# PETRONAS Petrol Station Fuel Consumption Forecast System

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## Abstract

*'PETRONAS Petrol Station Fuel Consumption Forecast System' is a study undertaken to computerize the process of forecasting of future fuel consumption at a typical PETRONAS petrol station. The need for forecast arises at any PETRONAS petrol station because the manager must place order of new fuel deliveries by minimum one week earlier as required by PETRONAS Dagangan Berhad. At the moment, manager places the order by filling paper form manually and faxing it to Mesra Link of PETRONAS Dagangan. Forecast of fuel consumption for a particular future period is not as easy as it seems. The amount of fuel ordered, which corresponds to the different tanker capacities and constrained by the maximum capacity of the station, relies on intuitive judgment of the manager. A good judgment comes from the experience of the manager who knows well of the unique consumption pattern at his or her station. Different station will exhibit different consumption pattern. The project was handled using the exploratory development cycle. It begins with analysis, design, development, testing and final evaluation of the system. The analysis methodology applied is structured interview with the manager in order to understand the business process. Next, a suitable design is drawn to convert the process into a computer system. The tool used is PROLOG, which provides the ready-built modules - knowledge base, working memory and inference engine, of an expert system. The study concludes that forecast is a heuristic decision-making and unique to different station thus warrants the need to capture the skill and forecast knowledge of manager in order to preserve the skill and knowledge. The study also discovers that the forecast skills and knowledge can be effectively mapped into production rules, thus enabling computer processing. Further research is necessary to enhance the intelligence algorithm of the system, to test the performance of the system in the operation setting and to evaluate acceptance by end-users who are the operation managers at PETRONAS petrol station. This paper will also highlight the future enhancement of the system.*

## Keywords:

Expert systems, Knowledge-based system, Forecasting

## Introduction

One of the roles of a manager at a PETRONAS petrol station is to make request for new supply of fuel periodically. A request form is filled and submitted to Mesra Link center at PETRONAS Dagangan Berhad (PDB). PDB compiles the requests from all stations nationwide. Management of Klang Valley Distribution Terminal (KVDT) will receive the compiled orders and prepare the delivery schedules. The tankers will deliver the requested amount of fuel on the requested dates to the requesting PETRONAS petrol stations. Therefore, it is necessary to place order early so that PDB and KVDT will have sufficient time to fulfill the demand. Usually, orders are placed for deliveries 2 and 3 weeks ahead. Although the need to do forecast is not explicit, every operation manager needs to know how to do it in order to place orders for fuel, which will be required only 2 and 3 weeks from the time, the order is placed. In case of serious under supply, manager can call for emergency load.

## Background of Study

Forecasting is very heuristic in nature. It requires judgments of the expert, which evolve from many years of experience [1]. Forecast results vary in different PETRONAS petrol stations due to differences in physical and social geographies of the locations. There are no particular steps to follow and station managers have to rely on rule of the thumb to decide on the schedule of supply delivery. In the context of petrol station managers forecasting fuel consumption, developing an expert system is appropriate. Expert systems could capture knowledge and experience of the manager to simulate the thinking or actions of that expert [2,3].

### Problem Statement

A manager at a PETRONAS petrol station uses experience and judgment to forecast fuel consumption. Forecasting fuel is crucial because it helps the manager to decide on how much fuel to order and when the fuel should arrive to ensure continuity of sales. If the forecast is inaccurate, the station's underground tank may dry up before the next tanker arrives. This will interrupt sales, cause dissatisfaction of customers and affect income and image of PETRONAS. Forecasting is implicitly done when the manager fills out an order form. Manager relies on intuition gained from experience to predict the fuel consumption. In the expert system's context, the manager is an expert because he or she possesses special knowledge of the factors influencing fuel consumption at particular station and is capable of predicting the possible outcome.

### Objectives

The main objectives of this project are to achieve the followings:

a. To understand how a manager at PETRONAS petrol station makes fuel consumption forecast.
b. To develop a prototype system that is capable of making fuel consumption forecast.
c. To implement rule-based artificial intelligence in the system.

### Scope of Study

The study focuses on how a manager at a typical local PETRONAS petrol station forecast the future consumption of fuel. At the moment, only petrol consumption is studied and no differentiation is made between leaded and unleaded petrol. The findings will be presented in flowcharts and explanation. An expert system prototype will be designed. The prototype stores historical data formulate rules and make predictions based on parameters input by user. Output is the amount required and the date of required delivery for a certain timeframe in the future.

## Methodology

The analysis phase requires the understanding of the existing fuel ordering system and the solicitation of knowledge. The domain expert will provide knowledge, which includes the domain problem and the rules to solve it. In this context, the manager of PETRONAS petrol station is a domain expert because he is the person whose experience and skill enable him to predict the future fuel consumption of the station. The next phase is design and prototyping. The objectives of the design include the following:

a. The system captures the manager's forecast knowledge through a set of rules.
b. The complexity is hidden from user through well-designed user interface.
c. The system provides explanation for its predicted outcome.
d. The system accepts feedbacks from human user and stores the shortcomings of its prediction as knowledge.

The knowledge engineer represents the knowledge acquired in computer coding [4]. The prototype is developed to solve problems in a small area of the domain and provide a test bed for preliminary design assumptions. Once the prototype has been implemented, the knowledge engineer and the domain expert are going to refine the system until it becomes a final system. This is done by using the prototype, conducting tests and rectifying the shortcomings.

## PPFS Logical and Physical Design.

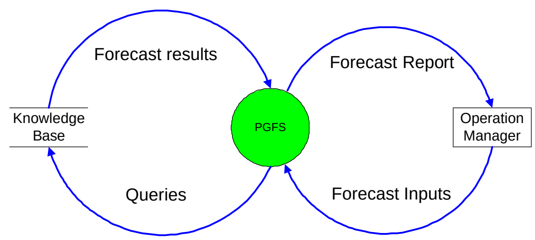


*Figure 1- Conceptual design of PPFS*

Figure 1 depicts the conceptual design of PPFS. Operation manager trigger the queries by inputting necessary forecast parameters. PPFS will extract related knowledge from its knowledge base. PPFS generates forecast report and the manager will provide feedback on the accuracy of the forecast. There is a possibility that new knowledge can be determined at this stage. It allows manager to compare

### PPFS System Architecture

This project intends to use rule-based expert system architecture. The rule-based system architecture is based on the major logical components: knowledge base and inference engine [5]. Figure 2 illustrates the system architecture of PPFS.

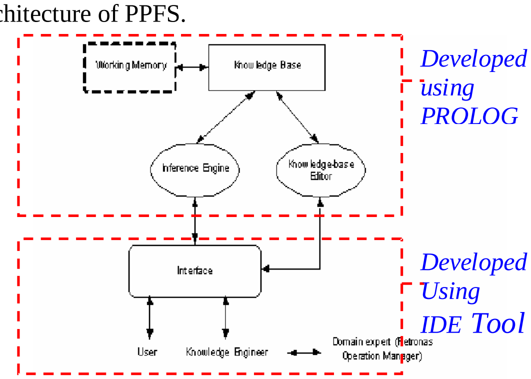


*Figure 2 - System Architecture of PPFS.*

The architecture consists of two parts: the back-end interface and the front-end interface. The back-end interface consists of the working memory, knowledge base, knowledge base editor and inference engine. These back-end components are developed using Prolog. The front-end interface provides the friendly GUI developed using an IDE tool.

*Front-end Interface.*

The user passes the parameter through the user interface to the inference engine to trigger the consultation process. Knowledge developer is responsible to capture knowledge from the domain expert and place that captured knowledge into system's knowledge base using rule-based representation. The user is anyone who uses the system for decision-making. It can be the manager or even the clerk.

Through the interface, the system will query the user for forecast parameters. The parameters that need to be specified by the user are as follows:

- Public calendar events such as public holidays and state holidays
- Localized calendar events such as night market, festivals, VIP visit etc.

*Back-end Interface.*

The inference engine performs two tasks. First to examine the status of the knowledge base and working memory so as to determine the facts are known at any time and to add any new facts that become available. Second, it controls the order in which inferences are made [6]. During the consultation session, the working memory module will store for facts that have been determined for that specific problem at hand. To be more specific, it stores the results of the inference process. The knowledge base contains the rules and the facts. The facts are various aspects of a specific domain that are known prior to consultation session (between user and expert system). The rules are heuristics, or rules developed through intuition, experience and judgment. For this project, the chosen knowledge representation is rule-based expert system. The knowledge is represented in the form of if…then… rules. The knowledgebase contains both general knowledge and case-specific information. The knowledge-base editor module allows the entry of rules specified by the knowledge engineer into the knowledge base during the developmental phase of the expert system. It allows various checks on the rules on consistency and completeness.

## Overall System Flow

The system applies a combination of question-and-answer style to capture parameters. Figure 3 represents the PPFS system flow.

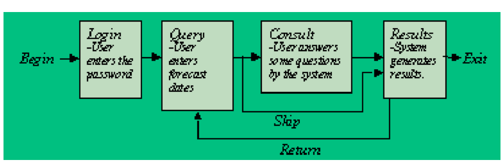


*Figure 3 – PPFS System Flow*

Parameters that need to be input are as follows:

- The forecast dates which includes the start date and end date.
- The dates for any public events such as public holiday and state holidays
- The dates for localized calendar events such as night market, festivals, VIP visits, etc.
- The outputs of the system are the schedule of expected arrival of tankers and the required amount of fuel.

## A Forecasting Example

In the following a forecasting example is presented that indicates the function of the expert system. Production rule is the best representation of expert knowledge for this project because the human experts prefer to define his knowledge in terms of IF-THEN situation-action rules.

*Table 1- Set Of Rules That Was Defined By The Human Expert And The PROLOG Code Equivalent To That Set Of Rules*

| No | Production facts/rules | PROLOG |
|---|---|---|
| 1 | IF Monday AND normal day, THEN order 27300 liters | normal(monday,27300). |
| 2 | IF Wednesday AND normal day, THEN order 27300 liters | normal(wednesday,27300). |
| 3 | IF Friday AND normal day, THEN order 27300 liters | normal(friday,27300). |
| 4 | IF Saturday AND normal day, THEN order 21840 liters | normal(saturday,21840). |
| 5 | IF pre festival days, THEN order 21840 liters | special(Event,Day,21840):member(Event,[prechi,prehar]). |
| 9 | IF post days after festival, THEN order 21840 liters | special(Event,Day,21840):- member(Event,[poschi,poshar]). |

Table 1 represents a sample of a set of rules that was defined by the human expert and the PROLOG code equivalent to that set of rules. In order to start the query, the forecasted dates and the fuel type are specified. Figure 4 shows the forecasted dates entered by the user.

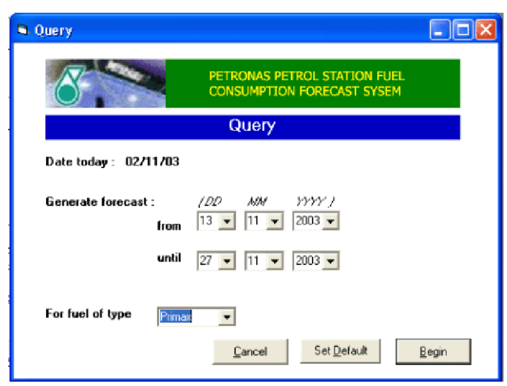


*Figure 4 - Forecasted Dates Entered By the User*

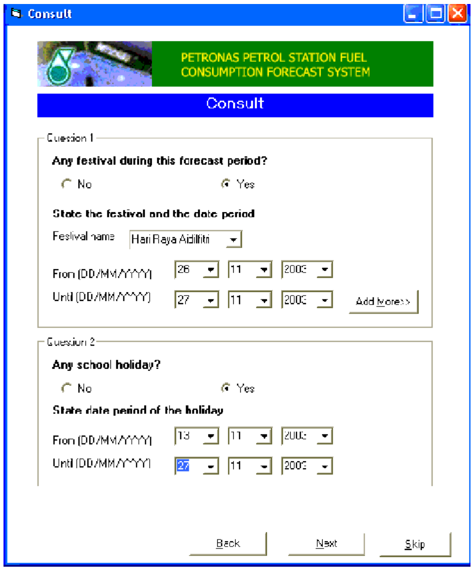


*Figure 5- 2 Questions on Public Events That Will Occur During the Specified Forecasted Period*

Figure 5 consists of 2 questions on public events that will occur during the specified forecasted period. Question 1 requires the user to state public festivals and the dates. Question 2 requires the user to specify any school holidays. Question 2 can also be used to specify other public holidays that would occur during the forecasted period.

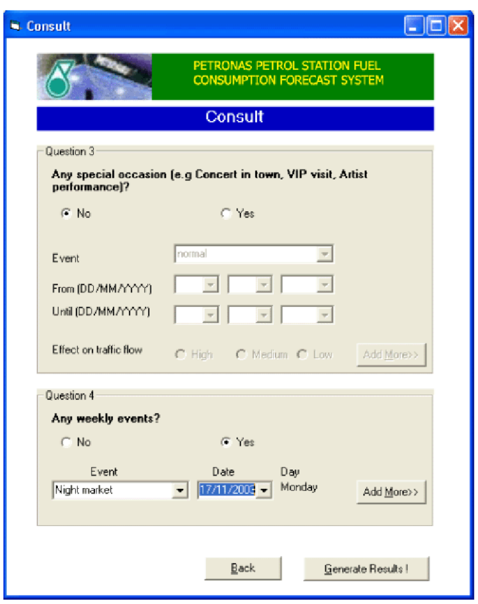


*Figure 6 – The Localized Event Questions*

Figure 6 depicts the localized events questions. User needs to indicate a special occasion such as VIP visits and carnival in Question 3. Question 4 requires the user to identify weekly events. Figure 7 depicts the output of the system is a report that shows the forecasted result based on the parameters specified by the user. It provides the date and the amount of fuel needed for that particular date.

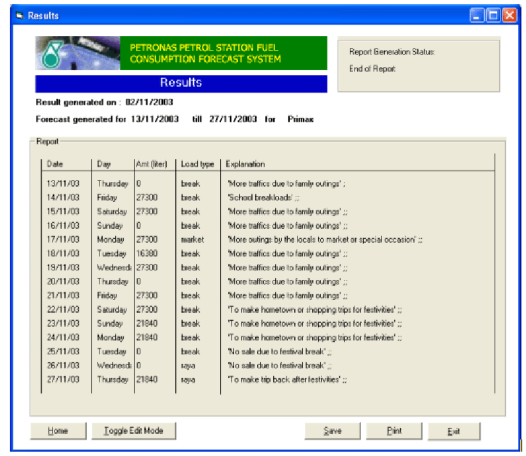


*Figure 7 - The Output of the System Is a Report That Shows the Forecasted Result Based On the Parameters Specified By the User*

## Discussion

The system definitely has its limitation that can be a subject on future enhancement or research. The system has limited consideration of forecast factors. For example, it does not consider factors such as weather's effect on consumption. The system also does not include user's feedback on accuracy.

### Recommendation for Future Enhancements

PPFS merely follows existing business process. Nevertheless, for future enhancements, it is suggested that the knowledge base to revise to include variable factors that could influence decision-making. An ideal expert system does not need a knowledge engineer. Since knowledge engineer will not be available all the time, the domain expert is expected to interact directly with the expert system for placing knowledge into the knowledge base. Another way is to integrate machine learning capabilities by enabling the system to perform automatic rules induction. The system should also be able to exhibit degree of confidence and precision for its forecast. This is important for human manager to decide whether or not to accept the system's recommendation. Continuous research will achieve a level where the expert system will mature into a fully automated system independent of human manager. It is capable of making accurate forecast and placing order to PDB directly.

## Conclusion

This research explores the potential of expert system in preserving the skills and knowledge of an experienced PETRONAS petrol station operation manager in predicting the required future supply of petrol. The study concludes that forecast is a heuristic decision-making and unique to different station. This warrants the need to capture the skill and forecast knowledge of manager in order to preserve the skill and knowledge when a new manager takes over. The study also discovers that the forecast skills and knowledge can be effectively mapped into production rules, thus enabling computer processing. A prototype was developed using rule-based knowledge representation. The system was tested with known condition-action inputs and outputs. The result was satisfactory but the validity of the testing can be questioned. Valid test results can be acquired from field experiment setup but unfortunately could not be achieved due to time constraint. Nevertheless, the project has met another two objectives of this project, which are creating a prototype; and implementing a rule-based artificial intelligence technology in it.

## Acknowledgement

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