UNIVERSITI TEKNOLOGI PETRONAS

EAB 4012 FINAL YEAR PROJECT II

FINAL REPORT

ELECTRICAL & ELECTRONIC ENGINEERING

Congestion Management of a Deregulated Power System Using Fuzzy Logic

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Submitted on 15th August 2012

CERTIFICATION OF APPROVAL

Congestion Management of a Deregulated Power System Using Fuzzy Logic

By

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A project dissertation submitted to the
Department of Electrical & Electronic Engineering
Universiti Teknologi PETRONAS
In partial fulfilment of the requirement for the
Bachelor of Engineering (Hons)
(Electrical & Electronic Engineering)

Approved:

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May 2012

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.

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LEE CHIN WAI

ABSTRACT

Regulated Power System is widely accepted and practised in several countries. The entire electric utility of this traditional system is entirely owned and managed by one organization or commonly the government. The dictation right, monopoly concept and with no third party to ensure the efficiency of the management had caused this structure of industry become less competitive and less efficient. When this problem arises, the solution is not a better set of rules, but a structural change.

With the ongoing liberalization of electricity markets, it is now moving towards the era of Deregulated Power System. This is a type of restructuring in Power Industry. The general mechanism of deregulation is to unbundle the Generation, Transmission and Distribution into generating companies (GENCOs), transmission companies (TRANSCOs) and distribution companies (DISTCOs). This unbundled system is very competitive as multiple GENCOs would compete among themselves to supply DISTCOs electric utility through short or long term contracts while the consumers are free to select any GENCOs that provide them with the best service and best price. Therefore, deregulation will be the future of realizing sustainable development at high efficiency.

However, in open access environment where the consumers and distributors are free to choose their own generation supplier, transmission congestion is a major concern of this unbundled system. Transmission congestion is the condition where power that flows across transmission lines and transformers exceeds the physical limits of those lines. The main reasons for congestion management are due to the increase demand of electricity usage, the construction of transmission is expensive and the pressure from environmental groups that restrict construction of transmission. The chances of transmission lines getting over-loaded is comparatively higher under deregulated operation because vary parts of the system are owned by different companies and under varying service charges.

Several conventional methods were used to manage congestion in transmission line. These methods are Linear Programming Method, Newton-Raphson Method, Quadratic Programming Method, Nonlinear Programming Method and Interior Point Method. The disadvantages of these conventional methods are complex mathematical formulation, unable to solve real-world large-scale power system problems, poor convergence and the system is slow when the variables are large. In recent years, Artificial Intelligence Method is frequently used as it can solve highly complex problems. Fuzzy Logic is one of the types under this Artificial Intelligence Method.

Hence, in this paper, Fuzzy Logic approach is implemented for congestion management. This approach deals with approximation rather than precision. The simple rule-based of Fuzzy Logic is using “IF X AND Y THEN Z”. The load flow of the transmission line will be used to model Fuzzy Logic in controlling transmission congestion and tested using IEEE Reliability Test System-1996 (RTS-96). The results showed the congestion level for Weekly Load and Daily Load using the data in IEEE RTS-96. With the congestion level, the price can be further determined by the distributor according to Zonal Pricing Method and Nodal Pricing Method.

ACKNOWLEDGEMENTS

I would like to take this opportunity to briefly recognize and express my appreciation and thankful to the group of people and agencies which have assisted me with my final year project for the past 2 semesters which is approximately nine months. Firstly, I would like to express my high appreciation to my Final Year Project supervisor, Ir. Dr. Perumal Nallagownden for continuous advice and guidance to me throughout the whole project. Ir. Dr. Perumal has been giving professional and useful recommendations to improve my Final Year Project from time to time. Apart from that, the Final Year Project Coordinator, Dr. Zuhairi Baharudin has been very helpful in guiding me on how to model Fuzzy Logic using Matlab. Although they are very busy, they still spare out their precious time to help me in completing this Final Year Project successfully. Last but not least, I would like to thank my family for supporting me in my Final Year Project, seniors and friends who have been lending a helping hand and supporting me at all time.

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Chapter 1: Introduction

1.1 Background of Study

In recent years, the power industry in whole world is undergoing reformation. In order to improve the efficiency in electricity production and utilization, deregulation is needed to unbundle the Generation, Transmission and Distribution into generating companies (GENCOs), transmission companies (TRANSCOs) and distribution companies (DISTCOs). Many power sectors have been established for this intention [1]. Deregulation is a type of modification of current existing regulating system. In developing countries, the main objective of power system deregulation is to attract various investments. The blooming economy had caused the high increment of electric demand. At the same time, deregulation can gradually reduce government commitment and role in power industry [2]. Besides that, deregulation can help in improving efficiency by introducing competition in new market [3]. By doing this, sustainable development at high efficiency can be realized in this significant infrastructure, the power industry.

1.2 Problem Statement

When the power system becomes deregulated, the open access environment will cause transmission congestion. The management of this problem is a new challenge to transmission operators. The open access environment is where the consumers and retailers are free to decide for their own generation supplier according to their favour price and services provided. Deregulated system caused the major problem of transmission congestion. For the better quality of service to the end user, Congestion Management is important to solve this problem. In these competitive markets, many methods are used to solve this problem. For this paper, the load flow of the transmission line will be used to model Fuzzy Logic in controlling transmission congestion. The model will be tested on 24-bus Reliability Test System – 1996 (RTS96).

1.3 Objectives & Scope of Work

The objectives of Project:

i. To understand the principles and concepts of Deregulated Power System
ii. To identify possible approaches to manage congestion in a deregulated power system
iii. Modelling Fuzzy Logic Approach for Congestion Management

Scopes of Work:

i. Research on topics to differentiate Regulated and Deregulated Power System
ii. Identify several Congestion Management methods
iii. Understanding the theory of Fuzzy Logic and apply it to control congestion in Deregulated Power System
iv. Simulate Fuzzy Logic using Matlab for Congestion Management

1.4 Feasibility of Project

The project of Fuzzy Logic to manage congestion in deregulated power system is feasible. This is because this method has been pertained to control congestion in networks [4] [5] and control the extension time of traffic light in single junction [6]. The simulation results for both cases have shown a better performance and higher efficiency. By using the Fuzzy Logic Toolbox in Matlab software, it is simple to do simulation. Hence, the same performance will be obtained when it applies in deregulated power system to manage the problem of congestion in transmission lines.

Chapter 2: Literature review

2.1 Regulated Power System

Regulated Power System is also known as vertically integrated and publicly owned electric utility. The entire electric utility which consists of generation, transmission, and distribution systems are owned and managed by one organization or commonly the government [7]. This is a traditional vertically integrated system that is commonly established and adapted in many countries for example, Malaysia. The simple illustration of regulated power system is shown in Figure 1.

There are some fundamental characteristics to identify a Regulated Power System. The most obvious trait is the dictation right of the government in several aspects of operation and production of electricity [7]. The monopoly concept withholds the demand to increase price as the end users has no freedom to set the selling price. Furthermore, there is no third party to ensure the efficiency of the management and lead to uncompetitive markets. Lastly, cross subsidies may occur which means a higher pricing for a group of end users to subside another group of end users with lower pricing.

When the structure of the industry is inadequate for competition, the solution is not just an enhanced set of rules, but a structural change. It will be the change from regulated power system to deregulated power system.

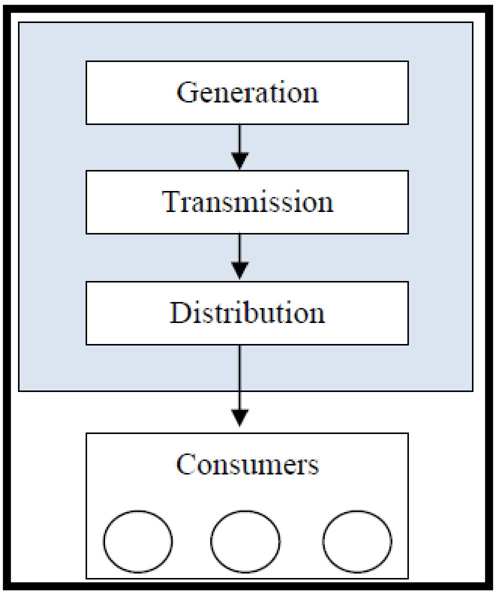


Figure 1: Regulated Power System

2.2 Deregulated Power System

2.2.1 Introduction

Deregulated Power System is also known as open power market, competitive power market, vertically unbundled market etc. The general mechanism of deregulation is to separate the entire electric utility including Generation, Transmission and Distribution into generating companies (GENCOs), transmission companies (TRANSCOs) and distribution companies (DISTCOs). Unbundling refers to disaggregating an electric utility service into its basic components and offering each component separately for sale with separate rates. However, deregulation involves not only unbundling, but also the separation of ownership and operation. Figure 2 shows the whole working principle of deregulated power system.

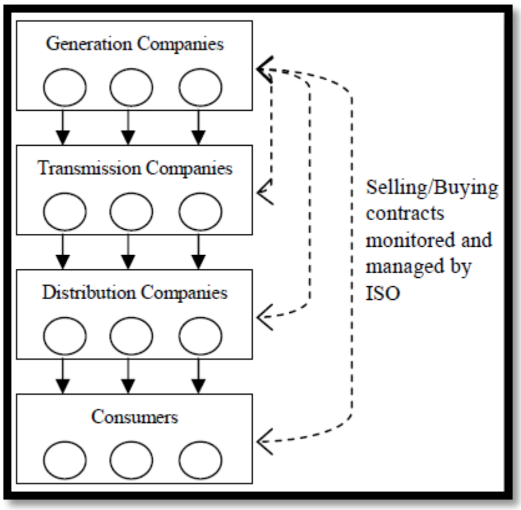


Figure 2: Deregulated Power System

In many countries, a central independent body, usually called the independent system operator (ISO), is set up to accommodate for the matching of supply with demand and also the maintenance of system reliability and security. Sometimes the system operator is also responsible for matching both the bids of generators and the demand bids to facilitate exchange. The term "independent" has the meaning of revealing the truth that the ISO are not allow to own or gain interests from any generation, transmission or distribution company [7].

The purpose of deregulated system is to make operations simpler. Trim down the expenditure of production to the minimum level and maximize returns by cutting down operating and maintaining costs are the roles of GENCO. For TRANSCO, it would lessen transmission losses and operate efficiently to justify delivery fees. DISTCO would also similarly reduce costs and negotiate with GENCO to get the best pricing with best services [8]. Most significantly, this system must be very concrete and strong so that it will not result in any interruption of the power system in the existing market flaw [9].

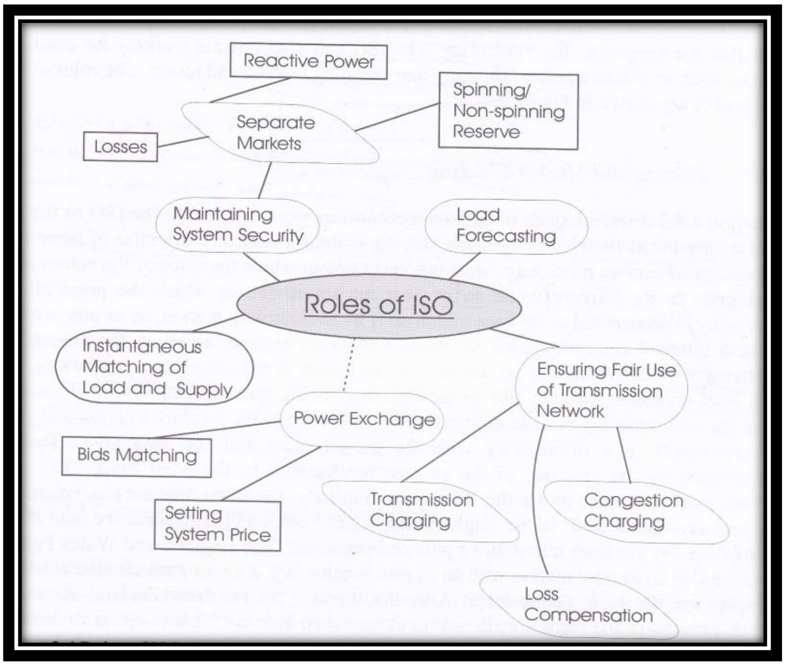


Figure 3: Roles of ISO

2.2.2 Advantages of Deregulated Power System

The ideal goals of restructuring or deregulation are to allow consumers to have more choices and support this achievement. Besides that, the quality and diversity of services can also be enhanced. Furthermore, it also helps to improve the competence of the electric industry [7]. The ability to produce cost reflective prices, reliable and secure electricity supplies and adequate infrastructure are the qualities that an efficient market should have.

The benefits of Deregulated Power System as compared to Regulated Power System [1]:

1. Lessen the burden of operating and maintaining the power system off the government.
2. Promoting reliable electricity production and quality consumer services.
3. No cross-subsidised exist between the competitive elements and the non-competitive elements of the market.
4. Prices for the non- competitive elements are transparent and non-discriminatory to all.
5. A Third Party, independent system operator (ISO) with no ownership interests in any company access is assured.

Besides that, deregulation only requires a very small financial budget. At all time, power is generated through the grid of transmission by the generation company with the lowest marginal price. The characteristics of load, load and peak duration curves, capacity of generation may be vary for different plants. However, when these vary information can be fully utilised, it will certainly saved additional capital resources.

The concept of deregulation is to create competition wherever possible. The generator has more flexibility in arrangement of production when the skill of selling electricity in the new industry increases. In order to offer a certain level of service reliability, the existence of a spot sector signifies that less idle capacity must be preserve [10]. The service standards provided will be more closely match with consumer preferences. When the agenda of electricity rates is proportional with the level of dependability, the end users could be offered precedence deal or package [10]. A competitive and economical power system in the generation of electricity would propose a much wider range of services comparatively to state monopolies or generators of regulated power system.

Finally, the innovation will be found in competitive market. Competition will enhance the responsiveness of firm towards consumer demands. Besides that, the financial will be monitor in better way, and able to fight on the price to be charged on the consumer. Meanwhile, the incentive to be innovative is still being enhanced [10]. Expanding an innovative end user facility is a better technique of minimizing the costs as well as a quicker way of curbing with issues which assures the modernizer a competitive margin.

2.2.3 Types of Deregulated Power System

Two dominant models of deregulated power system [1]:

1. The PoolCo Model, all energy and related communication and subsidiary services are traded in the central auction mechanism in a synchronized mode. The Independent System Operator (ISO) is responsible for scheduling the generators. It is also called centralise or maximalist ISO. The objective of this model is oriented towards the consumers. Transmission line constraints can be integrated only in the PoolCo model because the GENCO is not aware of the transmission line parameters.
2. Bilateral mode, all energy and related communication and subsidiary services services are traded bilaterally. It is also named as de-centralized or minimalist ISO. The role o f an ISO in this market is to run the real-time energy market, providing ancillary services and congestion management. The objective of this model is focusing the GENCO, subject to a set of standard constraints.

No.	Pool Co Model	Bilateral Model
1	Social welfare maximization	Profit Maximization model
2	Consumer payment minimization	Price taker/maker perspective
3	Security Constrained Unit Commitment	Probabilistic/ Stochastic model

Table 1: Classifications of Various Models [1]

2.3 Congestion Management

2.3.1 Introduction

When the power system is deregulated, the beginning of public admittance transmission have caused in the growing prominence of transmission congestion [4]. The open access condition is where the consumer and retailers are free to choose their own generation supplier through preset transmission lines. This is a major problems faced by this competitive electricity markets. Therefore, the proper implementation of congestion management in the emerging deregulated environment is becoming very important. The system operator (SO) needs an efficient, non discriminatory mechanism to solve the congestion problem.

Transmission congestion happened at the situation where additional power is scheduled or flows across transmission lines and transformers exceeds the physical limits of those lines [11]. Congestion occurs in transmission line when it is over-burdened because of the poorly scheduled generation patterns and load patterns from competitive bidding [12]. Congestion may occur due to improper management between generation and transmission utilities which has a consequence of unexpected emergency for example generation breakdown, abrupt increase of load demand, or malfunction of equipments [8].

Figure 4: Congestion in Transmission line

In the conventional power industry, the utility can achieved that by re-dispatching the cheapest generator(s) available while alleviating the constraints [10]. In the deregulated environment, generation and transmission are separated to different companies. Market end users are required to compensate a premium when their transactions cause congestion. Because of the parallel path flow nature of electricity in the network, a certain line could be overloaded by different transactions [13].

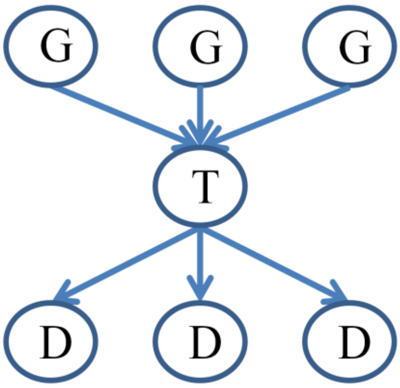


Figure 5: Multiple GENCOs distributed to multiple DISTCOs via a common transmission line

2.3.2 Reasons for Congestion Management

Major reasons for Congestion Management:

- Demand increases
- Construction of new transmission line is expensive
- Pressure from environmental group

In this globalized society, the power industry has undergone drastic transformation. This is because of privatization and deregulation process in whole world that has a significant impact in energy sector. The consequence of this reformation in power industry is the demanding usage of transmission grids. By exploitation of current resources power industry is managed so as to be closed to its rated capacity in deregulated electricity sector. This is to ensure that all companies in this industry can try to grow as much as possible. Existence of network constraints dictates that only a finite quantity of power can be transported between two locations on the electric grid [2]. It is considerable importance to have the potential to manage the flow of power through certain passageway in a network, specifically in a deregulated electricity sector.

An efficient congestion management can greatly reduce the congestion cost. When the congestion cost is very high, it is time for expanding transmission capacity. In general, if congestion management is efficient, the economic costs of congestion are reduced to a minimum and the given set of transmission resources are used resourcefully [14]. A dollar of investment in transmission capacity may have a great impact or effects depending on how efficiently the existing transmission system is utilized. Investment in transmission facilities will take years to recover back the investment cost [14]. Hence, unless congestion management brings no interruption on the power flow in transmission line, the single way out is to construct new transmission line with tremendous fund.

Non-government environment group strongly restrict in constructing a brand new transmission line. This is because the construction will destroy the nature beauty of our earth. As the construction covers a large area of land, the lifestyle and livelihood of the people is affected. Besides that, many forests need to be cut down due to the allocation of new transmission line. Therefore, more congestion management methods need to be investigated in order to fully utilize the current transmission capacity.

2.3.3 Problems when transmission congestion is not managed

Congestion on a transmission system cannot be tolerated except for a very short duration since this may cause cascade outages with uncontrolled loss of load. Congestion also leads to market inefficiency [2]. Transmission line overload may prevent the existence of new contracts, lead to additional outages, increase the electricity prices in some regions of the electricity markets, and can threaten system security and reliability [15]. New contracts mean more contractors of GENCOs are invited to tender, to build, operate and sell electric power at a specific price. All generators are allowed to compete to supply retailers by bonding them with a short period or long period contracts. Additional outages which are the interruption of power supplied will affect the customers. When the system's security and reliability are threatened, it is no longer immune to any interruption. The whole electrical system will easily shut down or break down. Hence an effective control action plan is essential to decrease the line overloads to the security limits in the minimum time.

2.3.4 Methods of Congestion Management

Traditionally, Classical Methods were used to manage congestion in transmission line effectively. However, with increase demand in electric usage and the technology advancement in software and hardware, Classical Methods cannot solve very complicated congestion problems. Those Classical Methods are clearly listed in Table 2.

Linear Programming Method is about linearization of objective function and also problems related to non negative variables [16]. Newton-Raphson Method involves optimality with the necessary conditions referred to as Kuhn-Tucker conditions [16]. Quadratic Programming Method deals with unique type of nonlinear programming whose constraints are linear meanwhile the objective function is quadratic [16]. Nonlinear Programming Method deals with problems involving non linear objectives and/or constraint functions [16]. Interior Point Method is suitable to work out large-scale linear programming problems very comprehensively.

Table 2: Classical Methods to manage congestion

<table>
<tr><th>No</th><th>Methods</th><th>Authors</th><th>Disadvantages</th></tr>
<tr><td rowspan="3">1</td><td rowspan="3">Linear Programming Method</td><td>T.S.Chung et al.</td><td rowspan="18">Complex mathematical Formulation [16]

Cannot solve real-world large-scale power system problems [16]

Poor convergence (can find only one result in a particular simulation run) [16]

System is slow when the variables are large [16]</td></tr>
<tr><td>E.Lobato et al.</td></tr>
<tr><td>F. Lima et al.</td></tr>
<tr><td rowspan="3">2</td><td rowspan="3">Newton-Raphson Method</td><td>S. Chen et al.</td></tr>
<tr><td>K.L.Lo et al.</td></tr>
<tr><td>X.Tong et al.</td></tr>
<tr><td rowspan="5">3</td><td rowspan="5">Quadratic Programming Method</td><td>J.A.Momoh et al.</td></tr>
<tr><td>N.Grudinin</td></tr>
<tr><td>G.P.Granelli et al.</td></tr>
<tr><td>X.Lin et al.</td></tr>
<tr><td>A.Berizzi et al.</td></tr>
<tr><td rowspan="3">4</td><td rowspan="3">Nonlinear Programming Method</td><td>G.L.Torres et al.</td></tr>
<tr><td>A.K.Sharma</td></tr>
<tr><td>D.Pudjianto et al.</td></tr>
<tr><td rowspan="4">5</td><td rowspan="4">Interior Point Method</td><td>Sergio Granville</td></tr>
<tr><td>Whei-Min Lin et al.</td></tr>
<tr><td>Wei Yan et al.</td></tr>
<tr><td>Ding Xiaoying et al.</td></tr>
</table>

In these few years, Artificial Intelligence Methods are widely used as it can solve highly complex congestion problems. This method is the science of making intelligent computer program. It can mitigate the disadvantages of Classical Methods. There are six different types under this technique as illustrated in Table 3. Each type has its own advantages of solving different kinds of congestion problems. In this paper, research done is focusing on Fuzzy Logic technique. The detailed discussion is included in next subtopic.

Table 3: Different types of Artificial Intelligence Methods

Methods	Different Types	Descriptions
Artificial Intelligence Methods	Fuzzy Logic Method	Using Fuzzy Set Theory dealing with approximation rather than precision [3].
	Artificial Neural Network	An interconnected group of neurons that uses connectionist approach to computation [3].
	Genetic Algorithm Method	Uses theory of survival of fittest [3].
	Evolutionary Programming	Based on metaheuristic optimization algorithm [3].
	Ant Colony Optimization	Based on the idea of ant foraging by pheromone communication to make path [3].
	Particle Swarm Optimization	Based on the ideas of social behaviour of organisms [3]. (animal flocking and fish schooling)

2.4 Fuzzy Logic

Traditionally, binary sets consist of two valued logic of 0 and 1 or true and false while fuzzy logic variables are in the range of 0 to 1 as in to some extent in between totally true or totally false. Fuzzy Logic is a type of multi valued logic which deals with reasoning of approximation rather than precision [17].

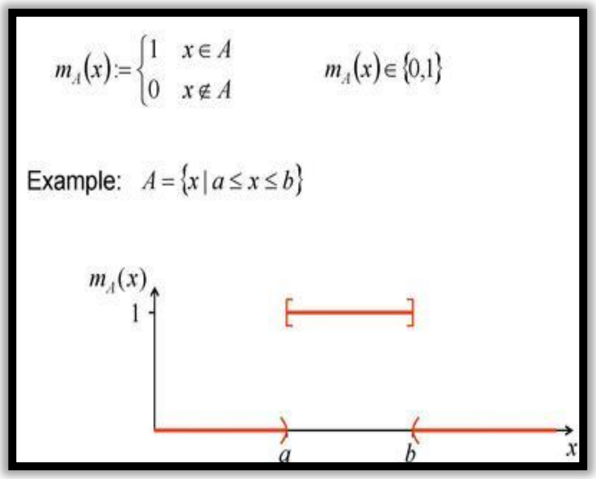


Figure 6: Equations and Graph of Binary sets

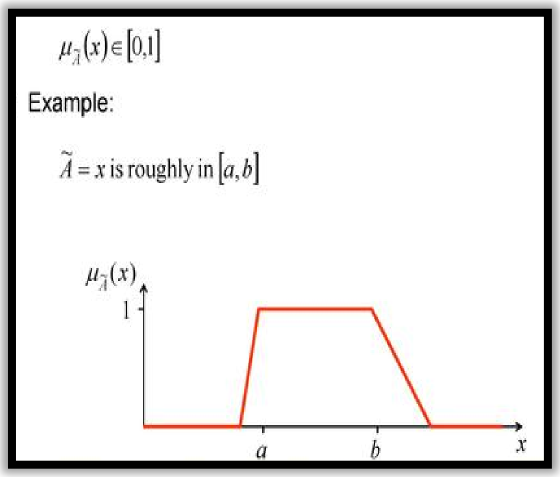


Figure 7: Equations and Graph of Fuzzy Logic

The benefits of applying this technique are it can accurately represents the operational constraints and fuzzified constraints are softer than traditional constraints [16]. Fuzzy Logic can be put into operation either in hardware or software as well as a combination of both. The pro of fuzzy logic is that by using indistinct, uncertain, imprecise, noisy, or missing input information, it is able to provide a straightforward way to comes to a particular conclusion [18]. This approach is to control problems imitates how a human would make decision, but the only difference is it reacts much faster. The simple rule-based of Fuzzy Logic is using “IF X AND Y THEN Z” [19]. One of the real life examples is by considering what you do when you are bathing. When the water is at high temperature, you will automatically adjust the water until it reaches the comfortable temperature. Fuzzy Logic is a better technique for organizing and managing data. Its speciality of mimicking human control logic has verified to be the best alternatives for several applications in control system. Hence, Fuzzy Logic is a very robust system.

There are two types of fuzzy logic which are:

- Type-1 fuzzy logic
- Type-2 fuzzy logic

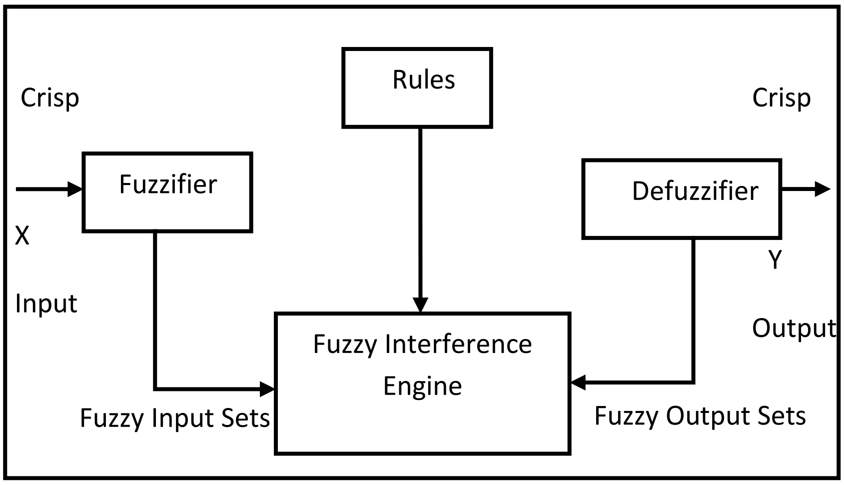


Figure 8: Type-1 Fuzzy Logic System

A Type-1 fuzzy logic method is shown in Figure 8. The input parameters in a fuzzy control system are charted into fuzzy sets, known as “Membership Functions”. “Fuzzification” is the process of transferring concrete input parameters to a fuzzy mode value. The output variables experience the opposite process, which is converting the fuzzy value to a crisp values, it is known as “defuzzification”.

The membership function has the magnitude of participation of each input and is represented in graphical. The roles of membership functions are to:

- Each of the input that are processed are given certain magnitude value
- Functional overlap between inputs are to be defined
- Output response are to be determined

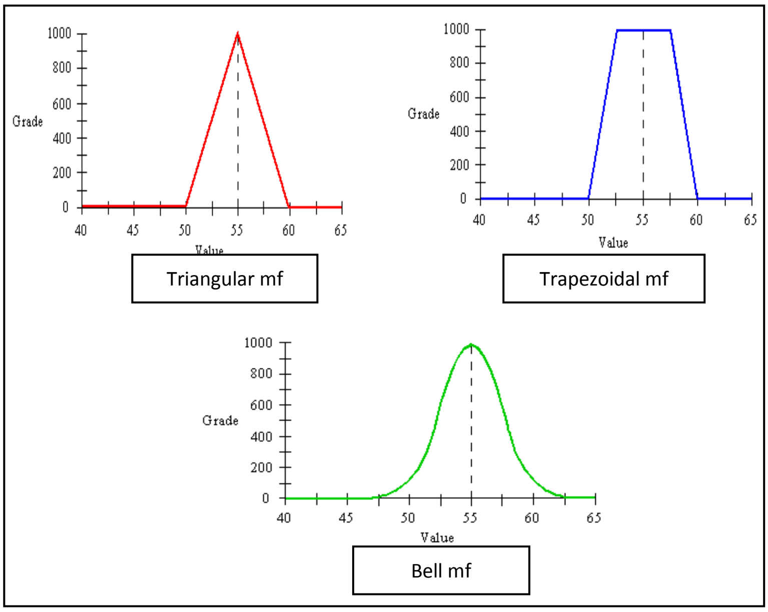


Figure 9: Various Types of Type-1 Membership Functions

The rule uses the input membership values as weighting factors to manipulate their impact between the fuzzy output sets and the final output conclusion. Once the functions are concrete, extended, and joint, they are defuzzified into a crisp output which control the entire operation of the fuzzy structure. There are different forms of memberships functions related with each input and output response for example, triangular shaped, or bell shaped as shown in Figure 9.

2.5 IEEE Reliability Test System -1996

2.5.1 Introduction

Reliability Test System 1996 (RTS-96) is an enhanced test system to be utilize in massive power system dependability evaluation studies. In this paper, the Fuzzy Logic techniques used to manage congestion will be performed on this system. This test system is a modified and updated version from the original IEEE RTS developed in 1979 to be a sign of revolutionize in evaluation methodologies and to defeat apparent insufficiency.

The first version of the IEEE Reliability Test System (RTS-79) was developed and published in 1979 by the Application of Probability Methods (APM) Subcommittee of the Power System Engineering Committee [20]. The purpose of this system was to create a standardized data base for testing and compares results from different power system reliability evaluation methodologies. RTS-79 also acts as a reference system that contains the core data and system parameters for variety reliability evaluation methods. However, this system is being enhanced with additional data and the second version of the RTS was developed (RTS-86).

The second version of RTS-86 was published with the objective of making the RTS more useful in assessing different reliability modeling and evaluation methodologies [20]. RTS-86 expanded the data system relating to the generation system which are the number of generating units, unite derated states, unit scheduled maintenance, load forecast uncertainty, and the effect of interconnection. The advantage of RTS-86 lies in the fact that it presented the system reliability indices derived through the use of rigorous solution techniques without any approximations in the evaluation process [20]. These exact indices are very useful in comparison of results from different techniques.

To meet the requirement of a better test system that can represent as much as possible, all the different technologies and configuration, the latest version of RTS-96 is developed and adopted.RTS-96 is a hybrid and atypical system.

2.5.2 System Topology

The system topology for RTS-96 is the same as the system topology of RTS-79. It is shown in Figured 1 and is labeled “Area A” [20].

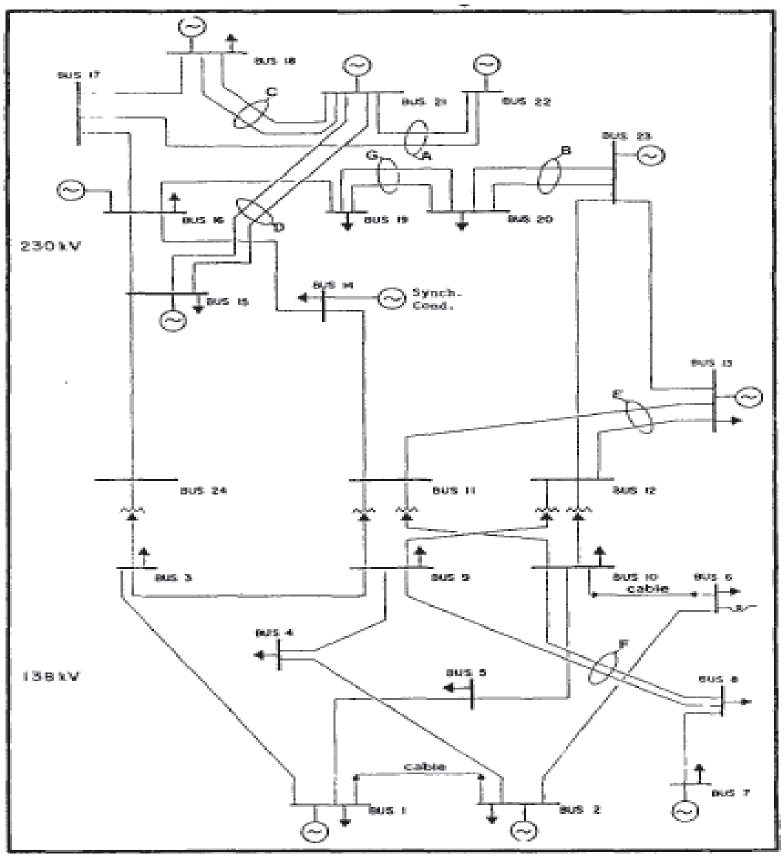


Figure 10: IEEE One Area RTS-96

2.5.3 Bus Data

The only changes of bus data from the RTS-79 is the bus numbering system. Table 4 lists the bus data for "Area A" [20].

Bus type: 1- Load Bus (no generation)

2- Generator or plant bus

3- Swing Bus

MW Load: load real power to be held constant

MVAR Load: load reactive power to be held constant

Table 4: IEEE RTS-96 Bus Data (One Area)

BUS	BUS TYPE	MW LOAD	MVAR LOAD	Sub Area	Base kV	Zone
101	2	106	22	11	138	11
102	2	97	20	11	138	12
103	1	180	37	11	138	11
104	1	74	15	11	138	11
105	1	71	14	11	138	11
106	1	136	26	11	138	12
107	2	125	25	11	138	12
108	1	171	35	11	138	12
109	1	175	366	11	138	13
110	1	195	40	11	138	13
111	1	0	0	11	230	13
112	1	0	0	11	230	13
113	3	265	54	12	230	14
114	2	194	39	12	230	16
115	2	317	64	12	230	16
116	2	100	20	12	230	16
117	1	0	0	12	230	17
118	2	333	68	12	230	17
119	1	181	37	12	230	15
120	1	128	26	12	230	15
121	2	0	0	12	230	17
122	2	0	0	12	230	17
123	2	0	0	12	230	15
124	1	0	0	12	230	16

2.5.4 System Loads

The weekly peak loads in percent of the annual peak is shown in Table 5. This seasonal load profile can be used to adapt to any system peaking season one desires to model [20].

Table 5: Weekly Peak Load in Percent of Annual Peak

Week	Peak Load (%)	Week	Peak Load (%)	Week	Peak Load (%)	Week	Peak Load (%)
1	86.2	**14**	75.0	**27**	75.5	**40**	72.4
2	90.0	**15**	72.1	**28**	81.6	**41**	74.3
3	87.8	**16**	80.0	**29**	80.1	**42**	74.4
4	83.4	**17**	75.4	**30**	88.0	**43**	80.0
5	88.0	**18**	83.7	**31**	72.2	**44**	88.1
6	84.1	**19**	87.0	**32**	77.6	**45**	88.5
7	83.2	**20**	88.0	**33**	80.0	**46**	90.9
8	80.6	**21**	85.6	**34**	72.9	**47**	94.0
9	74.0	**22**	81.1	**35**	72.6	**48**	89.0
10	73.7	**23**	90.0	**36**	70.5	**49**	94.2
11	71.5	**24**	88.7	**37**	78.0	**50**	97.0
12	72.7	**25**	89.6	**38**	69.5	**51**	100.0
13	70.4	**26**	86.1	**39**	72.4	**52**	95.2

Table 6 shows the assumed daily peak load in percent of the weekly peak and Table 7 shows the hourly load in percent of the daily peak where the climate zone chosen is summer weeks. The assumed load for each bus of the one area system is listed in Table 5.

Table 6: Daily Load in Percent of Weekly Peak

Day	Peak Load (%)
Monday	93
Tuesday	100
Wednesday	98
Thursday	96
Friday	94
Saturday	77
Sunday	75

Table 7: Hourly Peak Load in Percent of Daily Peak

Summer Weeks			Summer Weeks		
	Peak Load (%)			Peak Load (%)	
Hour	Weekday	Weekend	Hour	Weekday	Weekend
12-1am	64	74	**Noon-1pm**	99	93
1-2	60	70	**1-2**	100	92
2-3	58	66	**2-3**	100	91
3-4	56	65	**3-4**	97	91
4-5	56	64	**4-5**	96	92
5-6	58	62	**5-6**	96	94
6-7	64	62	**6-7**	93	95
7-8	76	66	**7-8**	92	95
8-9	87	81	**8-9**	92	100
9-10	95	86	**9-10**	93	93
10-11	99	91	**10-11**	87	88
11-Noon	100	93	**11-12**	72	80

2.5.5 Transmission System

RTS-96 is the expansion version of RTS-79. In Table 8, the transmission branch data which includes lines, cables, transformers, phase-shifter, and tie lines is listed.

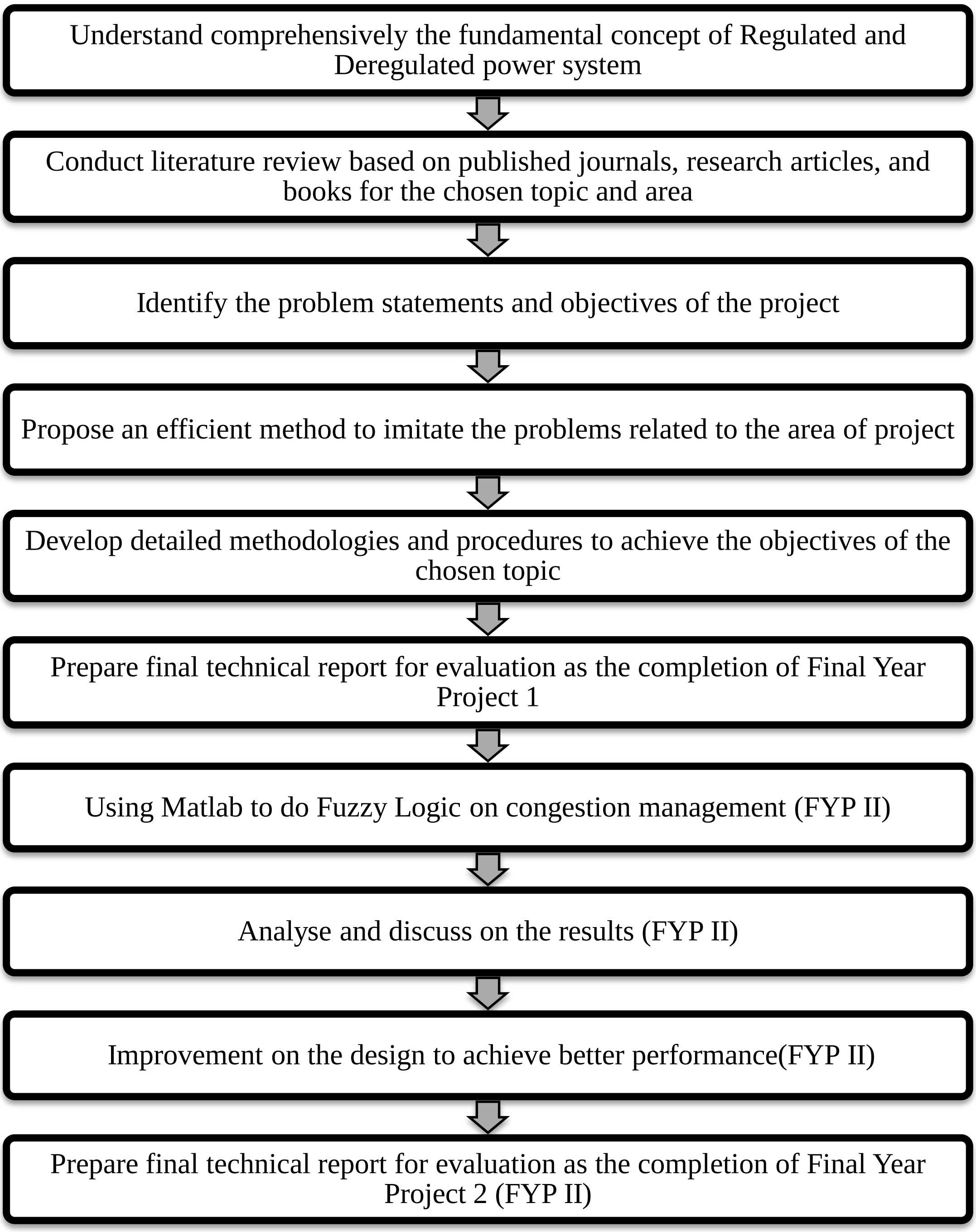
Table 8: Branch Data

ID	From	To	L	-Perm-		Tran.	R	X	B	Con	LTE	STE	Tr
#	Bus	Bus	miles	γ_p	Dur	γ_t	pu	pu	pu	MVA	MVA	MVA	Pu
A1	101	102	3	.24	16	0.0	0.003	0.014	0.461	175	193	200	0
A2	101	103	55	.51	10	2.9	0.055	0.211	0.057	175	208	220	0
A3	101	105	22	.33	10	1.2	0.022	0.085	0.023	175	208	220	0
A4	102	104	33	.39	10	1.7	0.033	0.127	0.034	175	208	220	0
A5	102	106	50	.48	10	2.6	0.050	0.192	0.052	175	208	220	0
A6	103	109	31	.38	10	1.6	0.031	0.119	0.032	175	208	220	0
A7	103	124	0	.02	768	0.0	0.002	0.084	0	400	510	600	1.015
A8	104	109	27	.36	10	1.4	0.027	0.104	0.028	175	208	220	0
A9	105	110	23	.34	10	1.2	0.023	0.088	0.024	175	208	220	0
A10	106	110	16	.33	35	0.0	0.014	0.061	2.459	175	193	200	0
A11	107	108	16	.30	10	0.8	0.016	0.061	0.017	175	208	220	0
A12-1	108	109	43	.44	10	2.3	0.043	0.165	0.045	175	208	220	0
A13-2	108	110	43	.44	10	2.3	0.043	0.165	0.045	175	208	220	0
A14	109	111	0	.02	768	0.0	0.002	0.084	0	400	510	600	1.03
A15	109	112	0	.02	768	0.0	0.002	0.084	0	400	510	600	1.03
A16	110	111	0	.02	768	0.0	0.002	0.084	0	400	510	600	1.015
A17	110	112	0	.02	768	0.0	0.002	0.084	0	400	510	600	1.015
A18	111	113	33	.40	11	0.8	0.006	0.048	0.100	500	600	625	0
A19	111	114	29	.39	11	0.7	0.005	0.042	0.088	500	600	625	0
A20	112	113	33	.40	11	0.8	0.006	0.048	0.100	500	600	625	0
A21	112	123	67	.52	11	1.6	0.012	0.097	0.203	500	600	625	0
A22	113	123	60	.49	11	1.5	0.011	0.087	0.182	500	600	625	0
A23	114	116	27	.38	11	0.7	0.005	0.059	0.082	500	600	625	0
A24	115	116	12	.33	11	0.3	0.002	0.017	0.036	500	600	625	0
A25-1	115	121	34	.41	11	0.8	0.006	0.049	0.103	500	600	625	0
A25-2	115	121	34	.41	11	0.8	0.006	0.049	0.103	500	600	625	0
A26	115	124	36	.41	11	0.9	0.007	0.052	0.109	500	600	625	0
A27	116	117	18	.35	11	0.4	0.003	0.026	0.055	500	600	625	0
A28	116	119	16	.34	11	0.4	0.003	0.023	0.049	500	600	625	0
A29	117	118	10	.32	11	0.2	0.002	0.014	0.030	500	600	625	0
A30	117	122	73	.54	11	1.8	0.014	0.105	0.221	500	600	625	0
A31-1	118	121	18	.35	11	0.4	0.003	0.026	0.055	500	600	625	0
A31-2	118	121	18	.35	11	0.4	0.003	0.026	0.055	500	600	625	0
A32-1	119	120	27.5	.38	11	0.7	0.005	0.040	0.083	500	600	625	0
A32-2	119	120	27.5	.38	11	0.7	0.005	0.040	0.083	500	600	625	0
A33-1	120	123	15	.34	11	0.4	0.003	0.022	0.046	500	600	625	0
A33-2	120	123	15	.34	11	0.4	0.003	0.022	0.046	500	600	625	0
A34	121	122	47	.45	11	1.2	0.009	0.068	0.142	500	600	625	0

ID#	= Branch identifier
γ_p	= Permanent Outage Rate (outages/year)
Dur	= Permanent Outage Duration (Hours)
γ_t	= Transient Outage Rate (outages/year)
Con	= Continuous rating
LTE	= Long-time emergency rating (24 hour)
STE	= Short-time emergency rating (15minutes)
Tr	= Transformer off-nominal ratio. Transformer branches are indicated by Tr $\neq 0$

Chapter 3: Methodology

3.1 Research Methodology



3.2 Project Activities

The following is a brief flow chart of this project. From the flow chart, the flow and direction of the project can be seen clearly. This is a guide that helps in developing and making this project successful.

Research On Topic	• Conduct research on Congestion Management in Deregulated Power System specifically on Fuzzy Logic Approach. • Research is done by referring journals, thesis, books, conference papers, technical reports, internet and interactive media (CD-ROM).
Fuzzy Logic based Congestion Control	• Familiarization with Fuzzy Logic Theory of its definition and its equations. • Understanding the applications of Fuzzy Logic on congestion management in deregulated power system.
Fuzzy Logic Simulation	• Simulate Fuzzy Logic using Matlab to control the congestion problem in deregulated power system.
Analysis and Improvement of Design	• If simulation does not give satisfy output, improvement should be carried out. • Design improvement involves the changes of design modelled that is made earlier to get a better performance.
Discussion on Results	• The performance of the Fuzzy Logic Approach on Congestion Management in Deregulated Power System will be analysed. • This new approach shoud give better performance as compared with the conventional approach.
Preparation of Final Technical Report 1 & 2	• Technical report which includes 5 chapters of Introduction, Literature Review, Methodology, Results and Discussions, and Conclusion will be prepared for evalution.

3.3 Tools

To accomplish this project, some tools are needed either for simulation or report writing purposes.

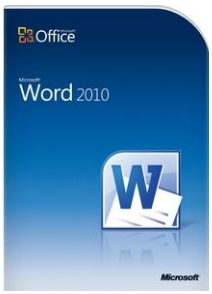


Figure 111: Microsoft Word

Figure 122: Adobe Reader

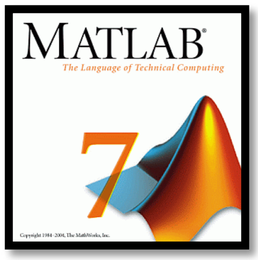


Figure 13: Matlab

3.4 Key Milestones and Gantt chart

3.4.1 Final Year Project 1

No	Details / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.	Topic Selection and Confirmation														
2.	Preliminary Research Work														
3.	Literature Review														
4.	Extended Proposal														
5.	Proposal Defence and Progress Evaluation														
6.	Fuzzy Logic Design														
7.	Interim Draft Report														
8.	Interim Report														

3.4.2 Final Year Project 2

No	Details / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.	Continuation of Final Year Project 1														
2.	Simulation of Fuzzy Logic using Matlab														
3.	Progress Report														
4.	Pre-EDX														
5.	Draft Technical Report														
6.	Final Technical Report Submission														
7.	Viva														

Process

Milestone

CHAPTER 4: RESULTS AND DISCUSSIONS

4.1 Fuzzy Input/Output Variables and Membership Function Design

The Fuzzy input and output variables should be a reflection of transmission line congestion. There are two input variables in this fuzzy controller which are:

1. The percentage of load in the transmission line
2. The price for the transmission line

And one output variable which is the condition of congestion level in the transmission line. The intervals of Load have been divided into 3 membership functions, which are as follows:

- Low
- Normal
- High

This membership functions in Figure 14 uses the combination of both triangular and trapezoidal graphs.

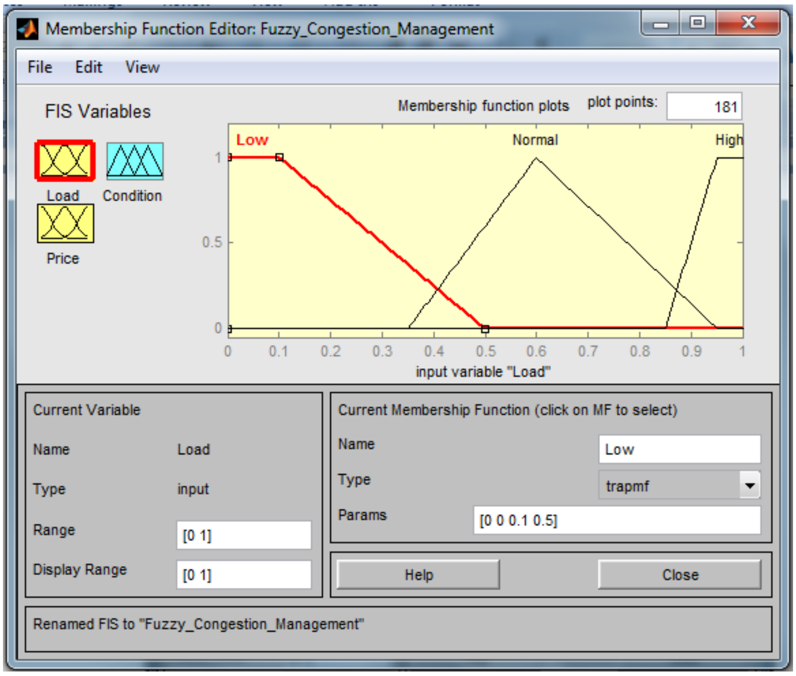


Figure 13: Membership function for Load

The intervals of Price have been divided into 3 membership functions, which are as follows:

- Cheap
- Average
- Expensive

This membership functions in Figure 15 uses the triangular graphs. It is skewed towards the expensive side. This is because the price is the charges to be charged to the user. Hence, users are normally more concern when they are being charged expensive price rather than cheap price.

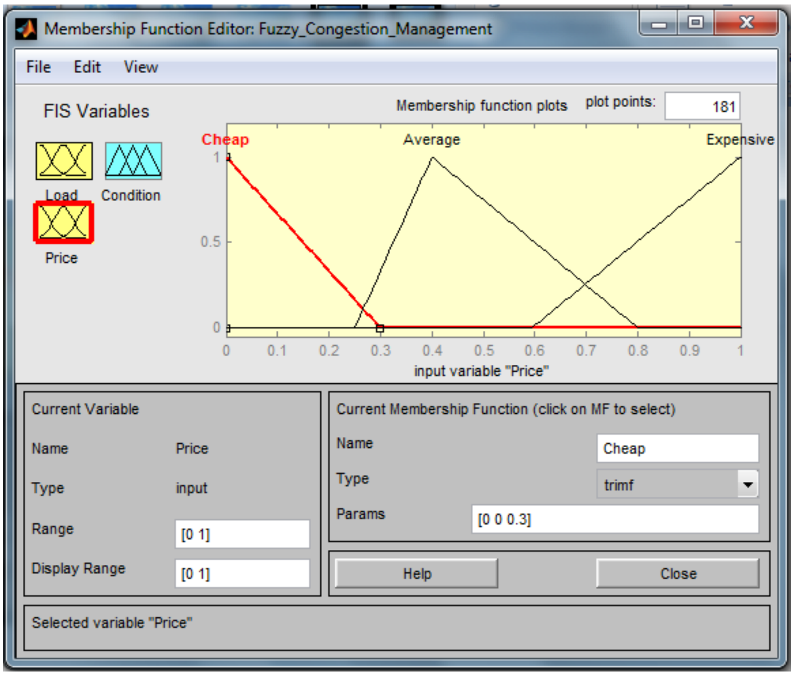


Figure 14: Membership function for Price

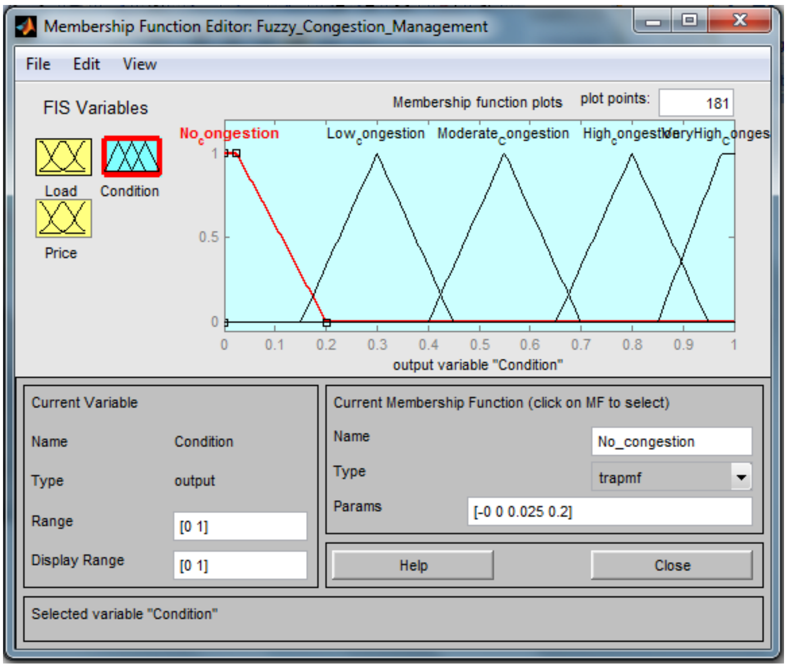


Figure 15: Membership function for Condition

The intervals of Condition have been divided into 5 membership functions, which are as follows:

- No Congestion
- Low Congestion
- Moderate Congestion
- High Congestion
- Very High Congestion

This membership functions in Figure 16 uses the combination of both triangular and trapezoidal graphs. This output that determines the congestion level in the transmission line.

4.2 Fuzzy Control Rules

The simple rule-based of Fuzzy Logic is using "IF X AND Y THEN Z" [19]. This simple *if-then* rule determines how the whole system operates. The controller shuld be described by using 3^2 = 9 possible combination of AND rules since we have two input variables that each has three membership functions. The working principle of Fuzzy rules imitates how human thinks when deciding the best choice to solve a problem face.

In this case, we have used only 7 rules instead of 9 rules. This is because the first rule can represent three rules. The first rule is:

- If Load is low, then Condition is no congestion.

It has the same meaning for the three rules as shown below:

1. If Load is low and Price is cheap, then Condition is no congestion.
2. If Load is low and Price is average, then Condition is no congestion.
3. If Load is low and Price is expensive, then Condition is no congestion.

This means that regardless of the price, when the Load is low, the problem of congestion will not occur. Figure 17 shows the 7 rules that were set for this system. The rules set are as follows:

1. If Load is Low, then Condition is no congestion.
2. If Load is High and Price is cheap, then Condition is Very High congestion.
3. If Load is High and Price is average, then Condition is High congestion.
4. If Load is High and Price is expensive, then Condition is Moderate congestion.
5. If Load is Normal and Price is cheap, then Condition is High congestion.
6. If Load is Normal and Price is average, then Condition is Moderate congestion.
7. If Load is Normal and Price is expensive, then Condition is Low congestion.

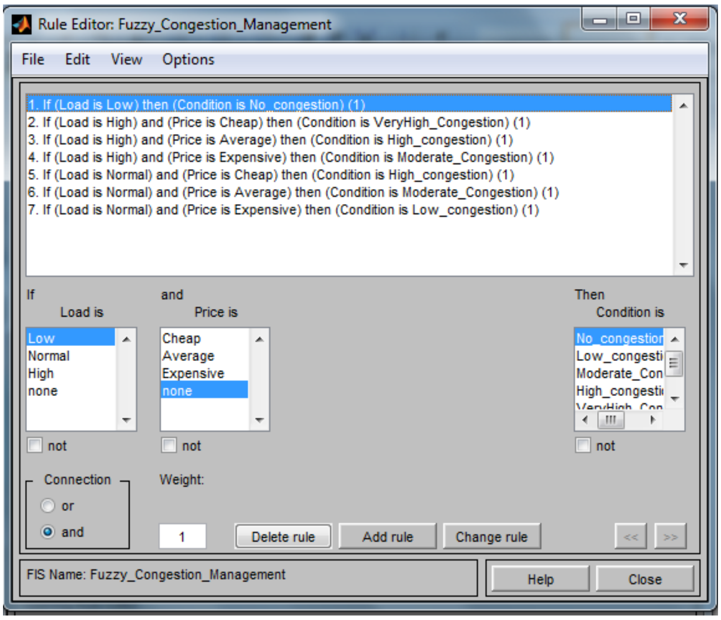


Figure 16: Rules set using Fuzzy Theory

4.3 Fuzzy Results

Figure 18 shown below is the Simulink for the Fuzzy Theory mentioned above. This Simulink diagram can link with the Fuzzy Membership Function Editor. By attaching the *.fis* file to the Fuzzy Logic Controller with Rule viewer, the results based on the Fuzzy Rule set above will be shown at the condition part. The results for the Fuzzy Logic can be shown in two different forms which are in surface viewer form and rule viewer form. For surface viewer, the results are represented in graph. The x-axis of the graph is Load, the y-axis is Price and the z-axis is Condition. For rule viewer, the results are represented in value form where the different value of Load and Price will provides a different value for Condition which is within the range from 0 to 1.

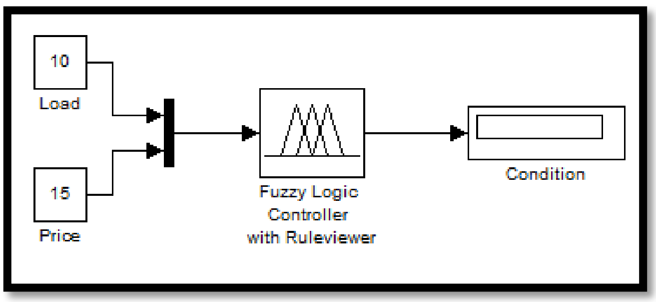


Figure 17: Fuzzy Logic in Simulink

Figure 19 is the results shown in Surface Viewer where the results are shown in three axis graph. Figure 20 is the results shown in Rule Viewer. The different value of inputs for both Load and Price will have a great impact on the final value at the output which is condition.

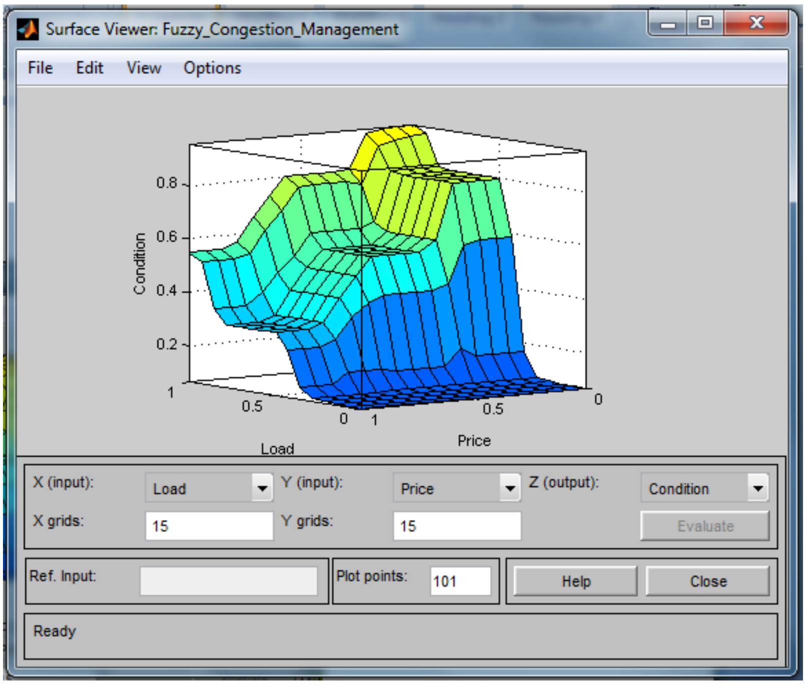


Figure 18: Fuzzy Surface viewer

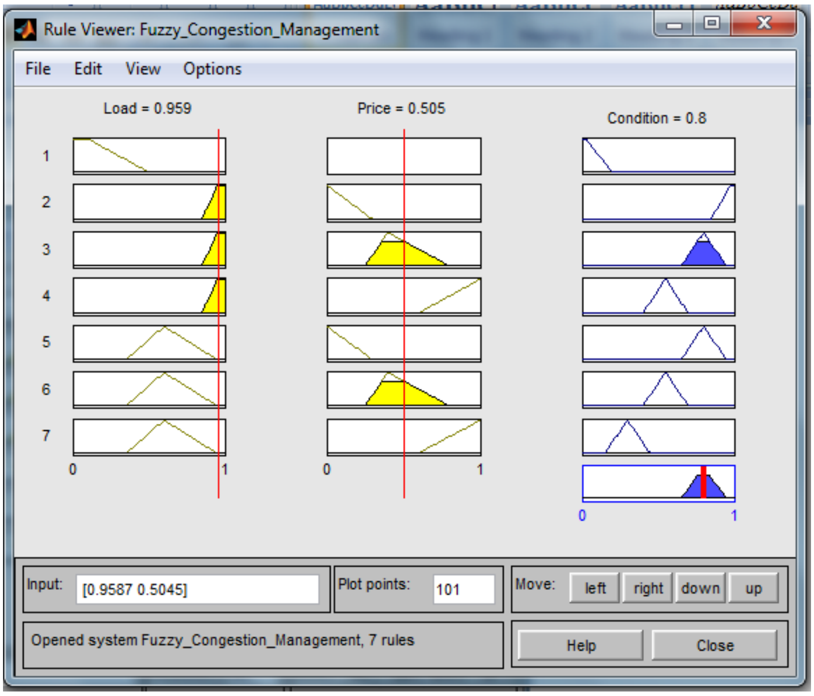


Figure 19: Fuzzy Rule Viewer

By using the Simulink for the Fuzzy Theory as shown in Figure 18, this system is tested using Weekly Load data from IEEE RTS-96. The Weekly Load value is obtained from the IEEE RTS-96 meanwhile the Cheap Price, Average Price and Expensive price is set at 0.150, 0.500 and 0.900 accordingly. The result from the testing is tabulated in Table 9.

Table 9: Congestion Level Results using IEEE RTS-96 Weekly Peak Load

Week	Peak Load	Price		
		Cheap (0.150)	Average (0.500)	Expensive (0.900)
1	0.862	0.818 (High Congestion)	0.633 (Moderate Congestion)	0.383 (Low Congestion)
2	0.900	0.885 (Very High Congestion)	0.736 (High Congestion)	0.486 (Moderate Congestion)
3	0.878	0.850 (Very High Congestion)	0.692 (High Congestion)	0.442 (Moderate Congestion)
4	0.834	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
5	0.880	0.852 (Very High Congestion)	0.700 (High Congestion)	0.447 (Moderate Congestion)
6	0.841	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
7	0.832	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
8	0.806	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
9	0.740	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
10	0.737	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
11	0.715	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
12	0.727	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
13	0.704	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
14	0.750	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
15	0.721	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
16	0.800	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
17	0.754	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
18	0.837	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
19	0.870	0.822 (High Congestion)	0.639 (Moderate Congestion)	0.389 (Low Congestion)
20	0.880	0.835 (High Congestion)	0.667 (Moderate Congestion)	0.417 (Low Congestion)
21	0.856	0.806 (High Congestion)	0.583 (Moderate Congestion)	0.333 (Low Congestion)
22	0.811	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
23	0.900	0.864 (Very High Congestion)	0.709 (High Congestion)	0.459 (Moderate Congestion)

24	0.887	0.845 (High Congestion)	0.683 (Moderate Congestion)	0.433 (Low Congestion)
25	0.896	0.859 (Very High Congestion)	0.701 (High Congestion)	0.451 (Moderate Congestion)
26	0.861	0.811 (High Congestion)	0.606 (Moderate Congestion)	0.356 (Low Congestion)
27	0.755	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
28	0.816	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
29	0.801	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
30	0.880	0.852 (Very High Congestion)	0.700 (High Congestion)	0.447 (Moderate Congestion)
31	0.722	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
32	0.776	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
33	0.800	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
34	0.729	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
35	0.726	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
36	0.705	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
37	0.780	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
38	0.695	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
39	0.724	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
40	0.724	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
41	0.743	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
42	0.744	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
43	0.800	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
44	0.881	0.836 (High Congestion)	0.669 (Moderate Congestion)	0.419 (Low Congestion)
45	0.885	0.842 (High Congestion)	0.679 (Moderate Congestion)	0.429 (Low Congestion)
46	0.909	0.872 (Very High Congestion)	0.724 (High Congestion)	0.474 (Moderate Congestion)
47	0.940	0.916 (Very High Congestion)	0.778 (High Congestion)	0.528 (Moderate Congestion)
48	0.890	0.850 (Very High Congestion)	0.700 (High Congestion)	0.440 (Moderate Congestion)

49	0.942	0.920 (Very High Congestion)	0.782 (High Congestion)	0.532 (Moderate Congestion)
50	0.970	0.942 (Very High Congestion)	0.800 (High Congestion)	0.550 (Moderate Congestion)
51	1.000	0.942 (Very High Congestion)	0.800 (High Congestion)	0.550 (Moderate Congestion)
52	0.952	0.942 (Very High Congestion)	0.800 (High Congestion)	0.550 (Moderate Congestion)

The Simulink for the Fuzzy Theory system as shown in Figure 19 is tested using Daily Load data from IEEE Reliability Test System 1996 (RTS-96). The Peak Load value is used in this simulation meanwhile the Cheap Price, Average Price and Expensive price is set at 0.150, 0.500 and 0.900 accordingly. The simulation result is tabulated in the Table 10.

Table 10: Congestion Level Results using IEEE RTS-96 Weekly Peak Load

Day	Peak Load	Price		
		Cheap (0.150)	Average (0.500)	Expensive (0.900)
Monday	0.930	0.897 (Very High Congestion)	0.760 (High Congestion)	0.510 (Moderate Congestion)
Tuesday	1.000	0.942 (Very High Congestion)	0.800 (High Congestion)	0.550 (Moderate Congestion)
Wednesday	0.980	0.942 (Very High Congestion)	0.800 (High Congestion)	0.550 (Moderate Congestion)
Thursday	0.960	0.942 (Very High Congestion)	0.800 (High Congestion)	0.550 (Moderate Congestion)
Friday	0.940	0.916 (Very High Congestion)	0.778 (High Congestion)	0.528 (Moderate Congestion)
Saturday	0.770	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)
Sunday	0.750	0.800 (High Congestion)	0.550 (Moderate Congestion)	0.300 (Low Congestion)

4.4 Discussions

From the results, the condition of the congestion level in the transmission lines can be identified. The DISTCOs and GENCOs companies can fix the price to be charged to the user according to the condition of the congestion level in the transmission line. When there is high demand in very high congested line, high price will be charged to the users that favour the electric utility which transmit through that line. This pricing strategy that based on Fuzzy Logic is the better way to control the energy usage.

There are two transmission pricing strategy that are suitable approaches to be taken for consideration in the long run. These methods are as listed below:

I. Nodal Pricing Method

II. Zonal Pricing Method

There are several factors to be considered such as geographical factors, mechanical factors and transmission losses when determining the most suitable transmission pricing method. Ultimately, the selected method must be able to benefit both the retailer and the end user.

The basic idea of nodal pricing is that different prices are charged at different individual buses. In other words, the price charged at each is the marginal cost of the next megawatt of power supplied to the ideology of Kirchhoff's Law in considering the power flow in each node. These nodes are then priced respectively accordingly to their individual measured power flow. Ideally, the prices per-unit power supplied should be the same provided there is no transmission constraint present in the system [17]. Difference in the nodal prices only occurs when there is an active transmission constraint present. On the whole, locations which implement this pricing strategy would require its market users to pay a different price according to the respective nodes. These charges are justified on the basis that the incremental cost which needs to be included at every bus is different and varies with the location.

The concept of Zonal pricing is uniform charges rate within a specific location. For this, each region/country is considered as a zone depending on the geographical size of the location. This is as opposed to considering the price of the individual node where consumers are located in the system. Consumers which fall under the Zonal pricing locations are required to send an hourly supply or demand bids one day prior to the physical delivery. Looking into real time implementation of Zonal pricing, this approach requires its participants to send in tits scheduled adjustment bits (SAB). This is somewhat similar to the bidding practices. The SAB is basically an avenue for consumers to adjust their respective schedules to the energy price vary through time.

CHAPTER 5: CONCLUSION AND RECOMMENDDATIONS

In conclusion, deregulation is a more promising system for the improvement of utility market as compared to the conventional regulated power system. The major concern in deregulation which is transmission congestion will be control using Fuzzy Logic. Transmission Congestion that is normally due to improper management between generation and transmission utilities which has a consequence of unexpected emergency for example generation breakdown, abrupt increase of load demand, or malfunction of equipments. Fuzzy Logic is one of the methods under Artificial intelligence Methods. This method is recently used to solve highly composite problems related to approximation type of problems rather than precision. Fuzzy Logic is using the simple rule-based of "IF X AND Y THEN Z". Simulation of Fuzzy Logic using Matlab for congestion management is done.

By implementing the concept of Fuzzy Logic, the congestion level in the transmission line can be determined. With this value shown, the retailers and suppliers are able to apply charges according to the users' requirement. The charges are advised to be based on the pricing strategies which are nodal pricing strategy and zonal pricing strategy. It is a more effective way in controlling the energy usage. At the same time, reducing the consumption of fuel and gas helps to conserve the resources for future generation.

This project is to be accomplished within the two semesters of studies. The objective of the projects is to understand the principles and concepts of Deregulated Power System. This objective is achieved in Final Year Project 1 and clearly shown in Chapter 2 of the report which is Literature Review. Another objective is to identify possible approaches to manage congestion in a deregulated power system. Several conventional methods are identified such as Linear Programming Method, Newton-Raphson method, Quadratic Programming Method, Nonlinear Programming Method, and Interior Point Method. However, the technique that is newly used is Artificial Intelligence Methods. Fuzzy Logic is under this Artificial Intelligence Methods. Finally, the last objective of modelling Fuzzy Logic Approach for Congestion Management has been discussed clearly in Chapter 4 of Results & Discussions. The results showed the congestion level for Weekly Load and Daily Load using the data in IEEE RTS-96. With the congestion level, the price can be further determined by the distributor according to Zonal Pricing Method and Nodal Pricing Method. Those objectives are satisfied and achieved in this final year project with firm commitment towards the methodology and planning arranged.

Bibliography

[1] S. Dhanalakshmi, "Market Modes for Deregulated Environment-A review," *IEEE Computer Society, Proceedings of ICETECT*, 2011.

[2] V.S Sundaram and T.Jayabarathi, "A congestion line flow control in deregulated power system," *Serbian Journal of Electrical Engineering*, vol. 8, no. 2, pp. 203-212, May 2011.

[3] Jin Zhong, Yixin Ni and H. Liu, "Deregulation of Power Systems in Asia: Special Consideration in Developing Countries," *Power Engineering Society General Meeting, IEEE*, vol. 3, pp. 2876-2881, 2005.

[4] A. Pitsillides and A. Sekercioglu, "Fuzzy Logic Based Congestion Control," *Department of Computer Science University of Cyprus.*

[5] I. K. Tabash *et al.*, "A fuzzy Logic Based Network Congestion Control Using Active Queue Management Techniques," *Journal of Scientific Research*, vol. 2, pp. 273-284, 2010.

[6] I. N. Azkerzade & M. Mahmood, "Control the Extension Time of Traffic Light in Single Junction by Using Fuzzy Logic," *International Journal of Electrical & Computer Sciences IJECS-IJENS*, vol. 10, no. 2, 2006.

[7] A.A. Osamah, "Restructuring Kuwait Electrical Power System: Mandatory or Optional?," *World Academy of Science, Engineering and Technology*, , p. 45, 2008.

[8] K. Vijayakumar, "Multiobjective Optimization Methods for Congestion Management in Deregulated Power Systems," *Journal of Eelctrical and Computer Engineering*, no. 8, 2012.

[9] B. Kuri and F. Li, "Effective Design for Competitive Electricity Markets," *IEEE*, vol. 2, pp. 1034-1038, 2004.

[10] L. L. Lai, Power System Restructuring and Deregulation, New York, USA: John Wiley & Sons Ltd, 1998.

[11] K. Karagory et al., "Topics On The Deregulation Of The Power Industry," *ECE Technical Reports*, 1992.

[12] Y.K. Wu, "Comparison of Pricing Schemes of Several Deregulated Electricity Markets in the World," *IEEE Transmission and Distribution*, 2005.

[13] E. Z. Zhou, "XML and data exchange," *IEEE POwer Engineering Review*, pp. 66-68, April 2000.

[14] J. W. Van Dyke and B.J. Kirby, "Congestion Management Requirements, Methods and Performance Indices," *California Energy Commission*, June 2002.

[15] N. Kamaraj & S. Balaraman, "Congestion management in deregulated power system using real coded genetic algorithm," *International Journal of Engineering Science and Technology*, vol. 2, no. 11, pp. 6681-6690, 2010.

[16] K. S. Pandya & S. Joshi, "A survey of optimal power flow methods," *Journals of Theoretical and Applied Information Technology*, 2005-2008.

[17] V. C. Ramesh, "A Fuzzy Multiobjective Approach to Contigency Constrained OPF," *IEEE Transactions on Power Systems*, vol. 12, no. 3, August 1997.

[18] M. Kumar, L. M. Saini, A. Kumar and S.K. Aggrawal, "Short Term Load Forecasting in Deregulated Electricity Markets using Fuzzy Approach," *Jounal of Engineering and Technology*, vol. 1, no. 1, Jan-Jun 2011.

[19] N. P. Padhy, "Congestion Management Under Deregulated Fuzzy Environment," *IEEE International Conference on Electric Utility Deregulation, Restructuring and Power Technologies (DRPT2004)*, pp. 133-139, April 2004.

[20] IEEE RTS Task Force of APM Subcommittee, "The IEEE Reliability Test System-1996," *IEEE Transactions on Power Systems*, vol. 14, no. 3, pp. 1010-1020, August 1999.