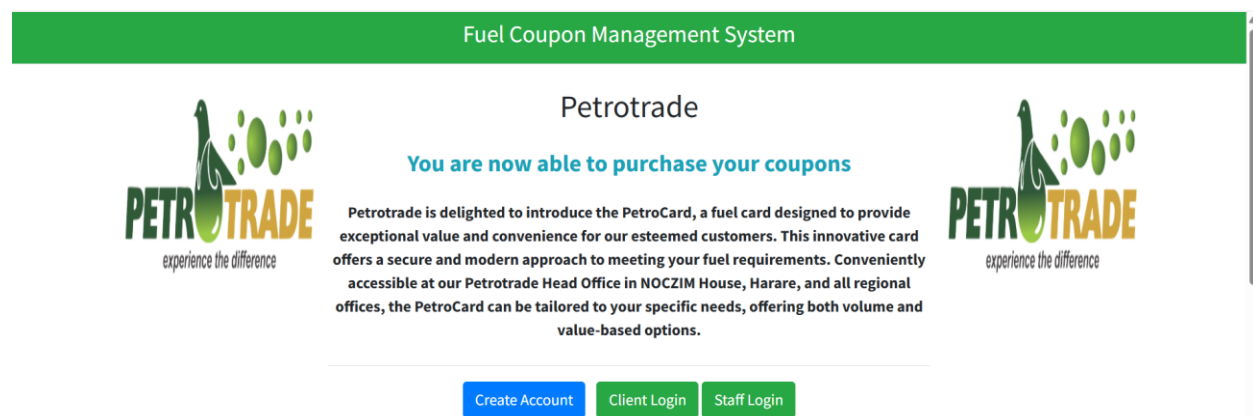


Figure 14 "Welcome Page"

4.3 Real-time Coupon Issuance Performance

One of system's objective was to develop a system that issues fuel coupon in real-time based on the user's account balance. If a customer has enough funds in the account, will be able to get a fuel coupon within a 10s interval but if they have insufficient funds, the account must be loaded to be able to purchase a coupon. The real-time coupon issuance performance was tested for speed,

reliability and error maximization. Some of the user's transaction failed to transact within the expected response time due to insufficient funds and network due to different locations. The results are as follows:

Metric	value
Average response time	5-10 seconds
Transaction success rate	90%
Failed transaction rate	10%
Manual system time	5 minutes (average)

With the system, under normal load and network connections a user will get a coupon with 10s. Transaction success rate was measured based on the fact that all the transactions were going to be successful but some of them failed. The researcher calculated the percentage of those who succeed against those who did not get the results in the expected time. Out of twenty people that tested the system, the workings were as follows:

Transaction success rate = $x/y \times 100$ where: x = success y = total

$$= 18/20 \times 100$$

$$= 90\%$$

Failed transaction rate = $100 - \text{transaction success rate}$

$$= 100 - 90$$

$$= 10\%$$

The results show that the paper based system was taking long as compared to the system. Instead of spending five minutes trying to get a fuel coupon, a user can now get a coupon within a short period of time.

The implementation of auto validation has contributed to error reduction. When a user has insufficient funds, the system will notify the user, so that they can load more funds into their accounts. As compared to physical visitation, once you did not bring funds to purchase the

coupons, you might not be able to get them within the expected time you were supposed to get them.

4.4 Evaluation of the Analytic Dashboard

The dashboard was designed to show fuel consumption based on the fuel coupons that has been redeemed. As soon as a coupon is redeemed, the steep of the graph will change its positon.

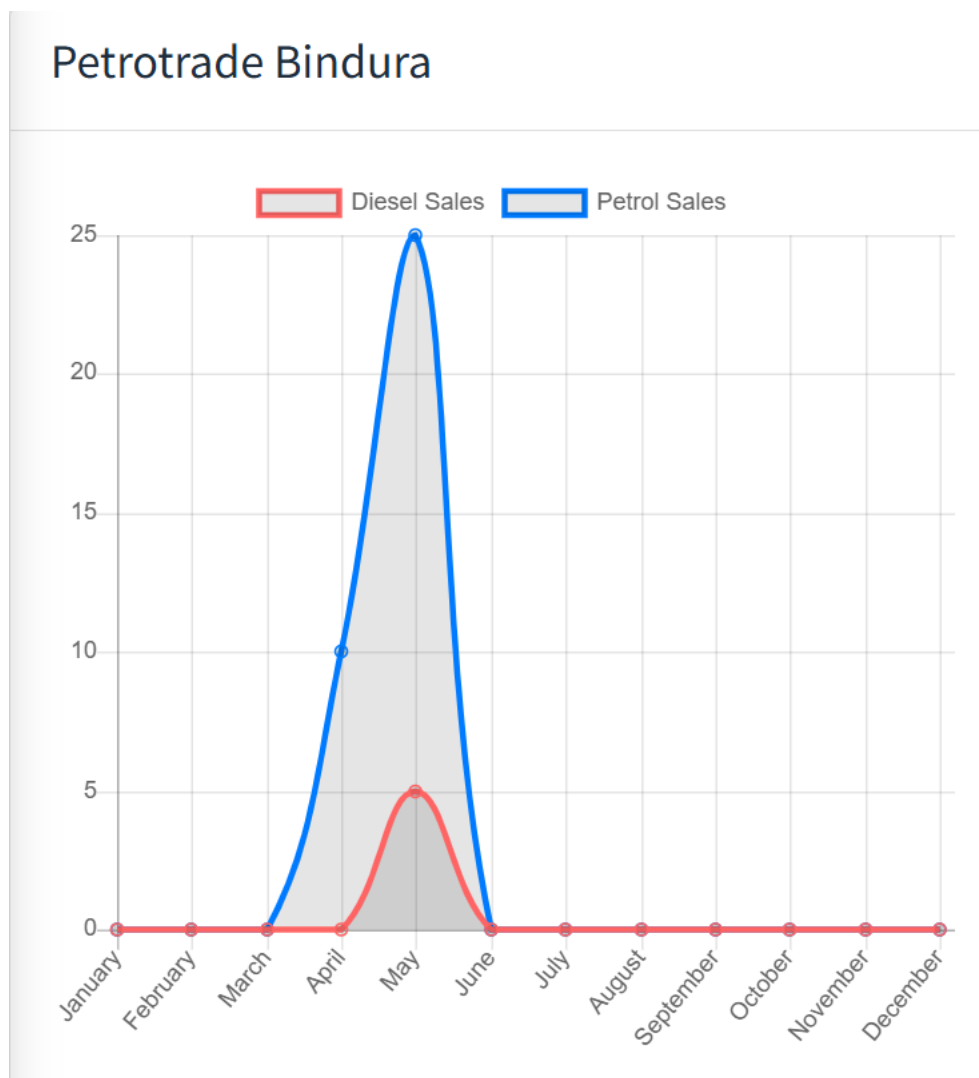


Figure 15 Fuel Consumption"

Figure 15 above show the current graph before another coupon was redeemed. The graph is showing that in the month of May, 25l of petrol has been purchased already and 5l of diesel has been purchased. After more coupons were redeem the graph was now as follows:

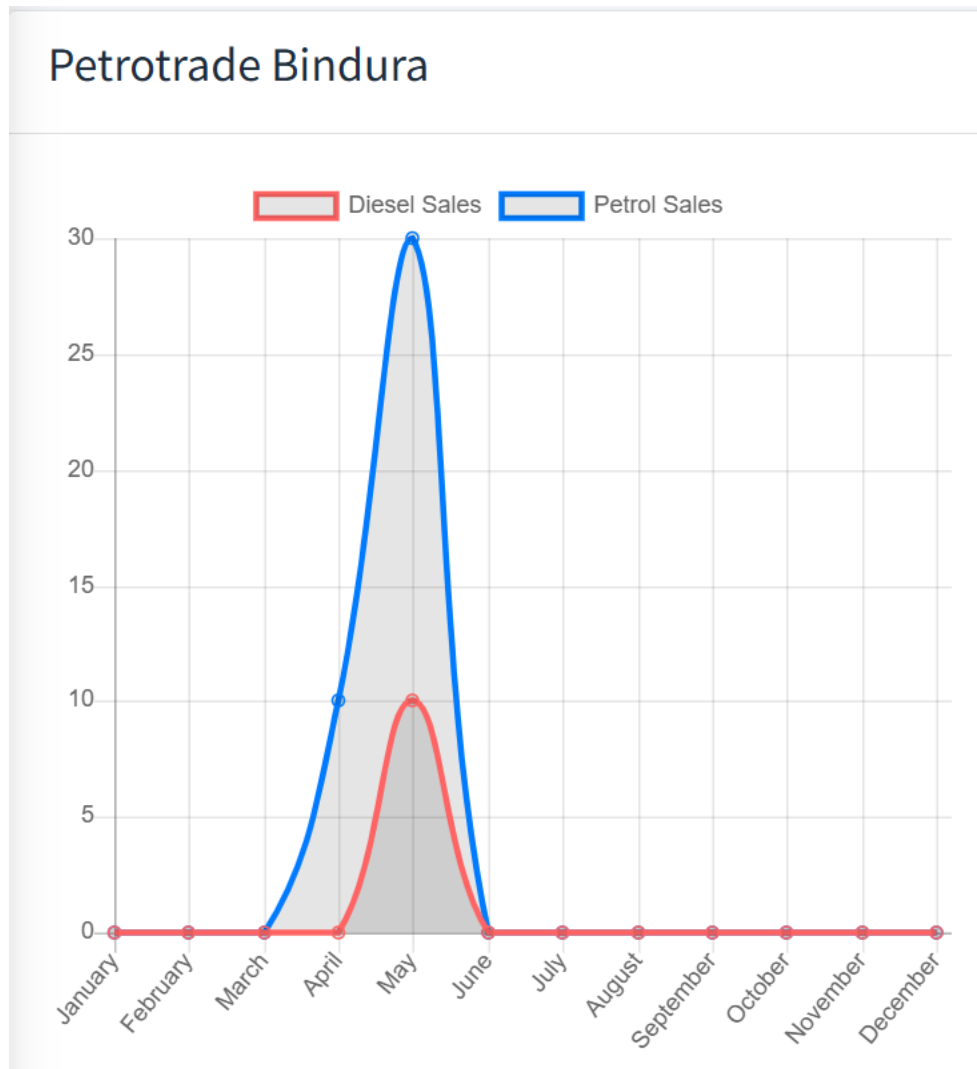


Figure 16 "Redeemed Coupon Graph"

Figure 16 above show that more fuel coupons had been redeem. From the first graph, it was showing that only 5l of diesel was already purchased but now the graph is on 10l. This goes to petrol as well has the graph has transformed from 25l to 30l. Showing that five more liters of petrol and five liters of diesel was purchased.

4.5 AI model evaluation.

Due to the model's affiance when dealing with complex datasets, it was able to predict the following month's fuel consumption based on the last months' fuel consumptions.

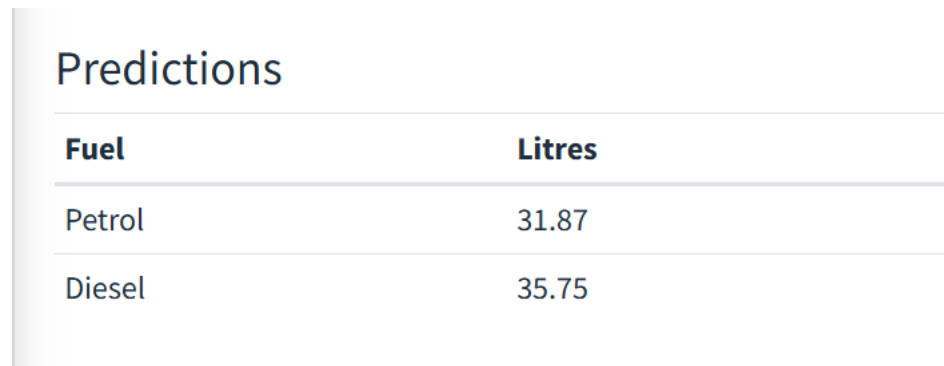


Figure 17 "Predictions"

4.6 System Reports



Figure 18 "Report"

Figure 18 above shows the system report based on the fuel coupons that have already been redeemed and those that are to be redeemed. This pie charts updates in real-time as soon as a coupon has been purchase, it will update. This will help managers to compile the reports for future use.

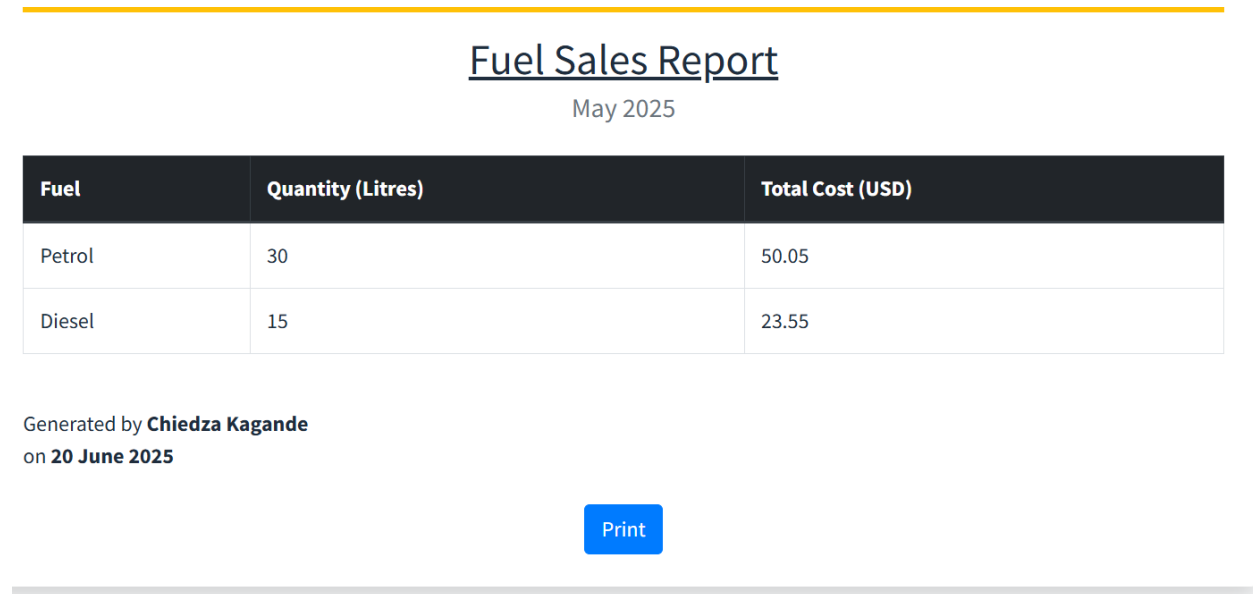


Figure 19 "sales"

Figure 18 shows fuel reports for the month of May. This research is part of the administrative dashboard in the system. It gives a clear summary of fuel based on fuel type. This include the total quantity of fuel purchased measured in liters and the corresponding total cost in united states dollars (USD). For instance, the dashboard shows that 30l of petrol was sold at a total cost of \$50.05 and 15l of Diesel at \$23.55. This allows for quick access to monthly reports without the stress of calculating and compiling reports manually.

Furthermore, the report includes a print button, enabling the admin to generate physical copies for filing, audit or management review purposes. This can improve data accessibility and record keeping, as report will be stored both digitally and physically

Sales
[Dashboard](#) / [Sales](#)

Enter Date

Sales

Fuel	Quantity (Litres)	Price	Total Cost	Purchase Date	Redeem Date	Expiry Date	Status
PETROL	10	\$1.63	\$16.3	2025-05-28	2025-05-28	2025-06-04	Already Used
DIESEL	5	\$1.57	\$7.85	2025-05-28	2025-05-28	2025-06-04	Already Used
PETROL	10	\$1.63	\$16.3	2025-05-28	2025-05-28	2025-06-04	Already Used
PETROL	5	\$1.63	\$8.15	2025-05-28	2025-05-28	2025-06-04	Already Used
DIESEL	5	\$1.57	\$7.85	2025-05-28	2025-05-28	2025-06-04	Already Used

Figure 20 "search"

4.7 Summary

This chapter presented the results after the implementation and testing of Fuel Coupon Management System with AI inference developed for PetroTrade. After conducting various forms of testing the system passed the expected standards or quality of a system based on performance and intuitive. The system was verified and validated to insure that correct data is being stored in the database. With that being said, after analyzing the system based on outcomes and user feedback, it was confirmed that the system is meeting all the research objectives and it is giving a favorable solution to PetroTrade when monitoring and managing fuel consumption.

Chapter 5: Conclusions and Recommendations

5.0 Introduction

This chapter focuses on the conclusion drawn by the author and recommendations after analyzing the implementing Fuel Coupon Management System with AI Inference when managing and monitoring fuel consumption. The chapter summarizes the key findings and insights gained during the development and evaluation of the system. The chapter provides recommendations based on the challenges that the researcher faced when developing and implementing the system. These recommendations are intended to guide different stakeholders such as future researchers, PetroTrade management and system developers. The conclusion drawn here also acts as a foundation for future researchers in the field.

5.1 Aim and Objective Realization

The core aim of the research was to develop a system capable of enhancing customer satisfaction for PetroTrade through developing a system that issues fuel coupons in real-time, a system that provides a dashboard for real-time fuel trends and an AI analytic dashboard that forecasts fuel trends. According to the study, the researcher was able to meet all the set objectives successfully. By issuing fuel coupons in real-time, the system had reduced customer's waiting period to get a coupon, therefore this has boosted customer satisfaction. The implementation of an AI analytic dashboard has helped to reduce time spent to make data-driven decisions and reports compilation to the management team. Instead of running through the papers, managers can just open the system and see fuel trends and future predictions.

5.2 Challenges Faced

During the research and system development, the author encountered a number of challenges.

Time constraints: it was strenuous to integrate laravel backend with the AI model within the given time to meet the academic deadlines. It takes time to train a model so as to get accurate results. After the model starts working, it needs to be integrated with the rest of the system. This was a bit challenging as the researcher would come across different errors. System integration can result in dysfunction of other system components.

Limited dataset: although the Random Forest Model was selected to be the most efficient model when making predictions, it performs best when a large dataset is provided to train it. The available dataset was small, which limits the models full potential performance. As the fuel sector deals with large datasets, re-training of the model in the long-run is important.

User acceptance: users' willingness to change from the use of traditional methods became a critical factor. Some users were afraid of migrating due to the unfamiliarity of using online systems and some were afraid of job security since the use of an online system will reduce manual labor needed. This showed that when developing system, user training and communication is very important to educate users the significant of using an online system.

5.3 Recommendations

For more accurate results, when using Random Forest Model to forecast fuel trends, the researcher recommends the use of a large with different data types. This is significant because Random Forest Model performs effectively when it has sufficient data to build multiple decision trees, allowing more accurate results. To add, beside the use of Random Forest Model, the researcher recommends the use of multiple models such as Linear Regression and Support Vector Regression (SRV). This helps to obtain more accurate results through comparing these models rather than relying on one model. This will enhance the reliability of the system's forecasting capabilities and supports better decision making.

The researcher also recommends the use of biometrics for verification when redeeming a coupon. This is for the sake of accountability when auditing the management of fuel consumption at PetroTrade.

Integration of the system with IoT. Linking the system with IoT devices will allow automatic fuel tracking. Also automating fuel distribution were customers can just pay for fuel using card at the filling station and fill their tank on their own. This will enable filling stations to gain more insights in real-time and manage fuel consumption as the IoT devices will be tracking fuel levels as well.

The researcher recommends user training. Users need training to get familiarity with the systems, this helps to remove fear of migrating from traditional methods to the use of online systems. The

training process must be more than just demonstrating the system but, help users to know how they can navigate within the system through hands-on training. Also helping them to understand outputs after interpreting data and allow them to communicate where change is required.

5.4 Conclusion

The Fuel Coupon Management System with AI Inference developed in this research successfully meets the needs of PetroTrade by addressing inefficiencies in manual fuel coupon management. The research has highlighted that the system improves operational efficiency unlike traditional methods that are paper based which leads to poor data visibility, fraud, inefficiencies and delays in decision making. The implementation of an AI model (Random Forest Model) which makes prediction based on the data provided, plays a crucial role for PetroTrade as it will help to save time of going through the papers as to analyze the data for the sake of forecasting fuel consumption.

In conclusion, integration of AI inference into PetroTrade's fuel coupon management system is more than just a technology advancement as it shows a smart shift towards smarter, more secure and more efficient resource management. This study has illustrated the system's feasibility and value, laying the foundation for broader adoption within the fuel sector and contributing meaning to digital transformation in Zimbabwe.

Works Cited

AnalyticLabs, 2024. Top 12 AI Tools for Data Analysis To Include In Your Tech Stack. *AnalytixLabs Blog*.

Anayo, O. H., Nwogbaga, N. E. & Monday O, E., 2016. Critical Review Of Petrol Station Management. *Journal of Multidisciplinary Engineering Science and Technology*, 3(1), pp. 1-7.

Anon., 2023. *Virginia Tech University Libraries. (n.d.) Interviews – Research methods guide*. [Online] Available at: <https://guides.lib.vt.edu/researchmethods/interviews/> [Accessed 24 May 2025].

apw, 2024. *Embracing AI: transforming fleet management in fuel industry*. [Online] Available at: <https://apwfuel.com.au/embracing-ai-transforming-fleet-management-in-the-fuel-industry/> [Accessed 1 March 2025].

Balla, 2024. *The AI Journal: 5 ways AI is revolutionising Fuel Management Systems*. [Online] Available at: <https://aijourn.com/5-ways-ai-is-revolutionising-fuel-management-systems/> [Accessed 4 March 2025].

Banlaw, 2025. *Fuel Management System Europe*. [Online] Available at: <https://www.banlaw.com/fms-locations/fuel-management-system-europe/> [Accessed 9 March 2025].

Belcic, I. & Stryker, C., 2024. *IBM: what is supervised learning*. [Online] Available at: <https://www.ibm.com/think/topics/supervised-learning/> [Accessed 17 March 2025].

Crabtree, M., 2024. *What is Machine Learning? Definition, Types, Tools & More*. [Online] Available at: <https://www.datacamp.com/blog/what-is-machine-learning/> [Accessed 20 February 2025].

Crivva, 2024. *fuel management system in india*. [Online] Available at: <https://crivva.com/article/fuel-management-system-in-india/> [Accessed 13 March 2025].

DATAtab Team, 2025. *linear regression*. [Online] Available at: <https://datatab.net/tutorial/linear-regression> [Accessed 2 March 2025].

Galooli, 2022. *what is Fuel Management*. [Online] Available at: <https://galooli.com/glossary/what-is-fuel-management/> [Accessed 18 March 2025].

GasNet, 2021. *automated fuel management system (FMS) for filling station*. [Online] Available at: <http://www.gasnet.ng/> [Accessed 7 March 2025].

Glover, E., 2024. *builtin: what is AI model.* [Online]
Available at: <https://builtin.com/articles/ai-models/>
[Accessed 18 March 2025].

Great Learning Editorial Team, 20205. *Random Forest Algorithm in Machine Learning.* [Online]
Available at: <https://www.mygreatlearning.com/blog/random-forest-algorithm/>
[Accessed 25 May 2025].

Hamed, M. A., Khafagy, M. H. & Badry, R. M., 2021. Fuel Consumption Prediction Model using Machine Learning. *International journal of advance computer science and application*, 12(11).

Hamed, M. A., Mohammed, H. K. & Rasha, M. B., 2021. Fuel Consumption Prediction Model using Machine Learning. *International Journal of Advanced Computer Science and Applications (IJACSA)*, 12(11).

IBM, 2021. *unsupervised machine learning.* [Online]
Available at: <https://www.ibm.com/think/topics/unsupervised-learning/>
[Accessed 13 june 2025].

IBM, 2023. *What are support vector machines (SVMs)?.* [Online]
Available at: <https://www.ibm.com/think/topics/support-vector-machine/>
[Accessed 1 March 2025].

IBM, 2023. *wht is AI inference.* [Online]
Available at: <https://research.ibm.com/blog/AI-inference-explained/>
[Accessed 18 March 2025].

IBM, 2024. *what is linear regression.* [Online]
Available at: <https://www.ibm.com/think/topics/linear-regression/>
[Accessed 2 March 2025].

IBM, 2024. *What is predictive analytics.* [Online]
Available at: <https://www.ibm.com/think/topics/predictive-analytics/>
[Accessed 1 March 2025].

Jain, S., 2025. *Bloomfire: what is data vs information.* [Online]
Available at: <https://bloomfire.com/blog/data-vs-information/>
[Accessed 18 March 2025].

Kalghati, G., 2019. Development of Fuel/Engine Systems—The Way Forward to Sustainable Transport. *ScienceDirect*, 5(3), pp. 510-518.

Kanage, V., 2023. *What Is Linear Regression? Types, Equation, Examples, and Best Practices for 2022.* [Online]
Available at: <https://www.spiceworks.com/tech/artificial-intelligence/articles/what-is-linear-regression/>
[Accessed 1 March 2025].

Lim, W. M., 2024. What Is Qualitative Research? An Overview and Guidelines. *Australasian Marketing Journal*, 0(0).

Lindeman, N., 2023. *Pointepro: 12 advantages and disadvantages of questionnaires*. [Online] Available at: <https://pointerpro.com/blog/questionnaire-pros-and-cons/> [Accessed 27 March 2025].

Luenendok, M., 2023. *Founderjar: What Is Technology? Definition, Types, Examples*. [Online] Available at: <https://www.founderjar.com/what-is-technology/> [Accessed 18 March 2025].

Manjunath, T. K. & Kumar, A., 2024. Fuel Prediction Model for Driving Patterns Using Machine. *Journal of computer science*, 20(3), pp. 291-302.

McLeod, S., 2023. *Simply Psychology: Questionnaire method in research*. [Online] Available at: <https://www.simplypsychology.org/questionnaires.html#Problems-with-Postal-Questionnaires/> [Accessed 27 March 2025].

Mugalla, s., 2022. A FILLING STATION SYSTEM WHICH IS MEANT TO HELP. *academia*, pp. 1-19.

Navleb, 2024. *GPS Tracking platform: maximizinf efficiency and savings of fuel monitorinf systems for fleet management*. [Online] Available at: <https://www.navleb.com/blog/The-Benefits-of-Fuel-Monitoring-Systems/> [Accessed 3 March 2025].

Nollora, L., 2023. In-Depth Look into Fuel Management Systems. *Fuel Systems*.

Nollora, L., 2025. *In-depth look into fuel management system*. [Online] Available at: <https://www.fuelststems.au/in-depth-look-into-fuel-management-systems/> [Accessed 12 March 2025].

Redtest, 2018. *Requirements Analysis – Understanding the Process & Techniques*. [Online] Available at: <https://reptest.com/en/knowledgebase/requirements-analysis/> [Accessed 2 March 2025].

Samsara, 2025. *fuel managements systems: increase efficiency, reduce cost*. [Online] Available at: <https://www.samsara.com/guides/fuel-management-system/> [Accessed 12 March 2025].

Sharma, P., 2024. *The Role of AI in Revolutionizing Fuel Management Systems*. [Online] Available at: <https://www.linkedin.com/pulse/role-ai-revolutionizing-fuel-management-systems-priyanka-sharma-ilbxc/> [Accessed 1 March 2025].

Sreekumar, D., 2023. *Researcher.life: What is Quantitative Research? Definition, Methods, Types, and Examples*. [Online] Available at: <https://researcher.life/blog/article/what-is-quantitative-research-types-and-examples/> [Accessed 21 March 2025].

Stryker, C. & Kavlakoglu, E., 2024. *what is artificial intelligence*. [Online] Available at: <https://www.ibm.com/think/topics/artificial-intelligence/> [Accessed 1 March 2025].

Stryker, C. & Kavlakoglu, E., 2024. What is artificial intelligence (AI)? . IBM.

Suizo, G., 2013. *The Evolution of Fuel Management*. [Online]
Available at: <https://www.automotive-fleet.com/148367/the-evolution-of-fuel-management/>
[Accessed 1 March 2025].

Takya, A., 2025. *AI in the fuel distribution control: usa cases, benefits and technologies*. [Online]
Available at: <https://www.leewayhertz.com/ai-in-the-fuel-distribution-control/>
[Accessed 12 March 2025].

Takyar, A., 2024. *LeewayHertz: AI in the fuel distribution control: Use cases, benefits and technologies*. [Online]
Available at: <https://www.leewayhertz.com/ai-in-the-fuel-distribution-control/>
[Accessed 7 March 2025].

The chronicle, 2021. *Authorities must thoroughly enforce new fuel management system*. [Online]
Available at: <https://www.chronicle.co.zw/comment-authorities-must-thoroughly-enforce-new-fuel-management-system/>
[Accessed 10 March 2025].

The Herald, 2020. *Motorists cry foul over fuel coupons*. [Online]
Available at: <https://www.herald.co.zw/motorists-cry-foul-over-fuel-coupons/>
[Accessed 12 March 2025].

The Investopedia team, 2025. *What is Artificial Intelligence (AI)*. [Online]
Available at: <https://www.investopedia.com/terms/a/artificial-intelligence-ai.asp/>
[Accessed 17 March 2025].

Tiwari, V., 2024. Role of Data Analytics in Business Decision Making. *knowledgeable research*, 3(1), pp. 18-27.

Twin, A., 2025. *Investopidia:KPIs: What Are Key Performance Indicators? Types and Examples*. [Online]
Available at: <https://www.investopedia.com/terms/k/kpi.asp/>
[Accessed 18 March 2025].

Uffizio, 2024. *what is fuel management system*. [Online]
Available at: <https://www.uffizio.com/blog/what-is-fuel-management-system/>
[Accessed 12 March 2025].

Zangana, H. M., 2018. design an Information management system for gas station. *International Journal of Advanced Research in Computer and Communication Engineering* , 7(9), pp. 1-6.