Electrical Load Forecasting for Small Scale Power System Using Fuzzy Logic

by

Nur Amalina Bt Mohd Razali

Project dissertation submitted in partial fulfillment of

the requirements for the

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(Electrical & Electronic Engineering)

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Universiti Teknologi PETRONAS

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CERTIFICATION OF APPROVAL

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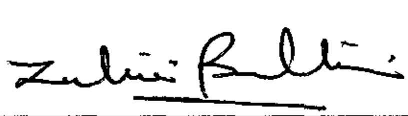
Approved by,



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TRONOH, PERAK

SEPTEMBER 2011

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

(NUR AMALINA BT MOHD RAZALI)

ABSTRACT

Electrical load forecasting is an essential activity and important function in power plant generation planning. It helps the plant involved to make appropriate decision on planning like shutdown or turnaround, decision on purchasing and generating electric power, load switching and infrastructure development. This report discusses the approach for short term load forecasting using fuzzy logic model. A background study concerning the importance of load forecasting in Gas District Cooling of Universiti Teknologi PETRONAS is portrayed. Literature review written consists of brief explanation of forecasting as well as few factors that affect the forecasting such as day type of forecast day, weather condition and previous load of the demand. These factors contribute great impact to distinguish weekly electricity load behavior. In order to achieve minimum error of forecasting, a suitable method which is using fuzzy logic approach is proposed. The fuzzyTECH software is used in developing a week to week ahead load forecasting model, together with Microsoft Excel. The model was tested and gives the results of satisfactory forecasting error. The model used is improved in order to obtain higher accuracy of load forecasting when it is testing with the actual data.

ACKNOWLEDGEMENT

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TABLE OF CONTENTS

LIST OF FIGURE

LIST OF TABLE

LIST OF ABBREVIATION

DDE : Dynamic Data Exchange

DoS : Degree of Support

GDC : Gas District Cooling

MAPE : Mean Absolute Percentage Error

kW : Kilowatt

STLF : Short Term Load Forecasting

UTP : Universiti Teknologi PETRONAS

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Forecasting demand is an essential activity and is one of the most important functions in power system planning and development. The field of forecasting is concerned with approaches to determining what future holds. It is also concerned with the proper presentation and use of forecasts [1]. Besides, the electricity generation cost also can be minimized as well as the electricity tariff can be controlled [2].

In Universiti Teknologi PETRONAS (UTP), the main power supply comes from Gas District Cooling (GDC) plant and from utility company Tenaga Nasional Berhad (TNB) as a backup. GDC consist of 2 no's of 4.2 MW generators, with maximum capacity of 8.4 MW. During normal operation, the generators are operating in island mode but during emergency, generators are parallel connected to TNB [3]. GDC plant is designed to produce electrical power and chilled water for UTP campus and in-plant use.

Electrical load forecasting can be divided into three categories: short-term forecasts which are usually from one hour to one week, medium forecasts which are usually from a week to a year, and long-term forecasts which are longer than a year. The forecasts for different time horizons are important for different operations within a utility company. The natures of these forecasts are different as well [4].

Different categories of load forecasting apply different type of models. The end-use modeling, econometric modeling, and statistical model-based learning are the most often used methods for medium and long-term forecasting. Meanwhile, variety of techniques such as regression methods, time series, neural networks, expert systems, support vector machines and fuzzy logic have been developed for short-term load forecasting.

The importance of electricity demand forecasting needs to be emphasized at all level as the consequences of under or over forecasting the demand are serious and will affect power plant company. If under estimated, the result is serious since plant installation cannot easily be advanced, this will affect the economy, business, loss of time and image [5]. If over estimated, the financial penalty for excess capacity as it is over estimated and wasting of resources.

Thus, throughout this project the data gathered from GDC-UTP are used for modeling short-term load forecasting specifically fuzzy logic model, in order to minimize the electricity consumption cost and reduce energy wastage during the generation period.

1.2 Problem Statement

1.2.1 Problem Identification

The operation and planning of a power plant requires an adequate model for electric power load forecasting. The reliability and effectiveness of the GDC-UTP plant can be determined by its performance. Many factors should be considered in electricity forecasting such as time factors, weather data; meteorological condition, calendar effects and the previous data load.

Since the electricity demand is fluctuating, complex and full off uncertainty, it needs a method to deal with it. The Fuzzy Logic System is applied which is the generalization of the usual Boolean logic used for digital circuit design. Under fuzzy logic, an input has associated with it a certain qualitative ranges.

1.2.2 Significant of the Project

The forecasting of power plant daily operation and is important for the economic and secure operation of power system. This project applied the Short Term Load Forecasting (STLF) method to predict daily consumption of GDC-UTP, by having one week ahead forecasting. Information derived from the STLF is significant to the system management of weekly, daily and hourly operation [6].

1.3 Objectives and Scope of Study

1.3.1 Objectives

The main objective of the study is to construct the Fuzzy Logic model to forecast UTP load demand data. The following sub-objectives were to be achieved from this study:

- To analyze historical UTP load demand data.
- To analyze the fundamental of Fuzzy Logic
- To understand the electricity demand behaviour of UTP.
- To produce a reliable and accurate forecasting model simulation of load forecasting by reducing the percentage error between the forecast and actual value of the load.

1.3.2 Scope of Study

In this project, the scope of the study will cover the following areas:

- Short term load demand in Universiti Teknologi PETRONAS.
- Historical data of electricity generated from GDC-UTP.
- Fuzzy Logic as a technique used in the forecasting method.
- fuzzTECH 5.52 software as the electricity forecasting tool.

1.4 Relevancy of the Project

This projects aims to minimizing electricity production costs by minimizing the amount of energy wastage during generation aligned with the Malaysian Government Green Technology Campaign; to reduce the energy usage. Thus, an accurate prediction for the electricity demand is very important to ensure sufficient, continuous and reliable supply to the consumers.

The forecast accuracy; Mean Absolute Percentage Error (MAPE) is measured based on the error statistic of forecast between the models for one week step. The overall MAPE is calculated by taking into calculation each week's MAPE. The lower overall MAPE shows a better accuracy of the forecasting model.

1.5 Feasibility of the Project

This project will be conducted for two semesters. This includes system research, development and improvement. In this project, the data for electricity consumption throughout the 26 consecutive weeks were obtained from GDC-UTP. The data was taken from both Jan 2010 and July 2010 semester, starting from 4 January 2010 until 4 July 2010, and for from 5 July 2010 until 31 Dec 2010 respectively (refer to Appendix A and Appendix B). This project is feasible to be conducted within the time frame and scope.

CHAPTER 2

LITERATURE REVIEW

2.1 Electrical Load Forecast

Load forecasting is very important nowadays for developed and developing countries to consume electricity efficiently. This concept come out when developed countries do not want to waste electricity and developing countries cannot waste electricity. After all, forecasting for future load demand requirement is the most important key for power system planning [7].

Forecast, by definition means the prediction of future events and conditions [8]. The term electricity forecasting referred to the act of making prediction on the future electricity demand using a certain method. The factors that may affect the forecasting result were taken into account.

Different type of forecasting methods is useful for different types of systems and defines the size of the system. Short term Forecasting – as hourly, daily or weekly forecasting; Mid- Range Forecasting – extend from a month to one year; and Long term Forecasting – ranging from one year to ten years. The short term load forecasting is especially significant for economic load dispatch, load management scheduling and optimum power flow with minimum transmission loss, fuel management and contingency planning.

The demand of electricity forms the basis for power system planning, power security and supply reliability. The need for forecasting models that evaluate the electric consumption with the highest level of accuracy is underlined by the black-outs for the whole Malaysia that occurred in 2005.

The relevance of forecasting demand for the utility company has become a much-discussed issue in the recent years which led to the development of new tools and methods for forecasting in last two decades.

2.2 Important Factors for Electricity Forecasting

During project research and development, there are several factors that may affect the electricity demand forecasting result. Based on the scope of location whereby this project was conducted, which is University Teknologi PETRONAS, the following input variables have been taken into account:

2.2.1 Previous week load consumption

From the study of the load data, it was found that the load demand on a particular day in a week and a week before is not much in difference. The load at a given hour is dependent not only on the load on the previous hour but also on the load at the same hour of the previous day. However, the load on particular day for this week and the last week, or the week before may be almost similar.

Hence, it is assumed that the load curve is somewhat similar to the load curve on the previous day. Thus, the previous load data could give significant contribution in forecasting the load.

2.2.2 Day type

There are significance differences in load consumption between weekdays and weekend. Load on different weekdays in the same may behave differently. The type of the day can be classified into two class; *public holiday* and *normal working day*. During public holiday, the normal electricity consumption may drop drastically, compared to normal working day.

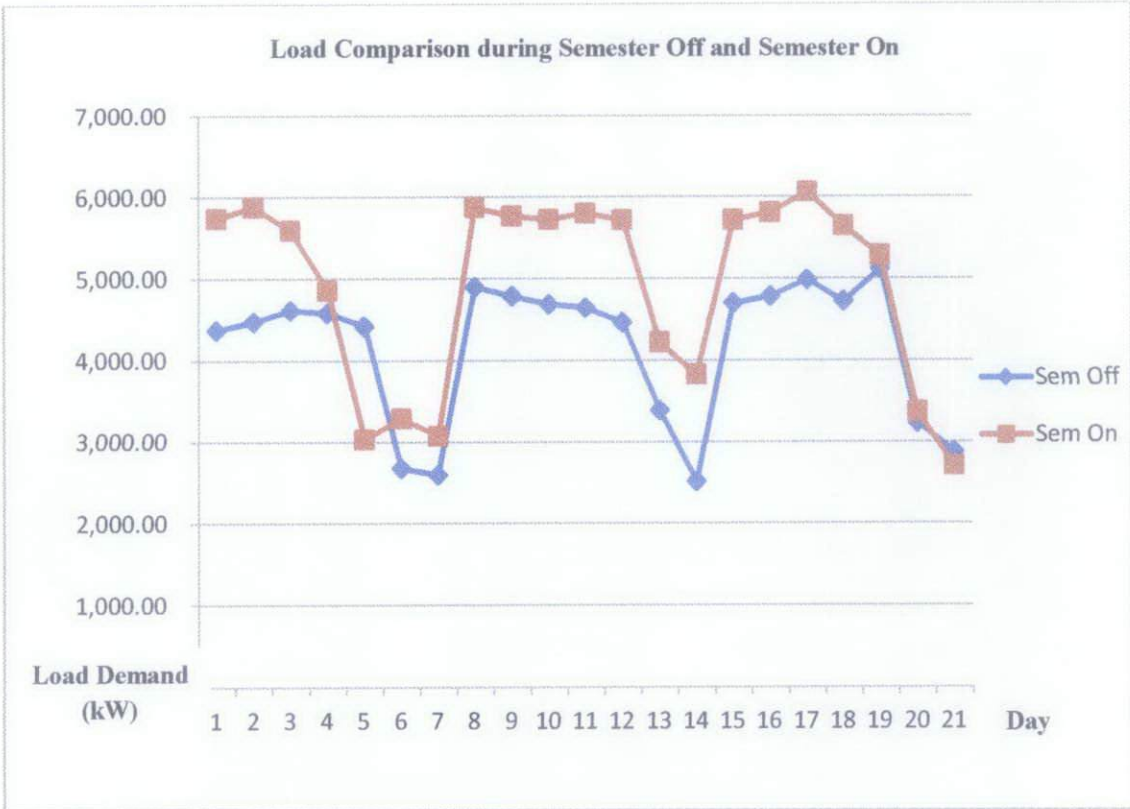

Figure 2.1: Load Comparison during Semester Off and Semester On

2.2.3 Semester type

The electricity demand rises when semester is on and drops during semester breaks. Thus, it is necessary to include the type of semester; *on* and *off* as the input. The graph in Figure 2.1 shows that the electricity demand during semester on (22 February until 3 Mac 2010) is slightly higher than the demand during semester off (4 until 24 January 2010).

During semester on, the activities conduct will increase the electricity demand, meanwhile during semester off, less activities conducted contribute to the lower demand of the load.

2.2.4 Day temperature

The influence of weather in energy consumption, particularly electricity demand, has been widely reported in the past. The weather condition will affect the day temperature. In fact, forecasted day temperature is the most important factors in short-term load forecasting.

From the data performance, the day temperature is interrelated with the electrical load demand. For example, during the hot day, the temperature rise will lead to higher electricity consumption when the fan speed is increase. However, when the weather is cold, the temperature is reduced lead to lower consumption of electricity as air-conditioner and the fan speed is reduced.

2.3 Fuzzy Logic Theory

In using our everyday natural language to import knowledge and information, there is a great deal of impression and vagueness. For example, question like "We're thinking of bringing Mr. X in on this next project: how do you feel about it?" with answers like "I really don't think it's very good, but if there's no one more appropriate, that's the way it goes" are the kind found in everyday events. It is inexpedient to discuss this "yes" on the same level with "yes" of "Mr.X is certainly most appropriate." [9].

For this reason, university of California Professor L.A. Zadeh extended the two-valued evaluation of 0 or 1, {1,0}, to the infinite number of values from 0 to 1, [0,1], and advanced the concept *fuzzy sets* at the beginning of the 1960s, publishing a paper in *Information and Control* entitled "Fuzzy Sets" in 1965.

Here { } brackets are used to indicate sets, but square [ ] brackets and parentheses ( ) are used to denote real-number closed intervals and open intervals, respectively. For example, they are used as follows:

$$[0, 1] = \{x|0 \leq x \leq 1\},$$
$$(0, 1) = \{x|0 < x < 1\},$$
$$[0, 1) = \{x|0 \leq x < 1\},$$

The first publication on fuzzy logic, which also coined its name, dates back to 1965. It was written in the U.S. by Lotfi Zadeh, Professor of Systems Theory at the University of California, Berkeley. From there, the history of fuzzy logic follows the pattern of number recent technologies: invented in the U.S., engineered in Europe, and mass-marketed in Japan [10].

In addition, Zadeh used the term *membership function* instead of characteristic function.

In contrast to binary sets that having binary logic (crisp logic), the fuzzy variables may have memberships values of not only 0 or 1. The values can range from 0 to 1. The difference between binary sets and fuzzy logic are as follows:

An ordinary subset A of a set U is determined by its indicator function, or characteristic function XA defined by:

$$X_A(x) = \begin{cases} 1, & x \in 0 \\ 0, & x \notin 0 \end{cases}$$

The degree to which the value of a technical figure satisfies the linguistic concept of the term of a linguistic variable is called degree of membership. For a continuous variable, this degree is expressed by a function called membership function (MBF). The membership functions map each value of the technical figure to the membership degree to the linguistic terms. The technical quantity is called the base variable [11].

The fuzzy logic usually is applied for the non-numeric linguistic variables. It is often used for facilitating the expression of rules and facts. The Fuzzy Logic uses IF-THEN rules which employ the linguistic variables (fuzzy variables) whose values are in the linguistic terms.

The rules are usually expressed in the form [12]:

IF variable IS property, THEN action

For multiple inputs, the following rule applied:

IF x IS a and y IS b, THEN z is c

As Fuzzy Logic method is being used in this project, the basic configuration is shown in Figure 2.2. The basic elements in fuzzy system are:

a) Fuzzification : mapping from the observed non-fuzzy input space to the fuzzy sets.

b) Fuzzy Rule Base: a set of linguistics rules or conditional statements in the form of “IF a set of condition IS satisfied, THEN a set of consequences are inferred”[11].

c) Fuzzy interference machine: decision making logic performing the interference operations of the fuzzy rules.

d) Defuzzification interface: defuzzifies the fuzzy outputs of the fuzzy inference machine and generates a non fuzzy (crisp) output which is the actual output of the fuzzy system [13].

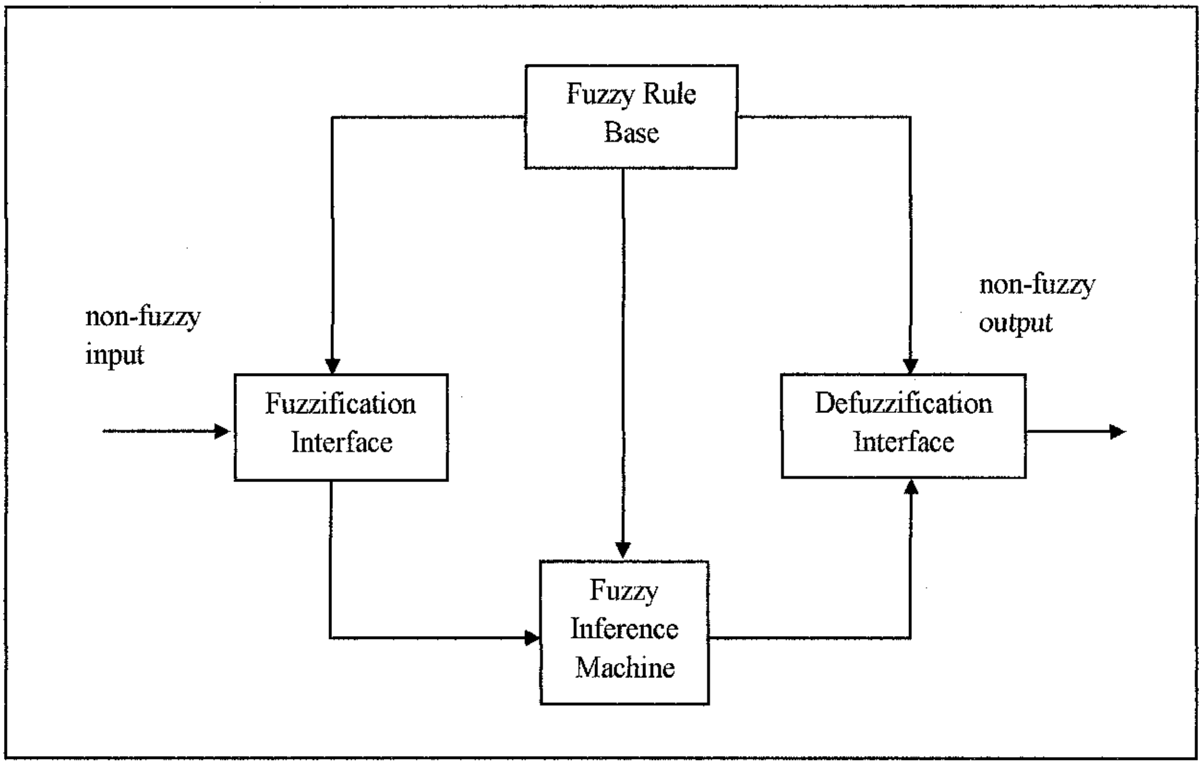

Figure 2.2: Basic Configuration of Fuzzy System

CHAPTER 3

METHODOLOGY/PROJECT WORK

3.1 Project Work Identification

In this project, two main software are required, the fuzzyTECH and Microsoft Excel. fuzzyTECH is the software for fuzzy logic-based solution. This software provides simple user interface for developing the load forecasting model especially for beginners since all the fuzzy logic algorithm are embedded within the program.

However, fuzzyTECH does not provide the interface for data management. Alternatively, fuzzyTECH can be linked together with the software for data interfacing such as the Microsoft Excel. The Dynamic Data Exchange (DDE) Links function, which is embedded inside the fuzzyTECH, can be used to link the system with the worksheet of the Microsoft Excel.

Data gathering is collected from GDC- UTP and will be analyze. The data analysis will be based on categories fixed, such as by a week or by a semester. Then, the model will be simulating using fuzzyTECH software and will be tested to verify it.

From the data obtained, the trending for load consumption are analyzed and grouped into different range. Then, the membership functions were established. The membership function of a fuzzy set is a generalization of the indicator function in classical sets. In fuzzy logic, membership function represents the degree of truth as an extension of valuation [14]. The next part is the construction of the Fuzzy IF-THEN Rule Blocks for each forecast output.

3.2 System Design and Construction (Stage 1)

The model design consists of Input-Linguistic Variables, Rule Blocks and Output-Linguistic Variables as shows in Figure 3.1. The current existing model was developed by using the system design approach as shown in Figure 3.2.

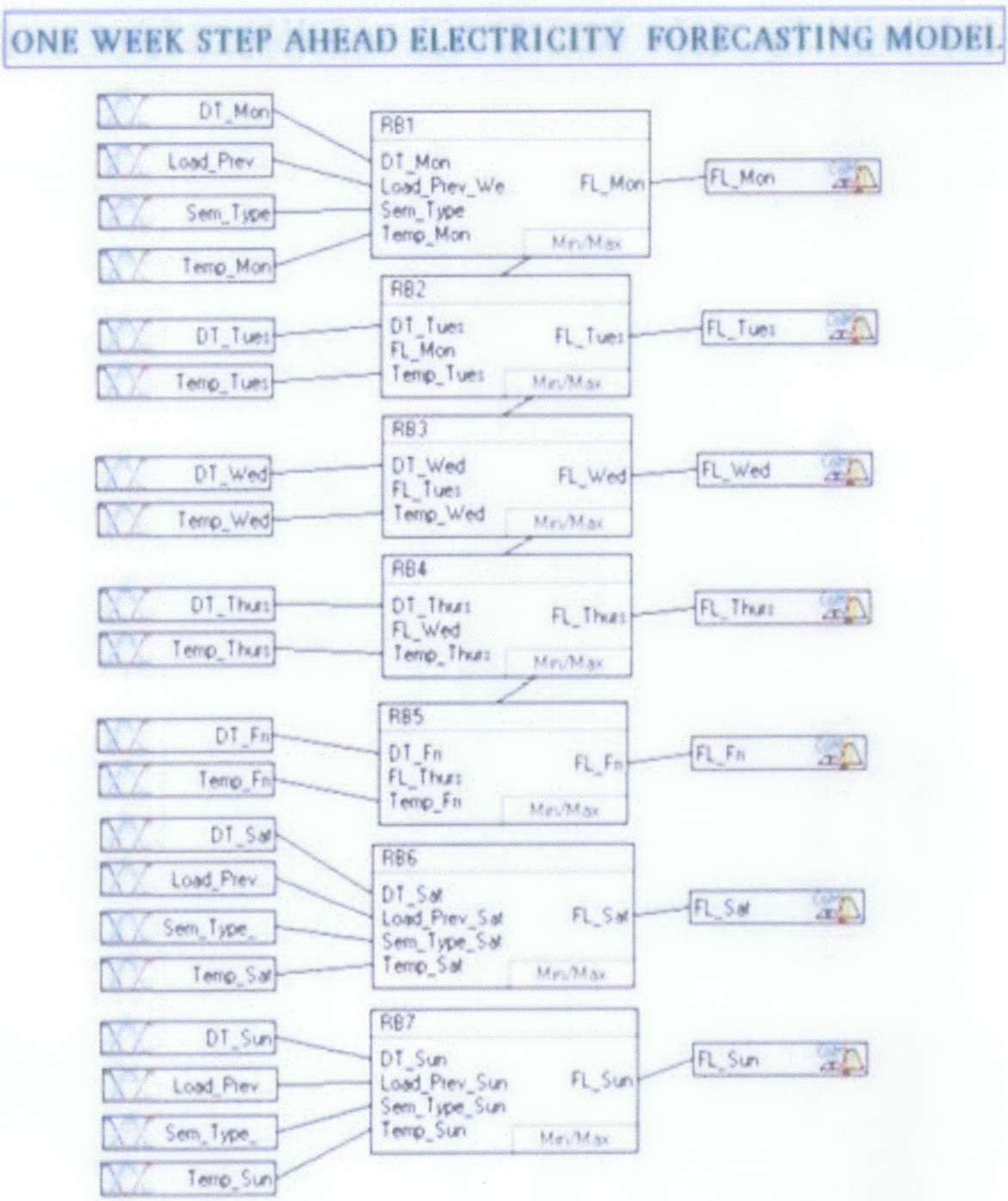

Figure 3.1: Forecasting Model Projector Editor

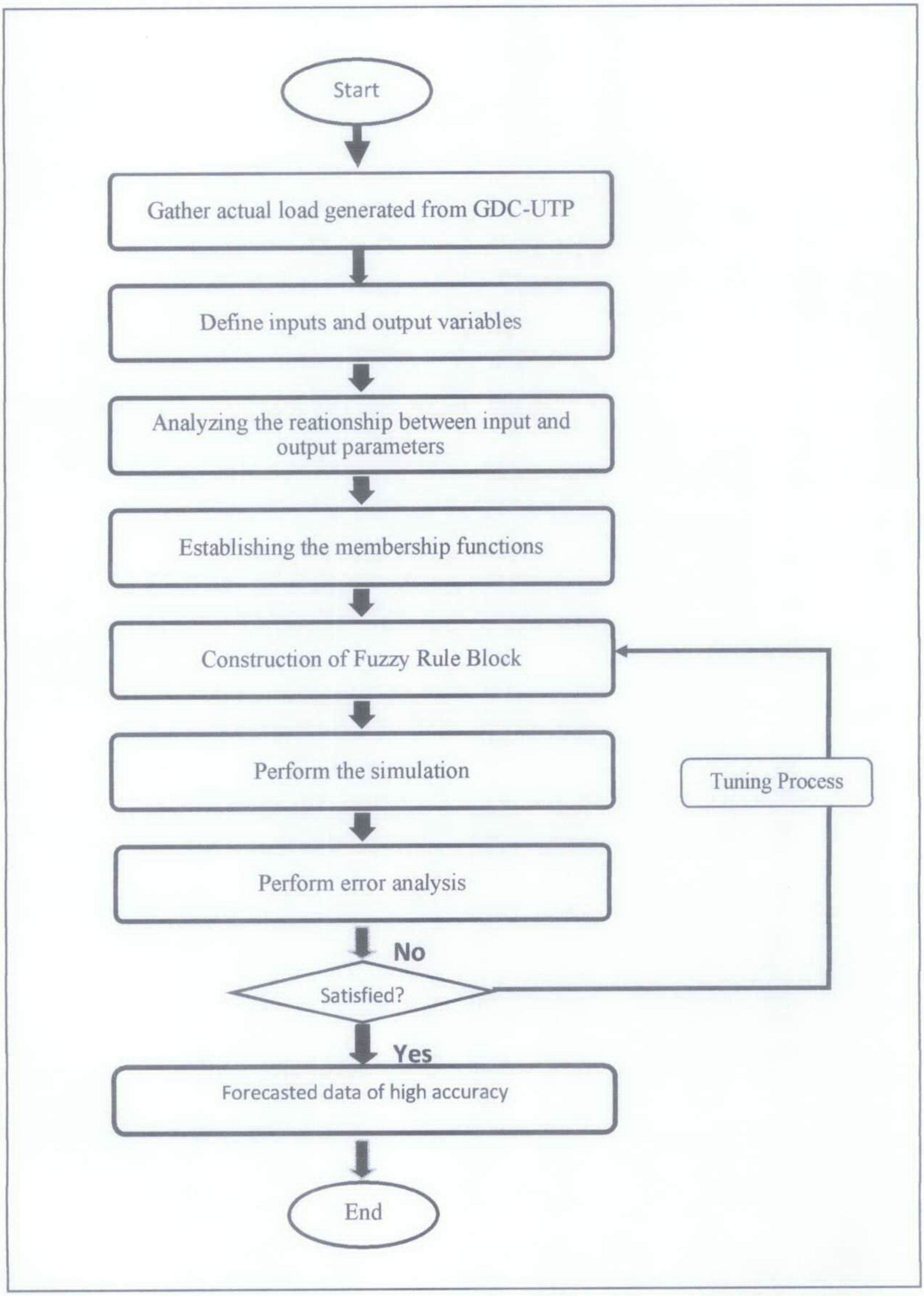

Figure 3.2: Flowchart for System Design Approach

Then, the membership functions for all linguistic variables can be established. This membership degree is represented by a value in the range of 0 and 1. A membership degree of 0 means no membership at all while a degree of 1 means absolute membership. Figures below show the membership of input and output variable.

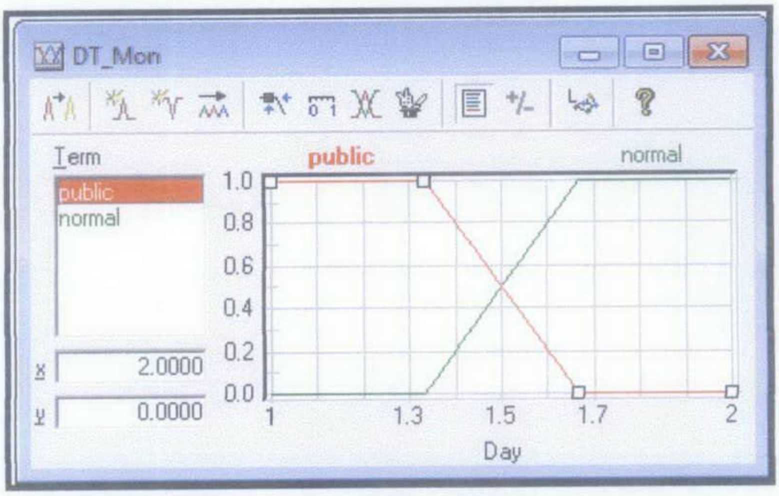

Figure 3.3: Membership function for input variable of Day Type

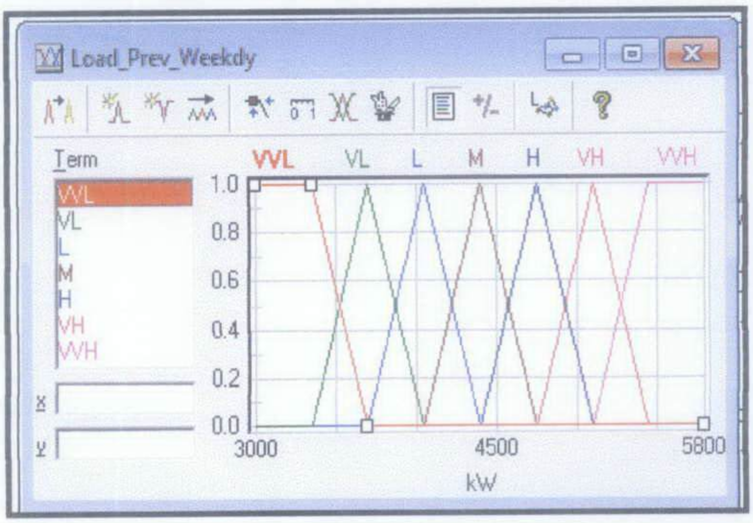

Figure 3.4: Membership function for input variable of Load Previous Weekday

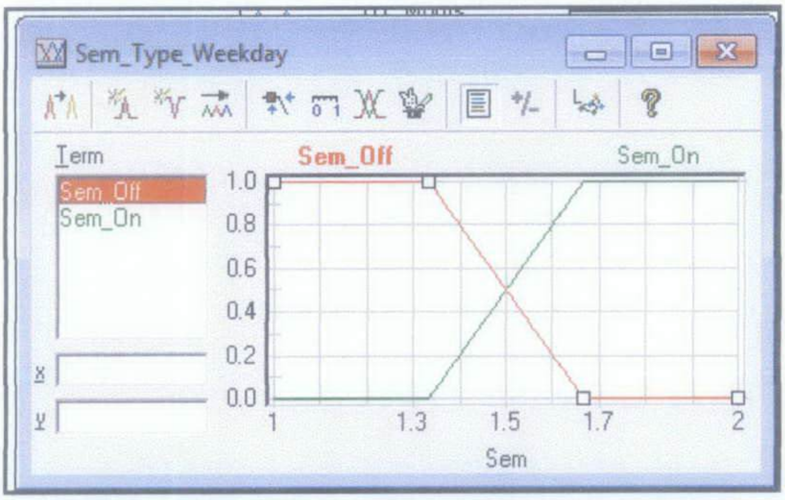

Figure 3.5: Membership function for input variable of Semester Type

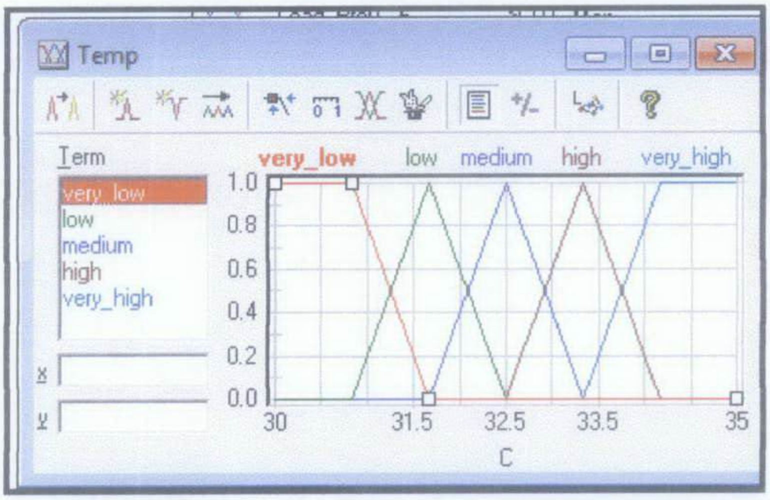

Figure 3.6: Membership function for input variable of Day Temperature

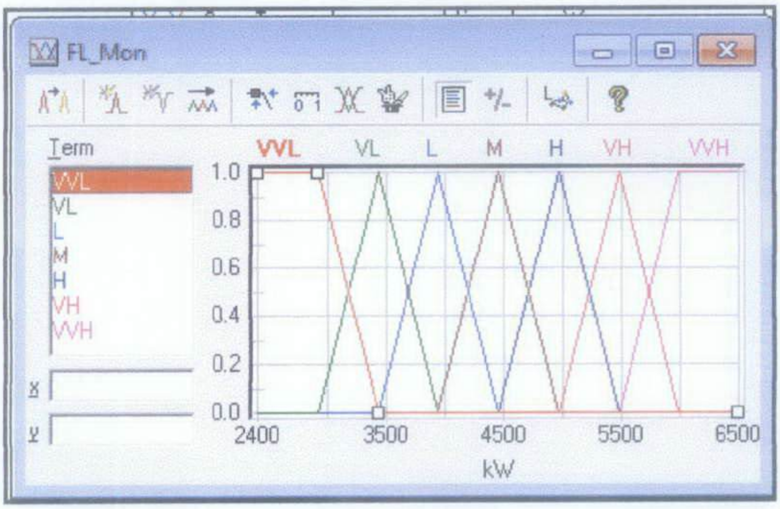

Figure 3.7: Membership function for output variable of Forecast Load

The next part is the construction of the fuzzy IF-THEN rule blocks. These rule blocks are the medium that connect system inputs and system outputs based on the If-Then rules. In Figure 3:8 below, the 'IF' column shows the input variables as the precondition of fuzzy rules. The 'THEN' column shows the output variables as the conclusion or consequence of the condition.

Spreadsheet Rule Editor - RB1

#	IF				THEN	
	DT_Mon	Load_Prev_Weekdy	Sem_Type_Weekday	Temp	DoS	FL_Mon
1	normal	H	Sem_On	high	0.90	H
2	normal	H	Sem_On	very_high	1.00	H
3	normal	M	Sem_On	very_high	1.00	VVH
4	normal	VH	Sem_On	medium	1.00	VH
5	normal	M	Sem_On	very_high	1.00	VH
6	normal	VH	Sem_On	very_high	1.00	VVH
7	normal	VVH	Sem_On	very_high	0.90	VH
8	normal	VVH	Sem_Off	high	1.00	M
9	normal	VVH	Sem_On	very_high	1.00	VVH
10	normal	VVH	Sem_On	high	1.00	VH
11	normal	VH	Sem_On	very_high	1.00	VH
12	normal	VH	Sem_On	high	0.80	VVH
13	normal	H	Sem_Off	high	0.70	VVL
14	normal	M	Sem_Off	medium	0.90	H
15	normal	H	Sem_Off	high	1.00	VH
16	public	VVH	Sem_On	very_high	1.00	VVL
17	public	VVH	Sem_On	high	1.00	VH
18	public	VH	Sem_On	medium	1.00	VH
19	normal	L	Sem_Off	very_low	1.00	L
20	normal	L	Sem_Off	medium	1.00	M

Figure 3.8: An example of Monday Rule Block

3.3 Program Simulation Process

Then the simulation began when user activating the Debug Interactive Mode button. The input is inserting in the Data Input column in Microsoft Excel as shown in Table 3.1. The input in term of crisp value then will be sent to the fuzzyTECH software through Dynamic Data Exchange (DDE) Link. The value of the forecast output will be computed, referring to the respected membership function values and the rule base. The output values then can be sent back to Microsoft Excel column address in the DDE Link Window, for easier management.

INPUT

	WEEK	
Insert previous weekday actual average load		kW
Insert previous week actual Saturday load		kW
Insert previous week actual Sunday load		kW
Insert forecast Monday maximum temperature		C
Insert forecast Saturday Temperature		C
Insert forecast Sunday Temperature		C
Insert forecast Weekday semester type		
Insert forecast Saturday Sem type		
Insert forecast Sunday Sem type		
Insert forecast Monday Day type		
Insert forecast Tuesday Day type		
Insert forecast Wednesday Day type		
Insert forecast Thursday Day type		
Insert forecast Friday Day type		
Insert forecast Saturday Day type		
Insert forecast Sunday Day type		
Insert forecast Tuesday maximum temperature		C
Insert forecast Wednesday maximum temperature		C
Insert forecast Thursday maximum temperature		C
Insert forecast Friday maximum temperature		C

Table 3.1: An example of Input Column in Microsoft Excel

OUTPUT

DAY	F	A	F-A	ABS F-A	ERROR
MONDAY					
TUESDAY					
WEDNESDAY					
THURSDAY					
FRIDAY					
SATURDAY					
SUNDAY					
				MAPE:	

Table 3.2: An example of Output Column in Microsoft Excel

3.4 Error Calculation

The mean average percentage error (MAPE) is computed in terms of weekly MAPE. The MAPE calculation of semester on and semester off can be calculated as follows:

$$Percentage\ Absolute\ Error = \frac{|Actual\ load - Forecast\ load|}{Actual\ load}\ x\ 100\%$$

$$MAPE = \frac{1}{N}\sum_{i=1}^{N}\left|\frac{P_A^i - P_F^i}{P_A^i}\right| X\ 100\%$$

Equation (3.4)

Where PA is actual load, PF is the forecasted load and N is the number of data points.

3.5 Process Fine Tuning

If the forecasted result shows high MAPE, then a process called fine tuning needed to be done. The fine tuning process is a trial and error process, that is repeated during simulation until an optimal result or an accurate model is obtained. The fine tuning involves the process of specifying and editing the IF-THEN rules as well as the DoS for the rules.

First of all, the number of rules in each block, and the configuration the rule were maintained. The manual adjustment will be started from the first rule block, which is the rule block for forecast day, for example Monday. In this process, all 26 weeks will be run one by one. In every week that was run, to which rules (in rule block Monday) it was related to will be noted and recorded.

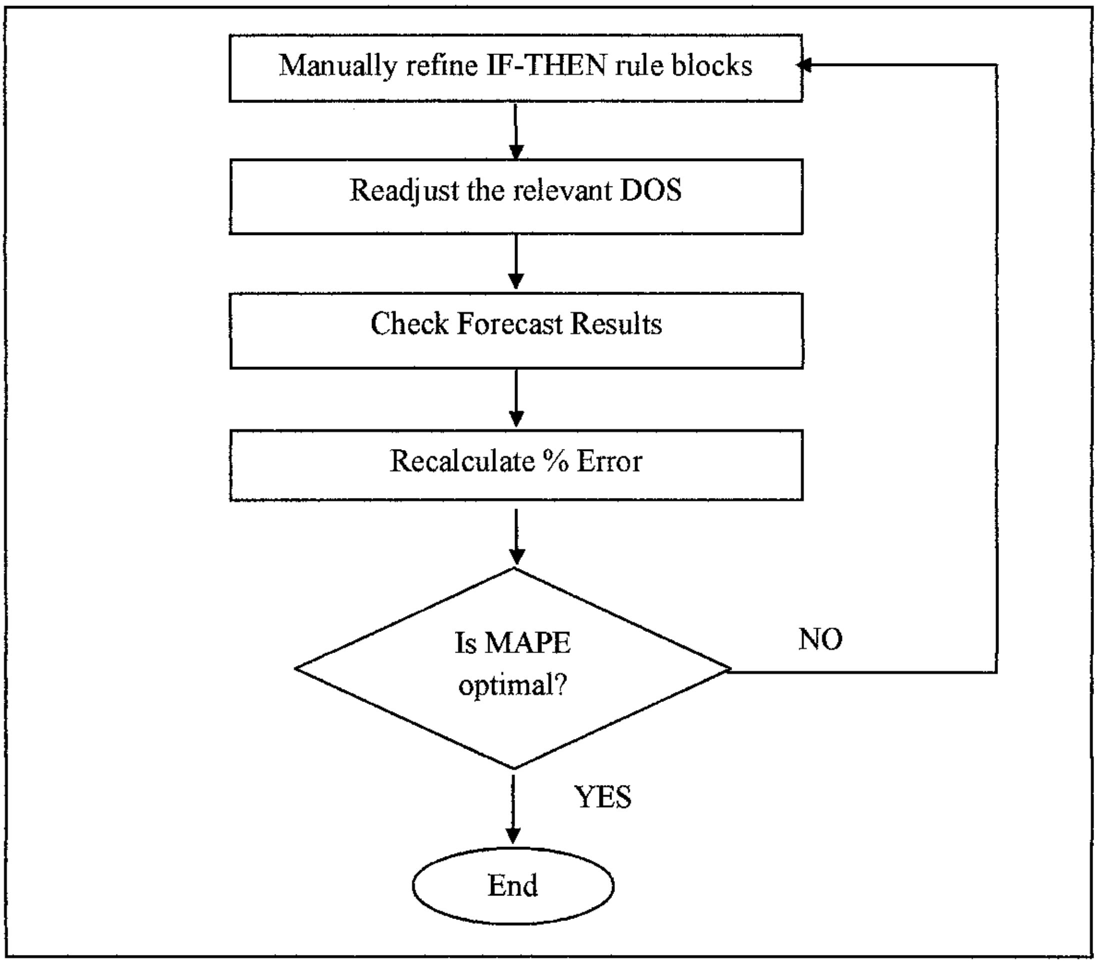

Figure 3.9: Process of Fine Tuning

After all the 26 weeks data has been gathered, weeks that may be sharing the same rules are grouped. By doing this, we now know which rules are affected the particular weeks output. Then, adjustment can be made to the Degree of Support of the respective rules, so that the percentage error between forecast value and actual load value on Monday is minimum and balance. The same action was repeated for Tuesday, Wednesday, Thursday, Friday and Saturday.

3.6 System Expansion (Stage 2)

In this stage, the membership function for the linguistic variable 'Temperature', 'Load_Previous' and 'Forecast Load' is expand. The purpose of this expansion is to increase the accuracy of the forecasting and drop off the resulted error. Figure 3.10 show an example for the expansion of membership function.

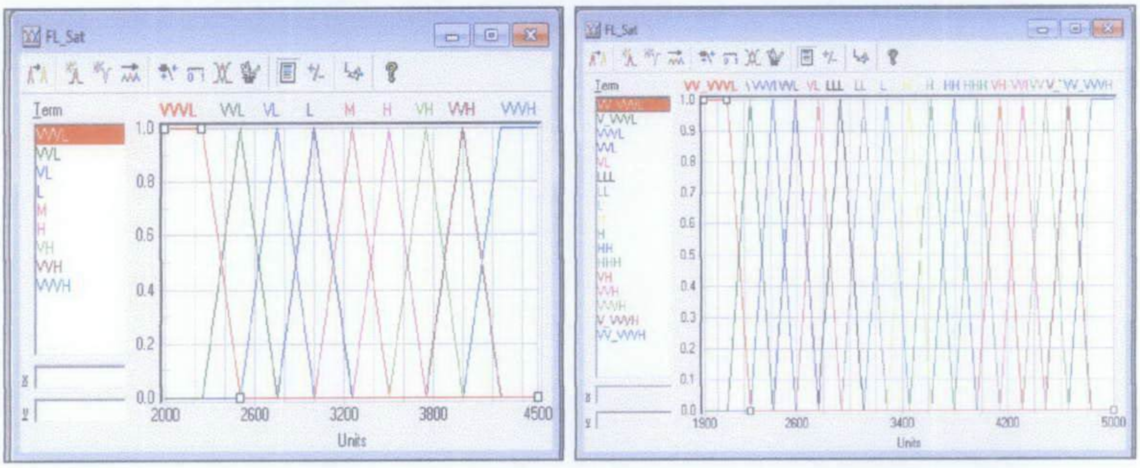

Figure 3.10: The Previous and New Membership Function

3.7 System Testing (Stage 3)

In this stage, the system is testing with the 2011 real time data for 26 weeks. The system was tested and checked for its accuracy without having any changes or modification. The datasheet for the electricity load demand and average daily temperature of year 2011 starting from 3rd January 2011 until 3rd July 2011 were available in Appendix C.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Simulation Result

4.1.1 Program tested using load demand data of year 2010

Week	MAPE	
	Stage 1	**Stage 2**
1	5.01	3.89
2	4.46	4.62
3	7.06	5.94
4	7.77	9.82
5	5.87	4.80
6	5.92	4.73
7	9.85	12.33
8	4.02	11.68
9	11.49	9.81
10	4.23	3.72
11	5.37	2.89
12	8.38	5.52
13	6.25	2.42
14	6.16	4.91
15	8.94	7.85
16	9.27	9.89
17	11.09	8.90
18	6.76	5.77
19	3.44	1.31
20	17.83	1.58
21	4.74	6.65
22	6.96	8.96
23	5.37	2.68
24	5.78	3.01
25	3.37	2.38
26	6.53	7.79
AVERAGE	7.00	5.92

Table 4.1: Overall Error Analysis (MAPE) for year 2010

4.1.2 Program tested using load demand data of year 2010 (semester on)

Week	MAPE	
	Stage 1	**Stage 2**
4	7.77	9.82
5	5.87	4.80
6	5.92	4.73
7	9.85	12.33
8	4.02	11.68
9	11.49	9.81
10	4.23	3.72
12	8.38	5.52
13	6.25	2.42
14	6.16	4.91
15	8.94	7.85
16	9.27	9.89
17	11.09	8.90
18	6.76	5.77
19	3.44	1.31
20	17.83	1.58
21	4.74	6.65
22	6.96	8.96
AVERAGE	7.72	6.70

Table 4.2: Error Analysis (MAPE) for year 2010 during semester on

4.1.3 Program tested using load demand data of year 2010 (semester off)

Week	MAPE	
	Stage 1	Stage 2
1	6.05	3.89
2	4.03	4.62
3	7.05	5.94
11	9.25	2.89
23	3.23	2.68
24	4.99	3.01
25	8.38	2.38
26	6.89	7.79
AVERAGE	5.11	4.15

Table 4.3: Error Analysis (MAPE) for year 2010 during semester off

4.1.4 Program tested using load demand data of year 2011

Week	MAPE
	Stage 3
1	28.57
2	18.12
3	21.77
4	13.27
5	48.70
6	25.69
7	29.93
8	3.64
9	4.63
10	9.28
11	4.18
12	4.92
13	4.96
14	7.92
15	9.25
16	14.82
17	10.00
18	14.60
19	9.75
20	14.19
21	3.24
22	43.30
23	6.40
24	4.80
25	45.45
26	40.93
AVERAGE	10.54

Table 4.4: Overall Error Analysis (MAPE) for year 2011

4.2 Discussion

The result of the fuzzy logic model will be shown in *Interactive Debug Mode* window.

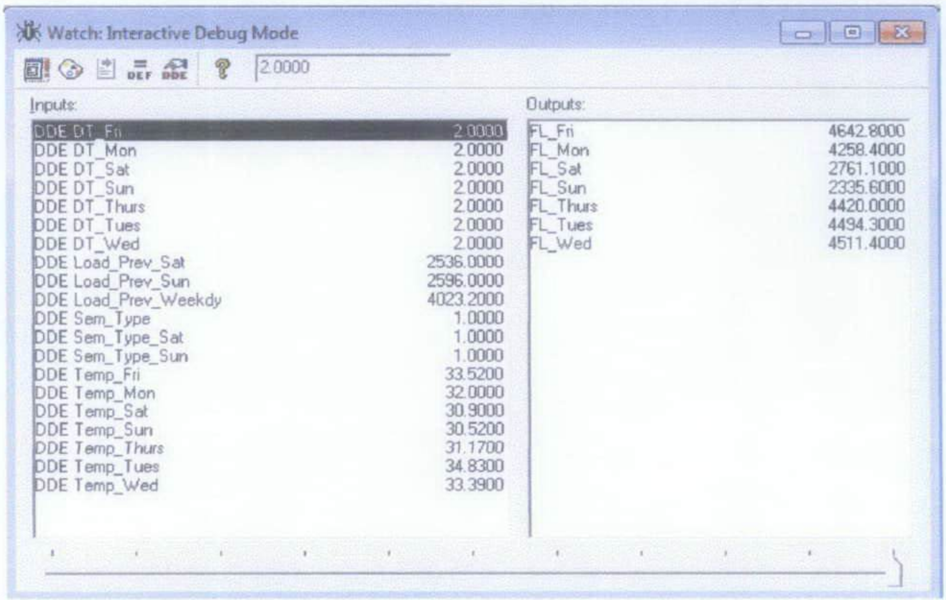

Figure 4.1: *Interactive Debug Mode* window

The output was computed based on Center of Maximum (CoM) deffuzification method.

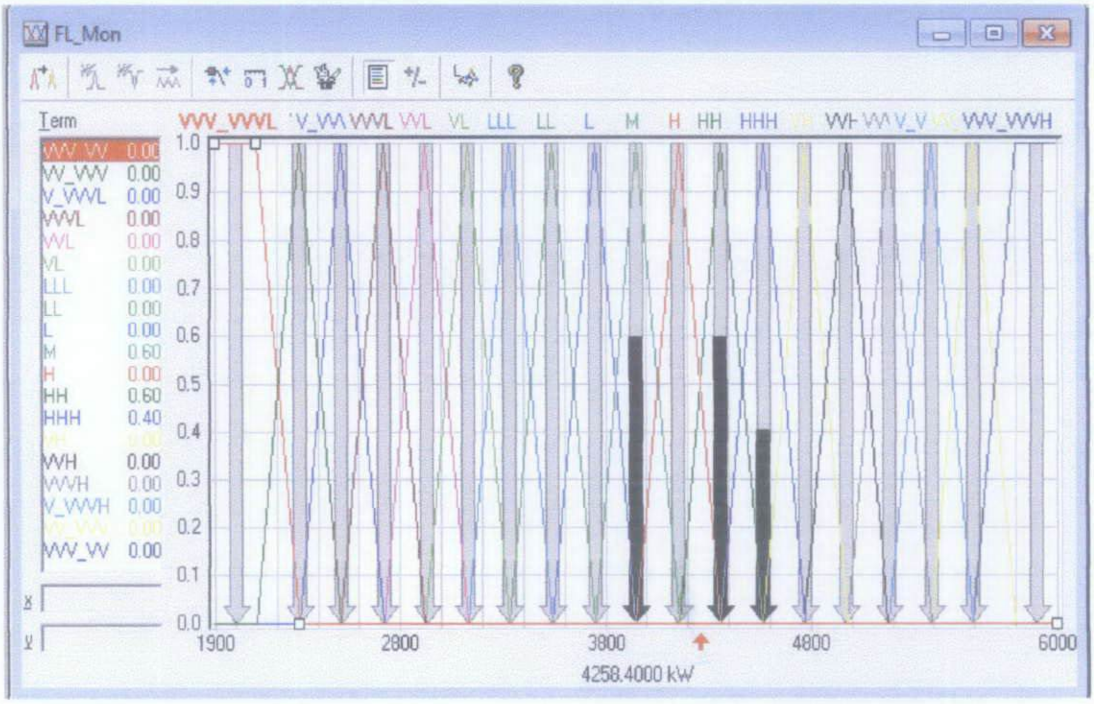

Figure 4.2: Output variable for forecast load on Monday

The fuzzy logic controller uses the following equation to calculate a weighted average of the forecast values.

$$x_{forecast} = \frac{3965.5(0.6)+4367.7(0.6)+4568.9(0.4)}{(0.6+0.6+0.4)} = 4266.98$$

In Stage 1, the system was created based on load demand data of year 2010. The system has an average MAPE of 7.00%. During semester on, an average MAPE is 7.72% whereas semester off yield the result of 5.11%. This condition happens probably due to unstable pattern of load demand.

In Stage 2, the system was a new system; using same data system. An overall average MAPE is slightly lower, which is 5.92%. Meanwhile, during semester on the resulted MAPE is 6.70% and 4.15% during semester off. The error decrease as the membership function (MBF) had been expanding. When MBF increase, this will allocate more terms to represent the condition stated. The rule blocks also become dense as the possibilities of rule blocks increase. The membership function and rule blocks that were used when running the program can be seen in Appendix D.

In Stage 3, the system was tested with real time data of year 2011 and resulted in higher forecast error, compared to the year 2010. One of the reasons is the changing in load demand pattern, from year 2010 to year 2011. Besides, the changing system of UTP from two-semester of study to three-semester of study also contributes to the different pattern of load demand.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The electrical load forecast for GDC is essential for the pre-planned scheduling and maintenance. As the main objective of the study is construct the Fuzzy Logic model in forecasting UTP load demand data, it had been achieved. The historical UTP load demand data and the electricity demand behaviour of UTP also can understand. Further study need to be explored to achieve the better result and as well as to improve in the future of load forecasting.

In this study, short term load forecasting was performed for two semester series, January and July 2010. The rule block properties like DoS and IF-THEN rules should be significant in showing the decrement and increment in the MAPE.

5.2 Recommendation

It is recommended to add the linguistic variable "Sem Type" to the rule block Thursday and Friday. The model needs to expand the membership function and increase the number of rules. If the numbers of rules are increased, this may improve the system model accuracy. The Degree of Support (DoS) of the respective rules also needs to be taken into consideration. The forecasting methodology with fuzzy parameters should give the forecasting results and below the range of 5% MAPE. The figure shows the recommended system with the linguistic variable "Sem Type" added to the respective rule block.

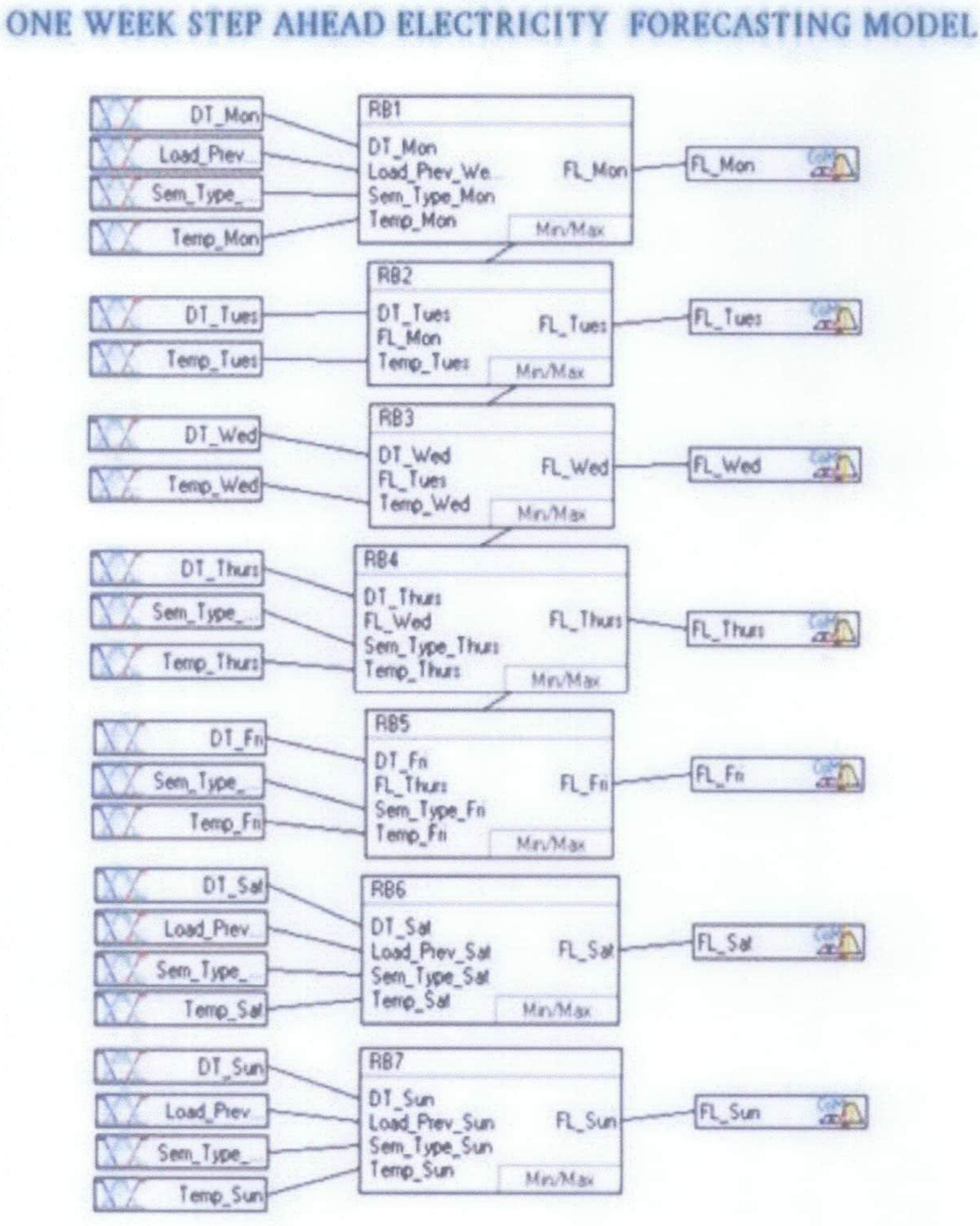

Figure 5.1: Suggested Project Editor

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APPENDIX A

UTP Electricity Load Demand and Average Daily Temperature for January 2010 Semester

	ELECTRICITY LOAD DEMAND (kW)								
Week No	1	2	3	4	5	6	7	8	9
Date	4-10 JAN	11-17 JAN	18-24 JAN	25-31 JAN	1-7 FEB	8-14 FEB	15-21 FEB	22-28 FEB	1-7 MAC
MONDAY	4372.00	4896.00	4,700.00	4,988.00	5,232.00	5,420.00	2,756.00	5,740.00	5,872.00
TUESDAY	4476.00	4788.00	4,782.00	5,112.00	5,228.00	5,688.00	3,252.00	5,880.00	5,768.00
WEDNESDAY	4616.00	4688.00	4,984.00	5,064.00	5,312.00	5,576.00	5,224.00	5,596.00	5,728.00
THURSDAY	4584.00	4648.00	4,724.00	5,060.00	5,396.00	5,380.00	5,376.00	4,856.00	5,800.00
FRIDAY	4416.00	4464.00	5,116.00	3,372.00	5,252.00	5,076.00	5,532.00	3,032.00	5,716.00
SATURDAY	2672.00	3388.00	3,236.00	3,184.00	3,624.00	3,420.00	3,780.00	3,288.00	4,220.00
SUNDAY	2592.00	2512.00	2,876.00	2,828.00	3,328.00	2,760.00	3,628.00	3,072.00	3,824.00
Average Weekday load (kW)	4492.80	4696.80	4,861.20	4,719.20	5,284.00	5,428.00	4,428.00	5,020.80	5,776.80

	AVERAGE DAILY TEMPERATURE (°C)								
MONDAY	32.00	31.43	35.67	34.34	32.67	31.73	35.67	34.34	33.85
TUESDAY	34.83	32.56	33.82	34.74	34.90	32.84	33.82	34.74	33.70
WEDNESDAY	33.39	33.67	33.31	32.00	32.70	33.70	33.31	32.00	34.17
THURSDAY	31.17	33.19	33.75	34.83	34.31	33.20	33.75	34.83	35.22
FRIDAY	33.52	33.12	33.64	34.70	33.05	33.67	33.64	34.70	35.11
SATURDAY	30.90	32.70	33.70	34.39	32.50	33.70	33.70	34.39	34.58
SUNDAY	30.52	34.06	33.48	35.36	30.83	34.06	33.48	35.36	34.67

	ELECTRICITY LOAD DEMAND (kW)								
Week No	10	11	12	13	14	15	16	17	18
Date	8-14 MAC	15-21 MAC	22-28 MAC	29 MAC-4 APR	5-11 APR	12-18 APR	19-25 APR	26 APR-2 MAY	3-9 MAY
MONDAY	5,720.00	4,516.00	5,684.00	5,844.00	5,428.00	5,960.00	3,596.00	5,504.00	5,248.00
TUESDAY	5,808.00	4,396.00	5,376.00	5,716.00	5,568.00	6,088.00	5,828.00	5,224.00	5,808.00
WEDNESDAY	6,056.00	4,660.00	5,788.00	5,930.00	5,676.00	6,336.00	5,784.00	5,384.00	5,764.00
THURSDAY	5,644.00	4,640.00	5,968.00	5,380.00	5,640.00	5,700.00	5,924.00	5,300.00	5,648.00
FRIDAY	5,284.00	4,608.00	5,872.00	5,284.00	5,592.00	3,372.00	5,848.00	3,320.00	5,416.00
SATURDAY	3,368.00	3,304.00	3,636.00	3,760.00	3,912.00	3,432.00	4,044.00	3,128.00	3,504.00
SUNDAY	2,704.00	3,456.00	3,880.00	5,428.00	3,780.00	3,432.00	3,640.00	2,932.00	3,468.00
Average Weekday load (kW)	5,702.40	4,564.00	5,737.60	5,630.80	5,580.80	5,491.20	5,396.00	4,946.40	5,576.80
	AVERAGE DAILY TEMPERATURE (°C)								
MONDAY	35.03	33.39	36.06	34.89	32.26	33.45	34.00	33.28	35.36
TUESDAY	35.50	34.09	30.50	33.89	34.09	35.28	33.61	29.67	34.56
WEDNESDAY	35.06	33.72	34.78	33.28	33.84	34.50	34.36	33.53	35.23
THURSDAY	32.64	34.31	36.81	34.14	32.95	35.06	33.06	35.22	34.71
FRIDAY	33.64	34.64	33.87	34.42	34.03	35.17	33.97	33.23	34.61
SATURDAY	33.03	35.03	33.67	34.31	32.31	34.20	33.86	34.03	36.36
SUNDAY	32.59	35.22	31.23	34.81	32.95	35.20	33.92	30.48	36.72

	ELECTRICITY LOAD DEMAND (kW)							
Week No	19	20	21	22	23	24	25	26
Date	10-16 MAY	17-23 MAY	24-30 MAY	31 MAY-6 JUNE	7-13 JUNE	14-20 JUNE	21-27 JUNE	28 JUNE-4 JULY
MONDAY	5,784.00	5,596.00	5,476.00	5,508.00	5,052.00	4,616.00	4,988.00	3644.00
TUESDAY	5,552.00	5,660.00	5,728.00	5,380.00	4,912.00	4,328.00	4,724.00	4636.00
WEDNESDAY	5,656.00	2,145.00	5,712.00	5,244.00	4,868.00	4,416.00	4,528.00	4620.00
THURSDAY	5,092.00	5,460.00	5,388.00	5,092.00	4,768.00	4,188.00	4,764.00	4740.00
FRIDAY	5,060.00	5,464.00	3,304.00	2,996.00	4,884.00	4,596.00	4,448.00	4504.00
SATURDAY	3,984.00	3,704.00	3,464.00	3,000.00	3,068.00	3,244.00	2,800.00	2784.00
SUNDAY	3,572.00	3,604.00	3,548.00	3,344.00	2,916.00	2,872.00	2,756.00	2436.00
Average Weekday load (kW)	5,428.80	4,865.00	5,121.60	4,844.00	4,896.80	4,428.80	4,690.40	4428.8
	AVERAGE DAILY TEMPERATURE (˚C)							
MONDAY	34.36	33.34	35.45	34.22	34.20	34.33	34.34	33.78
TUESDAY	34.47	32.22	34.70	33.81	32.62	35.56	33.97	31.92
WEDNESDAY	34.64	32.14	35.56	33.75	35.28	33.95	34.42	33.67
THURSDAY	32.25	35.20	34.36	36.06	32.64	31.95	33.53	34.70
FRIDAY	35.09	35.00	33.53	31.67	34.28	32.50	26.41	31.31
SATURDAY	36.06	30.06	35.86	33.44	35.22	34.92	33.31	33.37
SUNDAY	36.72	35.39	34.48	33.11	34.64	34.28	34.75	30.39

APPENDIX B

UTP Electricity Load Demand and Average Daily Temperature for July 2010 Semester

	ELECTRICITY LOAD DEMAND (kW)								
Week No	1	2	3	4	5	6	7	8	9
Date	5-11 JULY	12-18 JULY	19-25 JULY	26 JULY-1 AUG	2-8 AUG	9-15 AUG	16-22 AUG	23-29 AUG	30 AUG-5 SEPT
MONDAY	4576.00	4552.00	4,732.00	4,816.00	5,308.00	5,368.00	4,944.00	5,192.00	5,400.00
TUESDAY	4956.00	4600.00	5,120.00	4,972.00	5,124.00	5,276.00	5,044.00	5,308.00	3,292.00
WEDNESDAY	4800.00	4356.00	4,972.00	5,192.00	5,356.00	5,348.00	5,140.00	5,664.00	5000.00
THURSDAY	4732.00	4364.00	4,988.00	5,052.00	5,040.00	5,256.00	5,108.00	5,548.00	5000.00
FRIDAY	5176.00	4336.00	5,180.00	4,988.00	5,388.00	5,172.00	4,752.00	3,324.00	5,060.00
SATURDAY	2928.00	2796.00	3,116.00	3,028.00	3,640.00	3,568.00	3,172.00	3,392.00	2,848.00
SUNDAY	2624.00	2632.00	2,780.00	3,296.00	3,360.00	3,020.00	3,136.00	3,248.00	2,452.00
Average Weekday load (kW)	4848.00	4441.60	4,998.40	5,004.00	5,243.20	5,284.00	4,997.60	5,007.20	4,584.00
	AVERAGE DAILY TEMPERATURE (°C)								
MONDAY	33.75	33.09	33.72	30.48	33.47	34.84	32.56	34.70	34.03
TUESDAY	35.06	33.34	34.31	32.45	34.59	34.81	32.22	34.64	34.03
WEDNESDAY	35.20	34.89	31.61	31.70	33.06	36.22	32.61	37.08	34.56
THURSDAY	34.17	33.36	35.70	34.50	30.14	35.45	33.53	35.97	32.92
FRIDAY	33.28	34.67	33.59	32.39	34.45	33.47	33.75	34.17	34.50
SATURDAY	33.62	33.59	31.31	32.50	33.59	32.75	34.28	33.39	34.31
SUNDAY	32.38	31.36	34.56	33.20	33.08	33.17	32.95	34.03	32.28

	ELECTRICITY LOAD DEMAND (kW)								
Week No	10	11	12	13	14	15	16	17	18
Date	6-12 SEPT	13-19 SEPT	20-26 SEPT	27 SEPT-3 OCT	4-10 OCT	11-17 OCT	18-24 OCT	25-31 OCT	1-7 NOV
MONDAY	4,504.00	3,592.00	4,932.00	5,168.00	5,092.00	5,840.00	5,628.00	5,488.00	4,948.00
TUESDAY	4,360.00	3,676.00	5,028.00	5,364.00	5,540.00	5,840.00	5,516.00	5,200.00	5,112.00
WEDNESDAY	3,952.00	3,592.00	5,360.00	5,392.00	5,276.00	5,852.00	5,284.00	5,304.00	5,212.00
THURSDAY	2,280.00	2,684.00	5,064.00	5,020.00	5,352.00	5,700.00	5,080.00	5,388.00	5,168.00
FRIDAY	2,544.00	4,028.00	4,872.00	5,064.00	5,412.00	5,404.00	5,580.00	5,392.00	2,876.00
SATURDAY	2,460.00	2,568.00	3,548.00	3,576.00	3,616.00	4,136.00	3,528.00	3,168.00	3,084.00
SUNDAY	2,364.00	2,900.00	3,024.00	3,248.00	3,288.00	4,232.00	3,676.00	3,088.00	2,736.00
Average Weekday load (kW)	3,528.00	3,514.40	5,051.20	5,201.60	5,334.40	5,727.20	5,417.60	5,354.40	4,663.20
	AVERAGE DAILY TEMPERATURE (°C)								
MONDAY	34.20	35.14	33.72	33.53	31,92	33.61	34.45	34.48	32.25
TUESDAY	32.45	32.91	34.61	33.67	33.00	32.89	33.22	33.73	30.00
WEDNESDAY	33.31	32.59	32.12	33.83	35.67	35.73	36.03	31.25	33.23
THURSDAY	32.59	25.70	33.81	32.78	35.31	34.92	35.56	28.67	34.14
FRIDAY	34.53	34.23	33.42	32.84	32.23	32.84	34.31	33.00	35.17
SATURDAY	29.50	34.39	33.36	34.47	34.42	33.61	34.45	33.81	30.22
SUNDAY	33.81	34.25	34.17	33.78	35.22	34.00	35.70	34.12	28.45

	ELECTRICITY LOAD DEMAND (kW)							
Week No	19	20	21	22	23	24	25	26
Date	8-14 NOV	15-21 NOV	22-28 NOV	29 NOV-5 DEC	6-12 DEC	13-19 DEC	20-26 DEC	27-31 DEC
MONDAY	4,796.00	5,308.00	5,124.00	5,252.00	4,280.00	4,604.00	4,236.00	4020.00
TUESDAY	4,668.00	4,948.00	5,268.00	4,824.00	2,708.00	4,252.00	4,332.00	4192.00
WEDNESDAY	4,888.00	2,856.00	5,248.00	4,916.00	4,328.00	4,472.00	4,584.00	3812.00
THURSDAY	4,860.00	4,320.00	4,968.00	4,688.00	4,088.00	4,328.00	4,236.00	3452.00
FRIDAY	4,516.00	4,800.00	4,912.00	4,680.00	4,368.00	4,128.00	2,320.00	2060.00
SATURDAY	3,400.00	3,396.00	3,672.00	2,928.00	3,028.00	2,716.00	2,204.00	2152.00
SUNDAY	3,344.00	3,600.00	3,388.00	2,812.00	2,668.00	2,204.00	2,448.00	1992.00
Average Weekday load (kW)	4,745.60	4,446.40	5,104.00	4,872.00	3,954.40	4,356.80	3,941.60	3057.20
	AVERAGE DAILY TEMPERATURE (°C)							
MONDAY	27.47	32.30	33.12	32.89	30.09	31.58	31.08	32.87
TUESDAY	35.70	34.50	31.78	34.12	33.56	32.56	32.89	31.63
WEDNESDAY	32.86	33.21	34.20	32.61	29.84	33.25	30.78	31.42
THURSDAY	33.00	34.53	32.81	32.73	33.14	31.17	32.44	30.50
FRIDAY	32.56	32.86	33.70	32.73	28.64	33.61	31.20	28.86
SATURDAY	32.50	34.03	33.39	31.95	33.25	32.17	34.61	31.12
SUNDAY	32.00	31.48	32.78	31.62	30.06	29.90	31.56	30.23

APPENDIX C

UTP Electricity Load Demand and Average Daily Temperature for Year 2011

	ELECTRICITY LOAD DEMAND (kW)								
Week No	1	2	3	4	5	6	7	8	9
Date	3-9 JAN	10-16 JAN	17-23 JAN	24-30 JAN	31 JAN-6 FEB	7-13 FEB	14-20 FEB	21-27 FEB	28 FEB-6 MAC
MONDAY	2,684.00	4,124.00	4,696.00	4,728.00	4,612.00	4,804.00	5,196.00	5,132.00	5,112.00
TUESDAY	4,112.00	4,272.00	4,520.00	4,604.00	4,748.00	2,204.00	3,140.00	5,048.00	5,224.00
WEDNESDAY	4,288.00	4,468.00	4,428.00	4,792.00	1,508.00	4,492.00	5,396.00	5,416.00	5,288.00
THURSDAY	4,136.00	4,328.00	3,020.00	4,680.00	1,892.00	4,328.00	3,260.00	5,328.00	5,244.00
FRIDAY	3,972.00	4,128.00	4,568.00	4,756.00	1,460.00	5,232.00	3,152.00	5,232.00	5,480.00
SATURDAY	2,488.00	3,024.00	2,888.00	3,044.00	1,488.00	3,320.00	3,376.00	3,276.00	3,568.00
SUNDAY	2,532.00	2,596.00	3,156.00	3,028.00	3,020.00	3,268.00	3,240.00	3,336.00	3,364.00
Average Weekday load (kW)	3,838.40	4,263.00	4,246.40	4712.00	2844.00	4212.00	4028.80	5231.20	5269.60
	AVERAGE DAILY TEMPERATURE (°C)								
MONDAY	29.57	30.27	29.9	29.25	29.77	30.06	30.59	31.03	32.71
TUESDAY	31.43	29.87	30.62	30.28	30.35	31.22	28.52	32.70	32.32
WEDNESDAY	29.46	30.80	30.84	29.71	31.45	32.16	30.44	32.55	32.87
THURSDAY	28.27	30.70	28.90	30.24	30.08	32.42	32.11	30.34	30.23
FRIDAY	29.58	30.12	30.47	30.79	30.75	30.40	31.21	31.69	32.37
SATURDAY	29.88	29.26	29.09	30.18	31.50	29.70	30.92	30.83	32.29
SUNDAY	28.60	30.75	28.88	29.82	31.66	30.78	29.21	33.08	32.02

	ELECTRICITY LOAD DEMAND (kW)								
Week No	10	11	12	13	14	15	16	17	18
Date	7-13 MAC	14-20 MAC	21-27 MAC	28 MAC-3 APR	4-10 APR	11-17 APR	18-24 APR	25APR-1MAY	2-8 MAY
MONDAY	5,032.00	5,212.00	4,776.00	5,244.00	5,348.00	5,320.00	5,268.00	5,228.00	3,220.00
TUESDAY	5,140.00	5,180.00	5,000.00	4,968.00	5,524.00	5,320.00	3,444.00	5,328.00	5,152.00
WEDNESDAY	5,244.00	5,164.00	5,204.00	5,296.00	5,327.00	3,892.00	5,712.00	5,516.00	4,956.00
THURSDAY	4,612.00	5,172.00	4,784.00	5,324.00	5,352.00	5,244.00	4,936.00	5,400.00	5,260.00
FRIDAY	4,600.00	5,000.00	4,672.00	5,322.00	5,148.00	5,196.00	5,216.00	5,012.00	5,228.00
SATURDAY	3,296.00	3,328.00	3,256.00	3,952.00	3,504.00	3,356.00	3,408.00	3,224.00	4,028.00
SUNDAY	3,124.00	3,156.00	3,296.00	3,332.00	3,304.00	3,264.00	3,180.00	3,112.00	4,056.00
Average Weekday load (kW)	4925.60	5,145.60	4,887.20	5,230.80	5,339.80	4,994.40	4,915.20	5,296.80	4,763.20

	AVERAGE DAILY TEMPERATURE (°C)								
MONDAY	32.57	30.81	29.99	32.98	32.82	31.40	31.40	30.83	27.91
TUESDAY	30.04	30.69	29.85	30.43	31.49	31.56	32.20	31.42	31.26
WEDNESDAY	30.64	31.03	30.22	30.80	32.32	31.63	31.00	34.07	28.68
THURSDAY	30.42	31.84	31.75	32.37	30.06	32.38	30.69	31.96	31.21
FRIDAY	29.51	31.59	30.11	31.11	32.01	31.34	31.01	28.09	33.09
SATURDAY	31.10	28.21	28.10	32.41	29.96	30.09	29.01	26.88	33.38
SUNDAY	31.84	28.08	30.71	33.11	31.31	33.48	29.87	25.73	33.01

	ELECTRICITY LOAD DEMAND (kW)							
Week No	19	20	21	22	23	24	25	26
Date	9-15 MAY	16-22 MAY	23-29 MAY	30MAY-5JUNE	6-12 JUNE	13-19 JUNE	20-26 JUNE	27JUNE-3JULY
MONDAY	5,560.00	4,604.00	5,188.00	5,660.00	5,092.00	5,176.00	5,256.00	5,232.00
TUESDAY	5,676.00	3,064.00	4,916.00	5,460.00	5,564.00	5,468.00	1,468.00	5,128.00
WEDNESDAY	5,276.00	4,776.00	5,292.00	1,624.00	5,340.00	5,340.00	5,200.00	5,448.00
THURSDAY	5,112.00	5,104.00	5,336.00	5,448.00	5,276.00	5,004.00	5,380.00	5,416.00
FRIDAY	4,968.00	4,796.00	5,352.00	2,988.00	5,188.00	5,368.00	5,156.00	5,364.00
SATURDAY	3,688.00	3,152.00	3,544.00	3,140.00	2,812.00	3,176.00	2,676.00	1,112.00
SUNDAY	2,736.00	3,576.00	3,464.00	3,132.00	3,192.00	3,156.00	3,212.00	3,100.00
Average Weekday load (kW)	5,318.40	4,468.80	5,216.00	4,236.00	5,292.00	5,271.20	4,494.00	5,317.60
	AVERAGE DAILY TEMPERATURE (°C)							
MONDAY	33.05	31.59	31.32	32.91	31.71	32.41	32.28	31.38
TUESDAY	32.22	31.02	31.08	31.18	32.42	31.29	32.78	32.66
WEDNESDAY	32.09	31.54	33.02	31.53	30.66	29.19	30.90	32.26
THURSDAY	28.30	32.03	32.72	32.69	31.38	31.99	32.44	32.27
FRIDAY	31.92	31.99	31.66	33.67	31.74	31.31	32.76	31.31
SATURDAY	33.19	32.15	33.29	33.92	33.18	34.36	35.99	33.37
SUNDAY	32.23	32.42	33.01	33.23	32.50	33.59	31.98	30.39

APPENDIX D

Membership Function and Rule Blocks of Fuzzy Logic System

1) Membership Function

Condition	*Linguistic terms fuzzyTECH*	*Membership Function Definiton*

Input Variable

Day Type

public	Public Holiday	1
normal	Normal day	2

Semester Type

Sem_Off	Semester Break	1
Sem_On	Semester On	2

Previous Weekday Average Load

Tremendously Low	VVV_VVVL	1900-2116 kW
Vastly Low	VV_VVVL	2116-2332 kW
Extremely Low	V_VVVL	2332-2548 kW
Greatly Low	VVVL	2548-2764 kW
Very Very Low	VVL	2764-2980 kW
Very Low	VL	2980-3196 kW
Quite Low	LLL	3196-3412 kW
Medium Low	LL	3412-3628 kW
Low	L	3628-3844 kW

Medium	M	3844-4060 kW
High	H	4060-4276 kW
Medium High	HH	4276-4492 kW
Quite High	HHH	4492-4708 kW
Very High	VH	4708-4924 kW
Very Very High	VVH	4924-5140 kW
Greatly High	VVVH	5140-5356 kW
Extremely High	V_VVVH	5356-5572 kW
Vastly High	VV_VVVH	5572-5788 kW
Tremendously High	VVV_VVVH	5788-6000 kW

Previous Saturday Load

Extremely Low	V_VVVL	1900-2107 kW
Greatly Low	VVVL	2107-2314 kW
Very Very Low	VVL	2314 -2521 kW
Very Low	VL	2521-2728 kW
Quite Low	LLL	2728-2935 kW
Medium Low	LL	2935-3142 kW
Low	L	3142-3349 kW
Medium	M	3349-3556 kW
High	H	3556-3763 kW
Medium High	HH	3763-3970 kW
Quite High	HHH	3970-4177 kW
Very High	VH	4177-4384 kW
Very Very High	VVH	4384-4591 kW
Greatly High	VVVH	4591-4798 kW
Extremely High	V_VVVH	4798-5000 kW

Previous Sunday Load

Vastly Low	VV-VVVL	1900-2112 kW
Extremely Low	V_VVVL	2112-2324 kW
Greatly Low	VVVL	2324 -2536 kW
Very Very Low	VVL	2536-2748 kW
Very Low	VL	2748-2960 kW
Quite Low	LLL	2960-3172 kW

Medium Low	LL	3172-3384 kW
Low	L	3384-3596 kW
Medium	M	3596-3808 kW
High	H	3808-4020 kW
Medium High	HH	4020-4232 kW
Quite High	HHH	4232-4444 kW
Very High	VH	4444-4656 kW
Very Very High	VVH	4656-4868 kW
Greatly High	VVVH	4868-5080 kW
Extremely High	V_VVVH	5080-5292 kW
Vastly High	VV_VVVH	5292-5500 kW

Average Temperature for a Week (Monday to Sunday)

Humid	VVVL	25.0-25.9 °C
Wet	VVL	25.9-26.9 °C
Rainy	VL	26.9-27.9 °C
Cool	LLL	27.9-28.9 °C
Cold	LL	28.9-29.9 °C
Chilly	L	29.9-30.9 °C
Average	M	30.9-31.9 °C
Warm	H	31.9-32.9 °C
Bright	HH	32.9-33.9 °C
Sunny	HHH	33.9-34.9 °C
Very Sunny	VH	34.9-35.9°C
Hot	VVH	35.9-36.9 °C
Very Hot	VVVH	36.9-37.9 °C

Output Variable

Forecasted Load Demand: Monday

Tremendously Low	VVV_VVVL	1900-2116 kW
Vastly Low	VV_VVVL	2116-2332 kW
Extremely Low	V_VVVL	2332-2548 kW
Greatly Low	VVVL	2548-2764 kW
Very Very Low	VVL	2764-2980 kW
Very Low	VL	2980-3196 kW
Quite Low	LLL	3196-3412 kW
Medium Low	LL	3412-3628 kW
Low	L	3628-3844 kW
Medium	M	3844-4060 kW
High	H	4060-4276 kW
Medium High	HH	4276-4492 kW
Quite High	HHH	4492-4708 kW
Very High	VH	4708-4924 kW
Very Very High	VVH	4924-5140 kW
Greatly High	VVVH	5140-5356 kW
Extremely High	V_VVVH	5356-5572 kW
Vastly High	VV_VVVH	5572-5788 kW
Tremendously High	VVV_VVVH	5788-6000 kW

Forecasted Load Demand: Tuesday

Tremendously Low	VVV_VVVL	1900-2121 kW
Vastly Low	VV_VVVL	2121-2342 kW
Extremely Low	V_VVVL	2342-2563 kW
Greatly Low	VVVL	2563-2784 kW
Very Very Low	VVL	2784-3005 kW
Very Low	VL	3005-3226 kW
Quite Low	LLL	3226-3447 kW
Medium Low	LL	3447-3668 kW
Low	L	3668-3889 kW
Medium	M	3889-4110 kW
High	H	4110-4331 kW
Medium High	HH	4331-4552 kW

Quite High	HHH	4552-4773 kW
Very High	VH	4773-4994 kW
Very Very High	VVH	4994-5215 kW
Greatly High	VVVH	5215-5436 kW
Extremely High	V_VVVH	5436-5657 kW
Vastly High	VV_VVVH	5657-5878 kW
Tremendously High	VVV_VVVH	5878-6100 kW

Forecasted Load Demand: Wednesday

Tremendously Low	VVV_VVVL	2000-2237 kW
Vastly Low	VV_VVVL	2237-2474 kW
Extremely Low	V_VVVL	2474-2711 kW
Greatly Low	VVVL	2711-2948 kW
Very Very Low	VVL	2948-3185 kW
Very Low	VL	3185-3422 kW
Quite Low	LLL	3422-3659 kW
Medium Low	LL	3659-3896 kW
Low	L	3896-4133 kW
Medium	M	4133-4370 kW
High	H	4370-4607 kW
Medium High	HH	4607-4844 kW
Quite High	HHH	4844-5081 kW
Very High	VH	5081-5318 kW
Very Very High	VVH	5318-5555 kW
Greatly High	VVVH	5555-5792 kW
Extremely High	V_VVVH	5792-6029 kW
Vastly High	VV_VVVH	6029-6266 kW
Tremendously High	VVV_VVVH	6266-6500 kW

Forecasted Load Demand: Thursday

Tremendously Low	VVV_VVVL	1900-2121 kW
Vastly Low	VV_VVVL	2121-2342 kW
Extremely Low	V_VVVL	2342-2563 kW
Greatly Low	VVVL	2563-2784 kW
Very Very Low	VVL	2784-3005 kW

Very Low	VL	3005-3226 kW
Quite Low	LLL	3226-3447 kW
Medium Low	LL	3447-3668 kW
Low	L	3668-3889 kW
Medium	M	3889-4110 kW
High	H	4110-4331 kW
Medium High	HH	4331-4552 kW
Quite High	HHH	4552-4773 kW
Very High	VH	4773-4994 kW
Very Very High	VVH	4994-5215 kW
Greatly High	VVVH	5215-5436 kW
Extremely High	V_VVVH	5436-5657 kW
Vastly High	VV_VVVH	5657-5878 kW
Tremendously High	VVV_VVVH	5878-6100 kW

Forecasted Load Demand: Friday

Tremendously Low	VVV_VVVL	1900-2116 kW
Vastly Low	VV_VVVL	2116-2332 kW
Extremely Low	V_VVVL	2332-2548 kW
Greatly Low	VVVL	2548-2764 kW
Very Very Low	VVL	2764-2980 kW
Very Low	VL	2980-3196 kW
Quite Low	LLL	3196-3412 kW
Medium Low	LL	3412-3628 kW
Low	L	3628-3844 kW
Medium	M	3844-4060 kW
High	H	4060-4276 kW
Medium High	HH	4276-4492 kW
Quite High	HHH	4492-4708 kW
Very High	VH	4708-4924 kW
Very Very High	VVH	4924-5140 kW
Greatly High	VVVH	5140-5356 kW
Extremely High	V_VVVH	5356-5572 kW
Vastly High	VV_VVVH	5572-5788 kW
Tremendously High	VVV_VVVH	5788-6000 kW

Forecasted Load Demand: Saturday

Vastly Low	VV_VVVL	1900-2082 kW
Extremely Low	V_VVVL	2082-2264 kW
Greatly Low	VVVL	2264-2446 kW
Very Very Low	VVL	2446-2628 kW
Very Low	VL	2628-2810 kW
Quite Low	LLL	2810-2992 kW
Medium Low	LL	2992-3174 kW
Low	L	3174-3356 kW
Medium	M	3356-3538 kW
High	H	3538-3720 kW
Medium High	HH	3720-3902 kW
Quite High	HHH	3902-4084 kW
Very High	VH	4084-4266 kW
Very Very High	VVH	4266-4448 kW
Greatly High	VVVH	4448-4630 kW
Extremely High	V_VVVH	4630-4814 kW
Vastly High	VV_VVVH	4814-5000 kW

Forecasted Load Demand: Sunday

Vastly Low	VV-VVVL	1900-2112 kW
Extremely Low	V_VVVL	2112-2324 kW
Greatly Low	VVVL	2324 -2536 kW
Very Very Low	VVL	2536-2748 kW
Very Low	VL	2748-2960 kW
Quite Low	LLL	2960-3172 kW
Medium Low	LL	3172-3384 kW
Low	L	3384-3596 kW
Medium	M	3596-3808 kW
High	H	3808-4020 kW
Medium High	HH	4020-4232 kW
Quite High	HHH	4232-4444 kW
Very High	VH	4444-4656 kW
Very Very High	VVH	4656-4868 kW
Greatly High	VVVH	4868-5080 kW
Extremely High	V_VVVH	5080-5292 kW
Vastly High	VV_VVVH	5292-5500 kW

2) Rule Blocks

#	IF DT_Mon	Load_Prev_Weekdy	Sem_Type	Temp_Mon	THEN DoS	FL_Mon
1	normal	M	Sem_Off	H	1.00	HH
2	normal	HHH	Sem_Off	M	1.00	VH
3	normal	HHH	Sem_Off	VH	1.00	HHH
4	normal	VV_VVH	Sem_Off	HH	1.00	HHH
5	normal	VH	Sem_Off	HHH	1.00	VVH
6	normal	VH	Sem_Off	HHH	1.00	HHH
7	normal	HH	Sem_Off	HHH	1.00	VVH
8	normal	HHH	Sem_Off	HH	1.00	L
9	normal	HH	Sem_Off	HH	1.00	HHH
10	normal	VH	Sem_Off	HH	1.00	HHH
11	normal	HH	Sem_Off	HH	1.00	VH
12	normal	LL	Sem_Off	VH	1.00	LL
13	normal	VH	Sem_Off	L	1.00	HH
14	normal	M	Sem_Off	M	1.00	HHH
15	normal	HH	Sem_Off	M	1.00	H
16	normal	M	Sem_Off	H	1.00	M
17	normal	VH	Sem_On	HHH	1.00	VVH
18	normal	VH	Sem_On	H	1.00	VVVH
19	normal	VVVH	Sem_On	M	1.00	V_VVVH
20	normal	HH	Sem_On	HHH	1.00	VV_VVVH
21	normal	VVH	Sem_On	HH	1.00	VVV_VVVH
22	normal	VV_VVVH	Sem_On	VH	1.00	VV_VVVH
23	normal	HHH	Sem_On	VVH	1.00	VV_VVVH
24	normal	VV_VVVH	Sem_On	HHH	1.00	VVV_VVVH
25	normal	VV_VVVH	Sem_On	H	1.00	V_VVVH
26	normal	VV_VVVH	Sem_On	HH	1.00	VVV_VVVH
27	normal	VVH	Sem_On	VH	1.00	VVVH
28	normal	VV_VVVH	Sem_On	HHH	1.00	VV_VVVH
29	normal	V_VVVH	Sem_On	HH	1.00	VV_VVVH
30	normal	VH	Sem_On	VH	1.00	V_VVVH
31	normal	VVH	Sem_On	HHH	1.00	V_VVVH
32	normal	VVH	Sem_On	L	1.00	VH
33	normal	VVH	Sem_On	HH	1.00	VVVH
34	normal	VVVH	Sem_On	HHH	1.00	V_VVVH
35	normal	VVVH	Sem_On	H	1.00	VVH
36	normal	VVH	Sem_On	HHH	1.00	VVVH
37	normal	LL	Sem_On	HH	1.00	VVH
38	normal	VVVH	Sem_On	HH	1.00	VVV_VVVH
39	normal	V_VVVH	Sem_On	HHH	1.00	V_VVVH
40	normal	HHH	Sem_On	VL	1.00	VH
41	normal	HH	Sem_On	HH	1.00	VVH
42	normal	VVH	Sem_On	H	1.00	VVVH
43	public	V_VVVH	Sem_On	H	1.00	VV_VVVL
44	public	V_VVVH	Sem_On	HHH	1.00	LL
45	public	V_VVVH	Sem_On	HH	1.00	V_VVVH
46	normal	LLL	Sem_Off	LL	1.00	VVVL

Figure D.1: Rule Block on Monday

Spreadsheet Rule Editor - RB2

#	IF DT_Tues	FL_Mon	Temp_Tues	THEN DoS	FL_Tues
1	normal	HH	HHH	1.00	HH
2	normal	VH	H	1.00	VH
3	normal	HHH	HH	1.00	VH
4	normal	VVH	HHH	1.00	VVH
5	normal	VVVH	HHH	1.00	VVVH
6	normal	V_VVVH	H	1.00	VV_VVVH
7	normal	VV_VVVL	HH	1.00	VVV_VVVL
8	normal	VV_VVVH	HHH	1.00	VVV_VVVH
9	normal	VVV_VVVH	HH	1.00	VV_VVVH
10	normal	VV_VVVH	VH	1.00	VV_VVVH
11	normal	HHH	HHH	1.00	HH
12	normal	VV_VVVH	L	1.00	VVVH
13	normal	V_VVVH	HHH	1.00	V_VVVH
14	normal	VVV_VVVH	VH	1.00	VVV_VVVH
15	normal	LL	HH	1.00	VV_VVVH
16	normal	V_VVVH	LL	1.00	VVVH
17	normal	VVVH	HHH	1.00	VV_VVVH
18	normal	VV_VVVH	HHH	1.00	V_VVVH
19	normal	VV_VVVH	H	1.00	VV_VVVH
20	normal	V_VVVH	HHH	0.90	VV_VVVH
21	normal	V_VVVH	HH	1.00	VVVH
22	normal	VVH	H	1.00	VH
23	normal	HHH	VH	1.00	H
24	normal	VVH	HHH	1.00	HHH
25	normal	L	H	1.00	HHH
26	normal	HHH	VH	1.00	VH
27	normal	HHH	HH	1.00	HHH
28	normal	VH	HHH	1.00	VVH
29	normal	VVVH	HHH	1.00	VVH
30	normal	V_VVVH	HHH	1.00	VVVH
31	normal	VVH	H	1.00	VVH
32	normal	HHH	H	1.00	HH
33	normal	LL	HH	1.00	L
34	normal	VVVH	HH	1.00	VVVH
35	normal	VVH	HH	1.00	V_VVVH
36	normal	VVV_VVVH	H	1.00	VV_VVVH
37	normal	VV_VVVH	HH	1.00	V_VVVH
38	normal	V_VVVH	HH	1.00	VVH
39	normal	VVH	L	1.00	VVH
40	normal	VH	VH	1.00	HHH
41	normal	VVVH	HHH	1.00	VH
42	normal	VVH	M	1.00	VVVH
43	normal	HHH	H	1.00	H
44	normal	H	H	1.00	HH
45	normal	M	M	1.00	H
46	public	V_VVVH	HHH	1.00	LLL
47	public	HH	HH	1.00	VVVL
48	normal	VVL	LL	1.00	M

Figure D.2: Rule Block on Tuesday

Spreadsheet Rule Editor - RB3

#	IF			THEN	
	DT_Wed	FL_Tues	Temp_Wed	DoS	FL_Wed
1	normal	HH	HH	1.00	HH
2	normal	VH	HH	1.00	HH
3	normal	VH	HH	1.00	HHH
4	normal	VVH	H	1.00	VVVH
5	normal	VVVH	H	1.00	HHH
6	normal	VV_VVVH	HH	1.00	VVVH
7	normal	LLL	HH	1.00	VH
8	normal	VVV_VVVH	H	1.00	V_VVVH
9	normal	VV_VVVH	HHH	1.00	VVVH
10	normal	VV_VVVH	VH	1.00	VV_VVVH
11	normal	VVVH	HHH	1.00	VVVH
12	normal	VV_VVVH	HH	1.00	V_VVVH
13	normal	V_VVVH	HH	1.00	VVVH
14	normal	VVV_VVVH	HHH	1.00	VVV_VVVH
15	normal	VVVH	HH	1.00	VVH
16	normal	VV_VVVH	VH	1.00	VVVH
17	normal	V_VVVH	HHH	1.00	VVVH
18	normal	VV_VVVH	H	1.00	VVV_VVVL
19	normal	VVVH	HH	1.00	VH
20	normal	VH	VH	1.00	HHH
21	normal	H	HHH	1.00	H
22	normal	HHH	HHH	1.00	H
23	normal	HHH	HH	1.00	HH
24	normal	VH	VH	1.00	HH
25	normal	HHH	HHH	1.00	M
26	normal	VVH	M	1.00	HHH
27	normal	VH	M	1.00	VH
28	normal	VVH	HH	1.00	VVH
29	normal	VVVH	VVH	1.00	VVH
30	normal	VVH	H	1.00	VH
31	normal	VVVH	VVVH	1.00	VVVH
32	normal	LLL	HHH	1.00	HHH
33	normal	HH	HH	1.00	L
34	normal	L	HH	1.00	LLL
35	normal	VVH	H	1.00	VVH
36	normal	V_VVVH	VH	1.00	VH
37	normal	VV_VVVH	VH	1.00	V_VVVH
38	normal	V_VVVH	VVH	1.00	VH
39	normal	VVH	M	1.00	VH
40	normal	VVH	HH	1.00	VH
41	normal	HHH	H	1.00	HHH
42	normal	VVVH	HHH	1.00	VH
43	normal	VH	H	1.00	HHH
44	normal	VVVL	LL	1.00	M
45	normal	H	HH	1.00	H
46	normal	HH	L	1.00	H
47	normal	H	M	1.00	LL
48	public	VH	HH	1.00	VVVL
49	public	VVVH	HHH	1.00	VL
50	normal	L	LL	1.00	M

Figure D.3: Rule Block on Wednesday

Spreadsheet Rule Editor - RB4

#	IF DT_Thurs	FL_Wed	Temp_Thurs	THEN DoS	FL_Thurs
1	normal	HH	M	1.00	HHH
2	normal	HH	HH	1.00	HHH
3	normal	HHH	HH	1.00	HHH
4	normal	HHH	HHH	1.00	VVH
5	normal	HHH	HHH	1.00	VVVH
6	normal	VVVH	HH	1.00	VVVH
7	normal	VH	HH	1.00	VVVH
8	normal	VVVH	HHH	1.00	VH
9	normal	VVVH	VH	1.00	VV_VVVH
10	normal	VV_VVVH	H	1.00	V_VVVH
11	normal	HH	HHH	1.00	HHH
12	normal	VVVH	VVH	1.00	VVV_VVVH
13	normal	V_VVVH	HHH	1.00	VVVH
14	normal	VVVH	HH	1.00	V_VVVH
15	normal	VVV_VVVH	VH	1.00	VV_VVVH
16	normal	VVVH	HH	1.00	VVV_VVVH
17	normal	VVH	VH	1.00	VVVH
18	normal	VVVH	HHH	1.00	V_VVVH
19	normal	VVVH	H	1.00	VVH
20	normal	VVV_VVVL	VH	1.00	V_VVVH
21	normal	VVVH	HHH	1.00	VVVH
22	normal	VH	VVH	1.00	VVH
23	normal	HHH	H	1.00	HHH
24	normal	H	H	1.00	H
25	normal	H	HH	1.00	HHH
26	normal	M	HH	1.00	HH
27	normal	HHH	VH	1.00	VH
28	normal	VH	HHH	1.00	VVH
29	normal	VVH	L	1.00	VVH
30	normal	VH	HH	1.00	VVH
31	normal	VVVH	VVH	1.00	V_VVVH
32	normal	HHH	HH	1.00	VVH
33	normal	L	H	1.00	VV_VVVL
34	normal	VVH	HH	1.00	VVH
35	normal	VVH	H	1.00	VVH
36	normal	VH	VH	1.00	VVVH
37	normal	V_VVVH	VH	1.00	VV_VVVH
38	normal	VH	VH	1.00	VVH
39	normal	VH	LLL	1.00	VVVH
40	normal	HHH	HH	1.00	VH
41	normal	VVVL	HHH	1.00	H
42	normal	VH	H	1.00	VH
43	normal	M	HH	1.00	M
44	normal	H	M	1.00	H
45	normal	LL	L	1.00	LLL
46	public	LLL	VVVL	1.00	VVVL
47	public	HH	M	1.00	VL
48	normal	L	LL	1.00	M

Figure D.4: Rule Block on Thursday

Spreadsheet Rule Editor - RB5

#	IF			THEN	
	DT_Fri	FL_Thurs	Temp_Fri	DoS	FL_Fri
1	public	VH	HHH	1.00	VL
2	public	VVH	HH	1.00	LLL
3	public	V_VVH	HHH	1.00	LLL
4	public	VVH	VH	1.00	VVL
5	public	VVH	HH	1.00	VH
6	normal	HHH	HH	1.00	HH
7	normal	HHH	HHH	1.00	VVH
8	normal	VVH	HHH	1.00	LLL
9	normal	VVVH	HH	1.00	VVVH
10	normal	VVVH	HH	1.00	VVH
11	normal	VVVH	HH	1.00	V_VVVH
12	normal	VV_VVVH	VH	1.00	VV_VVVH
13	normal	V_VVVH	HH	1.00	VVVH
14	normal	HHH	HHH	1.00	HHH
15	normal	VVV_VVVH	HH	1.00	VV_VVVH
16	normal	VVVH	HHH	1.00	VVVH
17	normal	V_VVVH	HHH	1.00	VV_VVVH
18	normal	VV_VVVH	VH	1.00	LLL
19	normal	VVV_VVVH	HHH	1.00	VVV_VVVH
20	normal	VVVH	HH	1.00	LLL
21	normal	V_VVVH	HHH	1.00	V_VVVH
22	normal	VVH	VH	1.00	VVH
23	normal	V_VVVH	VH	1.00	V_VVVH
24	normal	VVH	M	1.00	VL
25	normal	HHH	HHH	1.00	VH
26	normal	H	H	1.00	HHH
27	normal	HHH	VVL	1.00	HH
28	normal	HHH	M	1.00	HHH
29	normal	HHH	HH	1.00	VVVH
30	normal	HH	HHH	1.00	HH
31	normal	VH	HH	1.00	VVVH
32	normal	VVH	M	1.00	VVH
33	normal	VVH	HHH	1.00	V_VVVH
34	normal	VVH	HH	1.00	VH
35	normal	VVH	HHH	1.00	VVH
36	normal	VVVL	HHH	1.00	M
37	normal	VVH	H	1.00	VVH
38	normal	VVVH	H	1.00	VV_VVVH
39	normal	VV_VVVH	H	1.00	V_VVVH
40	normal	VVH	HHH	1.00	VV_VVVH
41	normal	VH	H	1.00	HHH
42	normal	H	H	1.00	VH
43	normal	VH	HH	1.00	VH
44	normal	HHH	H	1.00	HHH
45	normal	M	LLL	1.00	HH
46	normal	H	HH	1.00	H
47	normal	H	M	1.00	VV_VVVL
48	normal	LLL	LLL	1.00	VVV_VVVL

Figure D.5: Rule Block on Friday

Spreadsheet Rule Editor - RB6

#	IF DT_Sat	Load_Prev_Sat	Sem_Type_Sat	Temp_Sat	THEN DoS	FL_Sat
1	normal	VL	Sem_Off	M	1.00	VL
2	normal	VL	Sem_Off	H	1.00	M
3	normal	M	Sem_Off	HH	1.00	L
4	normal	M	Sem_Off	VH	1.00	L
5	normal	LL	Sem_Off	VH	1.00	LL
6	normal	LL	Sem_Off	VH	1.00	L
7	normal	L	Sem_Off	HH	1.00	VL
8	normal	LLL	Sem_Off	HH	1.00	VL
9	normal	LLL	Sem_Off	HH	1.00	LLL
10	normal	LLL	Sem_Off	M	1.00	LL
11	normal	LLL	Sem_Off	LL	1.00	VVL
12	normal	VVL	Sem_Off	HHH	1.00	VVL
13	normal	LLL	Sem_Off	HH	1.00	LL
14	normal	LL	Sem_Off	H	1.00	VL
15	normal	VL	Sem_Off	HHH	1.00	V_VVL
16	normal	VVL	Sem_Off	M	1.00	V_VVL
17	public	L	Sem_On	HHH	1.00	L
18	public	M	Sem_Off	HH	1.00	LL
19	normal	L	Sem_On	H	1.00	H
20	normal	H	Sem_On	HH	1.00	M
21	normal	M	Sem_On	HH	1.00	HH
22	normal	HH	Sem_On	HHH	1.00	L
23	normal	L	Sem_On	HHH	1.00	VH
24	normal	VH	Sem_On	HH	1.00	M
25	normal	L	Sem_On	HH	1.00	H
26	normal	H	Sem_On	HHH	1.00	HH
27	normal	H	Sem_On	H	1.00	HHH
28	normal	HH	Sem_On	HHH	1.00	M
29	normal	M	Sem_On	HH	1.00	HHH
30	normal	HHH	Sem_On	HHH	1.00	LL
31	normal	LL	Sem_On	VVH	1.00	M
32	normal	M	Sem_On	VVH	1.00	HHH
33	normal	HHH	Sem_On	L	1.00	H
34	normal	H	Sem_On	VH	1.00	M
35	normal	LL	Sem_On	H	1.00	LL
36	normal	LL	Sem_On	HH	1.00	H
37	normal	H	Sem_On	H	1.00	H
38	normal	H	Sem_On	HHH	1.00	LL
39	normal	L	Sem_On	HH	1.00	M
40	normal	M	Sem_On	HHH	1.00	LLL
41	normal	VL	Sem_On	HH	1.00	H
42	normal	M	Sem_On	HHH	1.00	H
43	normal	H	Sem_On	HHH	1.00	HHH
44	normal	H	Sem_On	HH	1.00	VH
45	normal	HHH	Sem_On	HHH	1.00	M
46	normal	M	Sem_On	HH	1.00	LL
47	normal	L	Sem_On	L	1.00	LL
48	normal	LL	Sem_On	H	1.00	M
49	normal	M	Sem_On	HHH	1.00	M
50	normal	M	Sem_On	HH	1.00	H
51	normal	H	Sem_On	H	1.00	LLL
52	public	LLL	Sem_Off	M	0.80	VVL

Figure D.6: Rule Block on Saturday

Spreadsheet Rule Editor - RB7

#	IF DT_Sun	Load_Prev_Sun	Sem_Type_Sun	Temp_Sun	THEN DoS	FL_Sun
1	normal	VVL	Sem_Off	L	1.00	VVL
2	normal	VVL	Sem_Off	HHH	1.00	VL
3	normal	VL	Sem_Off	HH	1.00	VL
4	normal	VVL	Sem_Off	H	1.00	L
5	normal	LL	Sem_Off	HHH	1.00	VL
6	normal	VL	Sem_Off	HHH	1.00	VL
7	normal	VL	Sem_Off	L	1.00	VVVL
8	normal	VVVL	Sem_Off	H	1.00	VVL
9	normal	VVL	Sem_Off	M	1.00	VVL
10	normal	VVVL	Sem_Off	HH	1.00	VVVL
11	normal	VVVL	Sem_Off	HHH	1.00	VL
12	normal	VL	Sem_Off	L	1.00	VVL
13	normal	VVL	Sem_Off	LL	1.00	V_VVVL
14	normal	V_VVVL	Sem_Off	M	1.00	VVVL
15	normal	VVVL	Sem_Off	L	1.00	VV_VVVL
16	public	LL	Sem_On	HHH	1.00	VL
17	normal	VL	Sem_On	VH	1.00	VL
18	normal	VL	Sem_On	L	1.00	LL
19	normal	VL	Sem_On	HH	1.00	M
20	normal	M	Sem_On	VH	1.00	LLL
21	normal	LLL	Sem_On	HHH	1.00	H
22	normal	H	Sem_On	H	1.00	VVL
23	normal	L	Sem_On	VH	1.00	H
24	normal	H	Sem_On	M	1.00	VV_VVH
25	normal	VV_VVH	Sem_On	HHH	1.00	M
26	normal	M	Sem_On	HH	1.00	L
27	normal	L	Sem_On	VH	1.00	M
28	normal	M	Sem_On	HHH	1.00	VL
29	normal	VL	Sem_On	L	1.00	L
30	normal	L	Sem_On	VVH	1.00	L
31	normal	M	Sem_On	HHH	1.00	L
32	normal	L	Sem_On	HH	1.00	LL
33	normal	VL	Sem_On	HH	1.00	LL
34	normal	LL	Sem_On	HH	1.00	LL
35	normal	LL	Sem_On	HH	1.00	LLL
36	normal	LLL	Sem_On	HH	1.00	LLL
37	normal	LLL	Sem_On	HHH	1.00	LL
38	normal	LL	Sem_On	HHH	1.00	VVVL
39	normal	VL	Sem_On	HHH	1.00	LLL
40	normal	LLL	Sem_On	HH	1.00	LL
41	normal	LL	Sem_On	VH	1.00	LL
42	normal	LL	Sem_On	HHH	1.00	HHH
43	normal	HHH	Sem_On	VH	1.00	M
44	normal	M	Sem_On	HHH	1.00	LLL
45	normal	LLL	Sem_On	LLL	1.00	VVL
46	normal	VVL	Sem_On	H	1.00	LL
47	normal	LL	Sem_On	M	1.00	M
48	normal	M	Sem_On	H	1.00	L
49	normal	L	Sem_On	M	1.00	VL

Figure D.7: Rule Block on Sunday

APPENDIX E

Activities/Gantt Chart and Key Milestone

Gantt Chart and Key Milestone FYP I

Gantt Chart and Key Milestone FYP II

No	Detail/Week	1	2	3	4	5	6	7		8	9	10	11	12	13	14
1	Selection of Project Topic: Electrical Load Forecasting using Fuzzy Logic								MID SEMESTER BREAK							
2	Preliminary Research Work: Literature Review : Load Forecasting Literature Review : Fundamental of Fuzzy Logic															
3	Submission of Extended Proposal Defense															
4	Proposal Defense															
5	Project Work continue : Data Gathering Data Analyze Fuzzy Logic Model															
6	Submission of Interim Draft Report															
7	Submission of Interim Report															

Table E.1: Gantt Chart and Key Milestone FYP I

No	Detail/Week	1	2	3	4	5	6	7	MID SEMESTER BREAK	8	9	10	11	12	13	14
1	Project Work															
2	Submission of Progress Report 1															
3	Project Work continue : Model Improvement															
4	Submission of Progress Report 2															
5	Project Work continue : Finalize the Modification and Improvement															
6	Poster Exhibition															
7	Submission of Dissertation Report (soft copy)															
8	Oral Presentation															
9	Submission of Project Dissertation (Hard Bound)															

Table E.2: Gantt Chart and Key Milestone FYP II