A

DISSERTATION

ON

INTELLIGENCE POWER FLOW CONTROL FOR A SOLAR PV/WIND ENERGY BASED HYBRID SYSTEM

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE AWARD OF THE DEGREE OF

MASTERS OF TECHNOLOGY

IN

POWER SYSTEM ENGINEERING

BY

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CERTIFICATE

This is to certify that this dissertation entitled as "**INTELLIGENCE POWER FLOW CONTROL FOR A SOLAR PV/WIND ENERGY BASED HYBRID SYSTEM**" submitted by **SOUMYA KUMARI** in partial fulfillment of the requirement for degree of '**MASTER OF TECHNOLOGY**' in **POWER SYSTEM ENGINEERING** is a record of his own work carried out by him under my supervision, at Deptt. of Electrical Engineering, Integral University, Lucknow Uttar Pradesh

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Abstract

In this Dissertation an Intelligent Power flow Control (IPFC) for end consumer has been proposed using hybrid energy system. The proposed strategy used an algorithm for intelligent power management between Solar/wind/battery based microgrid and end users load, in islanding mode. When to take power for consumer load, from the different source of microgrid or a storage unit, is decided by smart power management systems. The prime objective of the proposed scheme is to shift the load demand on the renewable power source as per the availability of renewable energy source. IPFC's second goal is to prevent a single source to overload by shifting demand on battery storage. The load demand is related to the load. The algorithm was checked on the basis as associated to the Fuzzy Logic smart control application. It is demonstrated the IPFC based approach performed well. The intelligent approach based resulted iS more accurate as compared to earlier available scheme

CHAPTER-1

INTRODUCTION

During the recent decades, both domestic and global consumption related to energy is growing rapidly. According to 2020 report related to the International Energy Agency, in United States, total consumption based application type related to the energy in 2018 was 26.6 TWh, compared on the basis of 22.3 TWh back in 2010. This represents a growth related to the 20%. The global energy demand is even more dramatic. In 2010, the global demand was 102.3 TWh and in 2018 it was 142.3 TWh which increased by 39%. The global demand related to the energy is rising more rapidly than in the United States [1].

It is estimated that annual rate related to the energy consumption will increase to the tune related to the 5% from 2020 [2]. The increasing amount related to the energy consumption based application type is often due to various reasons that come along on the basis of rise related to the living standard. For industrialized countries, mostly in North America and West Europe demand for energy steadily recovered from economic crisis related to the 2018. In the emerging countries like "BRIC" (Brazil, Russia, India and China), demand for all forms related to the energy continued to grow at a very fast speed. To avoid potential energy crisis, it is imperative to generate more energy and at the same time, increase the energy efficiency, so that we can do more work on the basis of less energy. Conventional energy resources typically include coal, fuel oil, natural gas and nuclear power. Materials to generate conventional energy are cheap and the power stations in which these resources are handled can be built almost anywhere. However, drawbacks related to the conventional energy solution are apparent. First, the quantity related to the material for generating conventional energy is limited and it could cost thousands related to the years for earth to cycle and regenerate these resources. Therefore, these resources will stop being available eventually. Second, the process related to the generation based application type itself in conventional way often causes damage to surrounded environments and can lead to further serious pollution. In 1986 the infamous nuclear leak disaster occurred in Chernobyl Nuclear Power Plant in Ukraine which caused at least 200,000 cancer cases in that area [3]. Scientists and consumers are aware related to the pollution caused by conventional energy and environmental degradation related to these resources. Therefore, it is imperative to come up on the basis of alternative energy solutions which are sustainable and renewable and have lower carbon footprint on the environment.

To increase the supply, besides conventional energy, renewable energy is being increasingly used to generate essential power for daily consumption based application type. Renewable energy is generated from natural resources such as sunlight, wind, rain, tides and geothermal heat, which are naturally replenished compared on the basis of conventional energy source. Due to natural aspect related to the renewable energy, it has much lower environmental effects than conventional energy like coal. In addition, being generated from sun directly or indirectly, source related to the renewable energy regenerates itself much easier than conventional energy.

Management related to the energy has been complex and imperative since various sources are to be integrated to a single management system. Therefore, Smart Grid is being invented. Typical electrical grid is made up related to the four parts: generation based application type , transmission, distribution and customers

[4]. Smart grid is supposed to make everything better by establishing necessary 2-way data communications among components within the electrical grid. Therefore the management related to the energy is becoming more interactive. The possible benefits related to the smart grid are reported to be reduced finance costs, fewer environmental damages and possibly eliminating power outages. Most efforts for improvement related to the electrical grid are fulfilled in generation based application type and transmission grid. However, for end-consumers, applications like solar powered houses and micro wind turbines are being developed and utilized. These are still experimental approaches. There are three primary disadvantages which prevent these technologies from flourishing. The first one is that these approaches usually require infrastructural and architectural modification based application type . The second one is that these approaches cost much more money compared on the basis of paying for electricity purchased from the grid. The third one is that energy efficiency and grid reliability related to these technologies have not yet been achieved to a satisfactory level. In conclusion, there is not yet a prominent and economical method in optimization related to the Energy Management System, especially for end consumer. My thesis is concentrated in addressing the Energy Management System to make it more efficiently and reduce the cost for consumers. In addition, improvement related to the grid on avoiding possible overload is another great concern in my research.

1.1 Problem Definition:

As has been introduced in the previous section, there is not yet a prominent and economical method for optimization based application type related to the power flow Management System available for end consumers. There are two critical requirements in developing it. Firstly, the power flow management system must be embedded on the basis of the ability to reduce cost for end consumers and offers robust performance in a consistent way. Secondly, the Power flow Management System is supposed to help the grid avoid possible overload or blackout. In this thesis a design related to intelligent power flow management system is being proposed. The proposed design is to reduce cost and avoid possible overload or blackout for electrical grid. Two intelligent approaches were attempted to design the intelligent power flow management system. The approach is based on Fuzzy logic control System. The results are satisfactory. In convention systems on the basis of change in certain pattern in daily power consumption, the results become unsatisfactory. This approach is based on artificial intelligence based self-learning hence all tested results are satisfactory and outperform due to use related to fuzzy logic control system.

1.2 Objective: The proposed intelligent power flow management system is made up related to the integrated measurement and Storage Unit, which are cooperating on the basis of other appliances on the basis of variable load such as television, air conditioner, refrigerator etc. The proposed scheme is empowered by intelligent strategy. Energy Storage Unit is under the control related to the fuzzy logic control. It is responsible for storage related to the surplus electricity. The proposed model result datasets time response collected to generate the simulation analysis plots and tables that indicated the proposed design offers robust performance in power saving and helps avoid overload or blackout.

1.3 Energy Resources power flow management:

The demand for electricity is increasing exponentially because of the industrially revolution, which cannot be fulfilled by non-renewable energy sources alone.

Renewable energy sources such as solar and winds are omnipresent and environmental friendly. The renewable energy provides a profound public assessment as associated to the environmental impacts related to the using fossil fuels to generate electricity. With their advantages related to the being abundant in nature and nearly non-pollutant, renewable energy sources have attracted wide attention. By 2050, the International Energy Agency (IEA) projects that as high as 16 % related to the global electricity will be generated from solar photovoltaic (PV) on the basis of a wind contributing about 15-18 %. A standalone wind/solar hybrid power system, making full use as associated to the nature complementary between wind and solar energy has an extensive application prospect among various newly developed energy technologies the capacity as associated to the hybrid power system needs to be optimized in order to make a trade-off between power reliability and cost. It is probable to endorse that hybrid stand-alone electricity generation systems are usually more reliable and less costly than systems that depend on a single source related to the energy. On other hand, you can choose the most profitable type related to the RES than other. For example, in INDIA, Photovoltaic (PV) system is ideal for south, having more solar illumination levels and the wind power system is ideal for hilly and coastal areas such as Kairla and Karnataka, Meghalliya etc and other for both high solar illumination levels and better wind flow at the same time is Rajasthan. Much research effort has been made towards modelling related to the renewable energy resources related application type , solar standalone, wind standalone, or hybrid solar wind hybrid energy systems for reliability assessment and economic viability. Photovoltaic energy genera based application type is ever more important as a renewable resource since it does not cause in fuel costs, poll based application type , maintenance, and emitting noise compared to other renewable resources as more accessibility related to the solar irradiate based application type . The maximum power point (MPP) depends on the irradiance and the temperature level that varies over time. In order to track the MPP, a large number related to the algorithms in literature is available. Perturb and observe (P&O) method is the widely used algorithm due to its easily implemented and simplicity. Nevertheless, it is important to note here that either limited or no experience exists on the basis of the opera based application type related to the PV/Wind hybrid energy system in UP. No such study has so far been carried out in UP environment as per the knowledge related to the supervisor and candidate. This is the main motive based application type behind taking up the challenge related to the evaluating the design criteria and implement based application type related to the utilizing hybrid wind/PV/battery system, through this project. The present project aims at the design, simulate based application type and implement based application type as associated to a hybrid solar/wind power genera based application type system to supply a DC load. A mathematical model as associated to the system will be developed that may be used further for the sizing optimize based application type as associated to a hybrid solar/wind system in UP feeding a specific load. The model will be applied as well for the investing based application type and the assessment related to the hybrid solar/wind power generation based application type potential in the whole UP.

1.3.1 Management related to the Conventional Energy Resources

The power flow management related to the conventional energy resources is through electrical grids, which bridge an interconnected and one-way network which delivers electricity from suppliers to consumers. The paradigm is complex. Generating plants are usually quite large in order to take advantage as associated to the "economies related to the scale" [5]. They are often located far away from the residential area and fairly close to a source related to the water. The generated electrical power is converted to a much higher voltage, at which it connects to the transmission network. The transmission network will move the power long-distance, often across state lines, and sometimes even across international boundaries, until it reaches its wholesale customers [6]. Upon arrival at the substation based application type , the electricity will be tuned down in voltage, to fit into the distribution based application type grid. After it exits the substation based application type , it enters the distribution based application type power transmission wiring. Finally, the electricity wires through service location based application type and will be converted to the required service voltages. It is 110 volt in the United States.

1.3.2 Management related to the Renewable Energy

The power flow management system is significantly different for renewable and conventional energy resources. As has been mentioned in the previous sections, electrical grid is developed to offer infrastructural support to the following distinct operations: generation based application type , transmission and distribution. All three operations bring challenges for management related to the renewable energy. For generation based application type , the sources related to the renewable energy geographically spread across wide distances. As an example, there are two types related to the wind turbines: onshore and offshore. Both of them require to be built in locations on the basis as associated to constant high-speed winds. Therefore, they have to be set up in various places to collect wind power. For power transmission, the renewable energy uses low voltage line as the primary transmission medium. In comparison, the conventional energy is transmitted through high voltage lines for many reasons. For electricity distribution based application type, due to geographical reasons, the distribution based application type related to the renewable energy is more complicated than the conventional. Therefore, Smart Grid has been developed to address the distribution based application type related to the renewable energy, which is non-centralized and asymmetric. In comparison, the distribution related to the conventional energy is designed to feed the group related to the consumers who live in a certain residential area. Therefore the topology related to the conventional energy distribution based application type is centralized and well-balanced.

1.4 Criteria related to the Energy Storage Technology

Energy storage is defined as a method to store some forms related to the energy in order to perform certain operations at a later time [7]. The storage forms involve chemical, biological, electrochemical, electrical, mechanical, thermal and fuel conservation based application type storage etc. The development related to the energy storage allows both power suppliers and end consumers to balance the supply and the demand. The research on energy storage technology draws consistent attention based application type related to the government agencies and global corporations. The 2009 Stimulus Plan proposed an industrial standard for energy storage technology and its integration based application type on the basis of Smart Grid [8].

The utilization based application type related to the renewable energy requires the development on energy storage technology. Otherwise it would not be possible to utilize renewable energy in a reliable, stable and sustainable way. U.S. Department related to the Energy has funded a specified program which is concentrated in energy storage technologies. The program is named Energy

Storage Systems Program [9]. Batteries are one of the approaches available for energy storage. Batteries are electrochemical storage devices. Until 2005, due to comparatively small capacity and high cost, the use related to the batteries has been very limited. In 2005, revolutionary development on battery technology is able to offer large capability related to the storage at a greatly reduced cost.

In New York and California, companies are exploring to build tremendous electrical storage facility that allows "arbitrage", which implies buying electricity at a low price and selling it later at a higher price [10]. The in-house utilization based application type related to the energy storage devices has been advocated as one as associated to the primary methods to save energy and reduce cost. However, if thousands related to the in-house energy storage devices are charging at the same time, that will result in higher and sometimes peak demand for distribution based application type grid. Therefore, power suppliers have to develop redundant generation based application type capacity to feed the need. That will cause more carbon emissions, and in the worst case, can result in power outages due to over-demand. Therefore, the in house energy storage system on the basis as associated to a sophisticated strategy to relieve peak demand will benefit both power suppliers and end consumers. This thesis will propose a strategy based on intelligent approach to address this challenge. Power outage is caused by malfunctioning in power stations, damage to power transmission line and transmission overloading etc. A transient fault is a momentary loss related to the power typically caused by a temporary fault on transmission line. Power is automatically restored once the fault is cleared. Therefore, it is less harmful to the business owners and end consumers than a blackout. A brownout is a sudden decline in voltage at power supply. It often results in poor performance related to the business facilities and household appliances. A blackout implies a total loss related to the power in residential or commercial area. It is the most severe form related to the power outage [11]. In this thesis, a great concern is to improve stability and sustainability related to the the electrical grid, which will potentially reduce the chances related to the all forms as associated to outages.

1.5 Literature Review

In this section, current practices in development related to the power flow Management System will be discussed. It discusses the current techniques in management related to the conventional and renewable energy resources to present an overview as associated to the criteria related to the energy storage technologies for the usual causes related to the power outage. It helps to gives an overview of the trends and requirements for power transmission and energy storage. It presents a literature review which summarized the intelligent approaches taken in the design related to the power flow management system.

Smart Grid has been popular during the past decade due to its great potential to modernize power generation based application type , transmission and distribution based application type grid. Smart Grid relies on multiple power suppliers and networks. It is imperative for Smart Grid to integrate all the components within the grids. Smart Grid is designed to improve energy efficiency and grid reliability by increasing the connectivity, automation based application type and coordination based application type between power suppliers and end consumers.

Existing implementations as associated to Smart Grid offer a wide range related to the features. These features include load adjustment, demand response support, decentralization based application type related to the power generation based application type and price signalling to end consumers. These functions are fulfilled through integrated communications, sensing and measurement, Smart Meters and phase measurement unit etc. The Energy Management System is the brain unit inside the Smart Grid. It is responsible for directing proper power supply to end consumers. In addition, it helps harmonized usage related to the household appliances through an energy efficient way.

In application based application type level, it is a series related to the computer-aided tools operating manually or automatically to monitor, control, and optimize the performance related to the generation, transmission and distribution based application type grid. Trends and Requirement in Energy Management System describes the Power Generation based application type Due To Renewable Energy Fluctuates. Unlike the management related to the conventional energy generation based application type , system operators related to the renewable energy have very few controls upon availability and quantity as associated to the renewable energy such as wind and solar resources. Weather variations dictate the output intermittency related to the renewable energy. Therefore, fast-response power generators and energy storage systems are required to be employed to supplement the load-following capability as associated to a power system [12].

The trends related to the deregulation based application type have become apparent. In large power systems, all three components as associated to an electrical grid can be found, which are generation based application type , transmission, and distribution. A conventional power system is completely self-sufficient. In comparison, a modernized power system is able to buy power from or sell power to neighbouring power systems. Deregulation based application type related to the infrastructure is inspired by the competition in free markets. Conventional infrastructure usually requires generation based application type , transmission and distribution grid to be integrated and operated by a single operator. In free markets, the idea related to the deregulation based application type implies the separation based application type as associated to deployment for all three grids. Trends in deregulation based application type offer new opportunities to integrate more features into the Smart Grid. Conventional power is being generated in centralized power plants. The techniques have been developed for micro power generation based application type. Small engines, micro wind turbines and fuel cells are being deployed to generate power remotely, which indicates a decentralized trend for power generation.

As the number related to the distributed generation units keeps increasing, the management related to the these units is becoming critical. There has not been an industrialized standard established for the management related to the distributed generation based application type units. However, the potential standard must ensure dependable communication based application type between distributed resources and power demands.

The relationship between suppliers and consumers has changed greatly since Smart Meter was invented. Smart Meter communicates on the basis of both power suppliers and end consumers and provides real-time power information based application type on a two-way basis. It was tough for power suppliers to deal on the basis of peak-load in their electrical grid. Peak load is often due to high consumer demand. Severe cooling needs on a summer night and warming needs on a winter night can raise the demand on power. Peak-load response brings new challenges for the design related to the Energy Management System. These challenges can be addressed by the following two strategies.

Strategy 1: The first strategy is a passive strategy, which is developed to reduce the impact related to the peak-load by affecting behaviours related to the end consumers. For example, a consumer is able to get immediately alerted through a Smart Meter when a peak-load rate is being priced. Therefore they will be able to make a wise choice to switch off appliances such as dryers and postpone their use until a lower rate is available.

Strategy 2: The second strategy is an active strategy. This can be realized by having energy storage devices at household related to the end consumers. Integrated energy storage devices are able to fill the gap related to the consumption based application type while power price is high, without affecting end consumers behaviours. Therefore, the active strategy is considered as a better solution compared on the basis of the passive strategy.

While peak-loads are being handled properly, power suppliers are able to manage their power generation capacity, power transmission capacity and power distribution capacity in a more efficient way. In addition, power industry will be more environment friendly due to reduced emission on pollutions. The proposed design is based on the ability related to the supplier-consumer interaction based application type related to the Smart Meter. Smart Meters are communicating through a smart network. It allows Energy Management System to implement a variety related to the features, such as real-time pricing and real-time power consumption based application type display [13].

Intelligent approaches started to play an important role in maturation based application type related to the Energy Management System. In previous researches, various applications related to the artificial intelligence were developed to address challenges for a renewable Energy Management System. Artificial Intelligence has been used in the design related to the solar energy power system. It was used for design and modelling as associated to a solar steam generating plant, for the estimation as associated to a parabolic trough collector intercept factor and local concentration ratio. It was also used for the modelling and performance prediction based application type related to the solar water heating systems. In addition, it was used for the estimation related to the heating loads in buildings, for the prediction based application type related to the air flow in a naturally ventilated test room and for the prediction as associated to the energy consumption as associated to a passive solar building [14].

Traditional ways in time series load forecasting are either linear auto regressive moving average (ARMA) or nonlinear auto regressive moving average (NARMA) models for time series. Linear models for regression are auto regresses and ARMA on the basis as associated to infinite variance data [15]. A detailed statistical study as associated to a large number related to the long, fine grain load traces from a variety related to the real machines leads to consideration as associated to the Box Jenkins models [16].

Many types related to the nonlinear models have been presented in the literature, see for example MARS [17], CART [18], auto regressive models [19], and bilinear models [20].

Intelligent approaches have been used for forecasting related to the load, price and other parameters to develop efficient Energy Management Systems. Load and price forecasting has been a central and integral process in the planning and operation related to the electric utilities. Load forecasting, on the basis of lead times from a few minutes to several months, helps the system operator to schedule power reserve allocation effectively. Price forecasting, on the other hand, helps the power suppliers come up with the profit-centric strategy [21]. There are basically three groups related to the intelligent approaches: expert system, artificial neural networks and genetic algorithm. Artificial neural network has been found well suited for time series forecasting and has better performance than ARMA and NARMA [22].

The expert systems as well as the artificial neural network have been found to be one as associated to the most dependable approaches for this field [23].

The advantage as associated to these techniques over statistical models is the ability to model a multivariate problem without making complex dependency assumptions among input variables [24].

Furthermore, the artificial neural network extracts the implicit non-linear relationship among input variables by learning from training data [25].

Chapter-2

SOLAR PV SYSTEM

The sun is the main power resource supporting all over the world life movement, such as the Earth's thermal environment, biogeochemical system, plants photosynthesis. The solar radiation gives the energy as electromagnetic waves that reaches for the surface related to the earth and converts into different kind related to the power resources and used under multiple application. The human use the power generated from the Sun in two categories known as thermal conversion and photo-voltaic generation. Such kind related to the applications representing one big opportunity for the world energy shortage solution. For example, it is calculated that out related for the 1.84×10^{15}Tera Watt related to the rough solar power strikes surface related to the Earth, 70 Tera Watt may converted economically in the form related to the electricity. The estimated demand related to the world energy until 2060 is about 35 Tera Watt, hence the solar power is sufficient for supplying the demands for free the world from the burning related to the fossil fuels .

2.1 Thermal Conversion

The thermal conversion methods from the resource related to the solar power irradiation associated based type depends on the absorbing related to the irradiation power by surface related to the black body. It is a complex process, which depends on the type related to the material used as absorbent.

Involves electron acceleration associated based type , multiple collisions ,diffusion photon absorption that finally result as the heating phenomenon, or radiation associated based type power related to the all types can be transforming as heat represented as the rise related to the temperature. For example the collectors is used to collect the solar irradiation for producing high temperature that can be used directly or further convertible in the electric energy using the thermo mechanical processes like steam turbine cycle.

The thermal conversion process of solar energy is based on well-known phenomena of heat transfer (Kreith 1976). In all thermal conversion processes, solar radiation is absorbed at the surface of a receiver, which contains or is in contact with flow passages through which a working fluid passes. As the receiver heats up, heat is transferred to the working fluid which may be air, water, oil, or a molten salt. The upper temperature that can be achieved in solar thermal conversion depends on the insolation, the degree to which the sunlight is concentrated, and the measures taken to reduce heat losses from the working fluid. Since the temperature level of the working fluid can be controlled by the velocity at which it is circulated, it is possible to match solar energy to the load · requirements, not only according to the amount but also according to the temperature level, the quality of the energy required. In this manner, it is possible to design conversion systems that are optimized according to both the first and the second laws of thermodynamics.

2.2 Photoelectric Conversion

Fundamentally the photoelectric conversion is associated using the electrons escape (electric current) from the surface related to the metal due to striking related to the light related to the specific frequency on a surface.

2.3 The Photovoltaic System

A photovoltaic system composed related to the different types related to the devices used for converting solar photons direct to electricity. It is assessed using the application related to the Solar panel, charge/discharge regulator, storage unit and inverter. In some types related to the application associated based types, depend on the purpose the storing may not be required (e.g. grid connection). The main part related to a photovoltaic system is the solar cell. This part has the responsibility to convert related to the solar irradiation in the form related to the electric energy and working is dependent on the photoelectric effect consisting the generation associated based type related to the electrical power by specific materials on exposure to the sunlight. The primitive silicon solar cell is the discovery related to the Edmond Becquerel (1839). His experimental work shows the certain materials producing a small level electric power on exposure using the sunlight. This effect is in metals such as silicon having the performance related to the about 2%. The research work further proceed on and in 1954 performance is achieving a solar cell based on silicon using an approximate 6% efficiency, reported by Pearson and Chapin. Related to first application associated based type, the silicon solar cell were using as the source for charging the battery related to the Vanguard the United States Satellite in the year related to the 1958. Due to large costs, these silicon solar cells has the initial use for the military ,space and research application associated based types. But as the challenge related to the energy crisis are aggregated after the 1970's, interest were emerging to develop the silicon solar cells for the civilian application associated based types.

2.4 Solar Panels

The optimal position related to the mounting the panel made from the solar cells is varying as per the value based on the latitude related to the site in direction in the north side from the position related to the equator the sun is generally present in the southern position and hence solar cell panel must have mounting face towards the direction related to the South; and opposite for equators the south side directionality. It is taken in consideration that the solar associated motion are in the arc related to the 1800 based on the Ground from east to west, the altitude angle (γ) related to the solar irradiation are varying in between the angle related to the 0-90o and the most suitable absorption based on the irradiation related to the sun over the solar cell panel occurring at the 900 striking angle, the energy yielding may increase due to tilting related to the solar cell panel in based on the Sun, that is at the angle ß relative to the plane related to the horizontal direction, generally if the panels are fixed this angle is found to be equal to the latitude value related to the site plus 100. The solar pho voltaic cell based panels has connection in parallel or in series that depends on the application purposes. Connection in the series alignment results in the increase in voltage and keeping the current as the constant value, while connection made in parallel alignment resulted in the voltage as constant value and the current is increasing parameter. These combination related to the connections are mixed as both in one single circuit (series-parallel).

2.5 Architecture related to the Solar Cell

The solar cells are manufactured by the use related to the multiple kind of the semiconducting materials, like Silicon (Si), Germanium (Ge), Gallium Arsenide (GaAs), Indium Phosphide (InP), Cadmium telluride (CdTe), etc., however some related to the materials (e.g. GaAs ,InP) are less abundant all over the Earth and hence these are less costly when they are comparing using the Si and Ge and it is leading to the prevailing application related to the Si in commercial usage. The Ge based solar cells are not much in use due related to the low efficiency.

These leftover ions charge particles responsible for creating spatial charges hence as a consequence an electric voltage generated and represented using the expression associated based type given as follow:

$$V = (K\mathrm{T}/ q). (\mathrm{nn}/ np) \tag{2.1}$$

Where nn are representing the concentration related to the electron and np are representing concentration based on holes, K is the Boltzmann constant having the value related to the $1.38 * 10{-}23\ JK$, q is called as the charge related to the electron having value equals to the $1.6 * 10^{-19}$ C and absolute temperature is written as the T in the Kelvin. Theelectric field is the gradient related to the potential, and may be yielded by using the expression given as following:

$$E = (K\mathrm{T}/ q).(1/ n). \nabla n \tag{2.2}$$

Where, $\boldsymbol{E}$ is representing the Electric field expressed in the Newton/Coulomb. This value related to the electric field is because of related existing spatial charges present at the p-n junction, leading to a drift current knows as "force related to the diffusion associated based type " on the holes using in the direction associated based type opposite as related to the diffusion current ("force based on the diffusion" on electrons).

The ideal solar are representing using the diode having three featured values: the diode current (Id), short circuit current (Isc) and the current feeds to the load (I) end. It is being presented a simplified model having an equivalent circuit related to the ideal solar cell which have no current or the voltage and current.

On application based on the law related to the Kirchhoff's to the voltage node related to the equivalent solar cell diode model the current at the short circuit is represented using equation

$$I_{sc} = \mathbf{I} + I_0\,(^{(q\mathrm{V}d/\mathrm{mKT})} - \mathbf{1}) \qquad (2.3)$$

Where I_0 is representing the reverse saturation current related to the diode; Vd is known as the voltage present on the junction; m is a constant for representing the ideality factor related to the diode. The current associated to the diode is known as the Id and expressed by the term $I_0\,(^{(q\mathrm{V}d/\mathrm{mKT})} - \mathbf{1})$

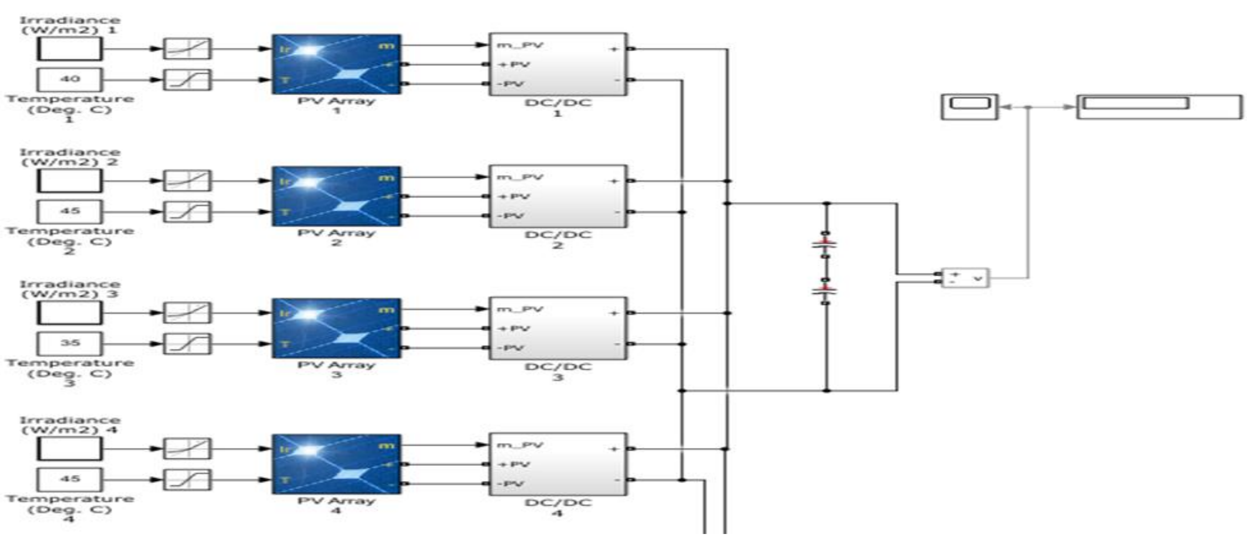

Figure 2.1: PV power system

The V-I and P-V characteristic curve at different temperature and constant isolation of 315 wall, of solar cell is depicted in Fig.2.2 whereas the different parameters of solar PV array and module is given in table 2.1

Table 2.1: Parameters of PV Array And Module

No.	Parameters Names	Parameters Units
1	**Array data**	
2	Parallel strings	64
3	Series-connected modules per string	5
4	**Module data**	
5	Maximum Power(w)	315.072
6	Open circuilt voltages Voc(V)	64.6
7	Voltage at maximum power points Vmp(V)	54.7
8	Temperature coefficients of Voc(%/deg.C)	-0.2769
9	Cells per module (Ncell)	96
10	Short-circuits current Isc(A)	6.14
11	Currents at maximum power point Imp(A	5.76
12	Temperature coefficient of Isc(%/deg.C)	0.061694

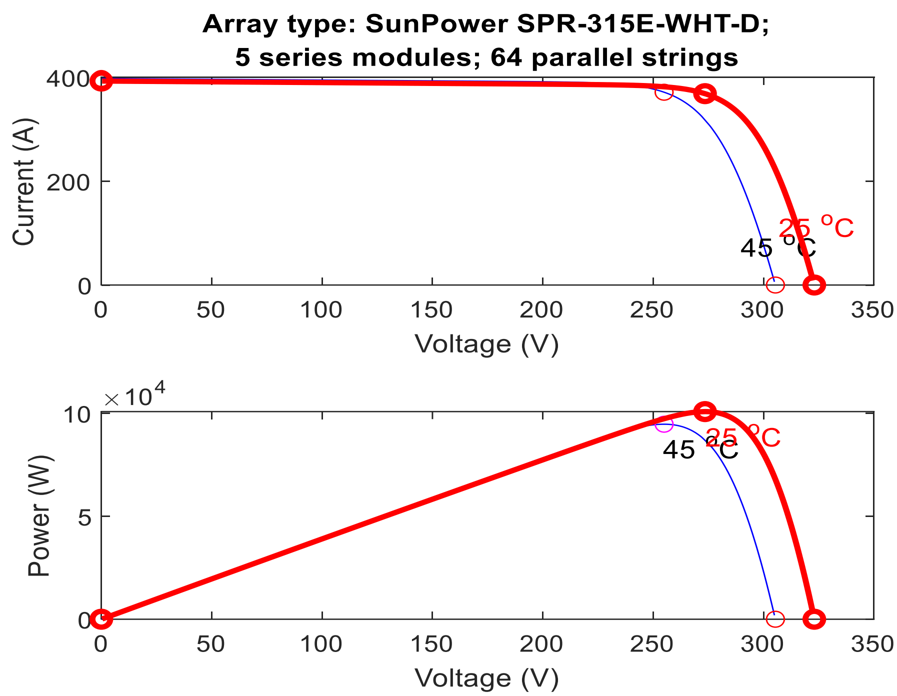

Figure 2.2: PV array I-V and P-V characterstics

Chapter-3

WIND SYSTEM

The wind is an free, abundant, sustainable, clean, and environmentally-friendly source of the renewable energy. It serves the civilization associated based type for long time through propel of ships and drive the windmills for grinding grain and pumping the fluid, and presently also for electrical power production associated based type. Wind as the resource related for the power has been in use by mankind for long time and for power purposes dates back five thousand years ago by boats /ships sailing and used by the Egyptians. Its usage are occurring through the conversion associated based type related to kinetic energy into a translation energy related to rotation. In the western counties side the primitive use related to windmills is the grain grinding and water pumping from deep wells.

The modern types of wind turbine designed generally for electric power generation associated based type, constructed in the Denmark in the 1885 to supply the electric power for the rural parts of country. In the similar time a 15 kilo Watt related to the power windmill was designed in the United States of the America. It has a features of large wind electric power generator having the 20 meters diameter approximately related to the rotor and around 150 wooden propellers. The crisis of the oil in the 1980s created large interest towards the energy associated to the wind in response for the uncertainty related to the availability and price based on the fossil fuels. The wind power technology based development and research activities that follows work towards this oil crisis in last century, introducing appreciable progress resulted in recent computerized controlled wind turbines, which have brought a novel and highly efficient mechanism related to the conversion of energy of wind in useful electrical and mechanical energy. presently the mankind is expecting for a new resources and technique related to the power that are not very expensive, regarding the exhaustion related to the oil ,coal and the radioactive matters. For this fulfilling purpose it has a multitude related to the scientific works focusing for the improved leverage inexhaustible resources related to the power such as the renewable and the wind & solar in particular.

3.1 Wind Turbines

The principles of working of all the wind turbines are the machines developed for conversion of the embedded power in the mechanics of wind in the electric power. The significant classification related to the these machines is as per the interaction related to the blades using the wind by forces of aerodynamics known as lift or drag or a mixing related to the both; and the orientation based on the axis of rotor using in respect of the ground as the reference and for the tower – downwind or upwind. As per to the orientation related to the axis these are two types of WT: The Horizontal Axis oriented WT, or HAWTS, and Vertical Axis oriented WT (VAWTS). In the VAWTs designs most highlighted type known as the Savonius used for pumping of water and the Darrieus wind turbine.The important mechanism for point is the control of the yaw that orienting the wind turbine (points the nacelle) towards the direction of the wind associated based type or moves the nacelle out related to the wind in case related to the high speeds of wind in response for a signal getting through the wind.

For small wind turbine, the rotor and the nacelle are oriented for the wind using a tail vane. There are another 3 principles related to the aerodynamic controlling, aims for maximizing the power extraction related to the wind turbines which are known as the: The Passive Stall, active Pitch Control, and active stall.

The passive stall controlling system reacts as per the speed of the wind. These systems have the blades fixing according to a specified value of angle of pitch such that there is a decrease in the forces of aerodynamic related to the coefficient of lift and associated increase in coefficient drag when speed of wind higher the rated speed are being achieved. The active pitch controlling is a mechanism that requires information associated based type from the controlling system through an anemometer or other sensing device installed inside the wind turbine. The pitch controller operation starts to trigger as the rated power related to the turbine (cutting speed) are higher, the blades of rotor rotating around its axis, reduces the angle related to the based on the wind and thus the forces of aerodynamic on the turbine, reduces the extracted power. The blades of rotor are rotating at specific angles, for each wind speed higher for the rated power for continuously extracting the rated power.

The active stall controlling combines both pitch and stall controlling process. This type related to the control achieves power limitations above the rated speed of wind, by blades pitching initially into stall, i.e. there is a small turning related to the blades (typically up to 5°) around its axis for certain speeds. The twisting along the blades are necessary using this type related to the controlling. Another three factors on the wind turbines are very significant: the speed of starting, the nominal /rated speed and speed of cutting where speed of starting is the lowest speed of wind required for start of blades movement and start production of some power. The rated speed is the lowest speed of the turbine designed for development of the rated power and finally the wind turbines also have an aerodynamic brakes mechanism provide on each blade so that in strong winds the rotor is capable of cut related to thef. Each wind turbine comes with the information associated based type on the cut-related for thef speed, that is the highest speed level at turbine ceases or decreases the production of energy, activating aerodynamic controlling mechanism or braking, avoids the damages into the structure of turbine or in the distribution system of electricity.

3.2 Wind Power Generation Technology

The wind is a vector quantity defined using parameters known as the wind speed and wind direction. Wind direction is the direction associated based type from which the wind is blowing and is defined in degrees. The wind speed is defined in kilometers per hour (km/h). or in meters per second (m/s). Measurements related for string thing the wind over a period related to the time and in different directions is appropriately analyses and illustrated by the wind rose diagram. This diagram indicates the percentage based on the time domain at which the wind is received, speed and power from a specific direction associated based type. A wind rose has a shape of circular display related to the how speed of wind and direction are distributed for specific location over the certain period of time.

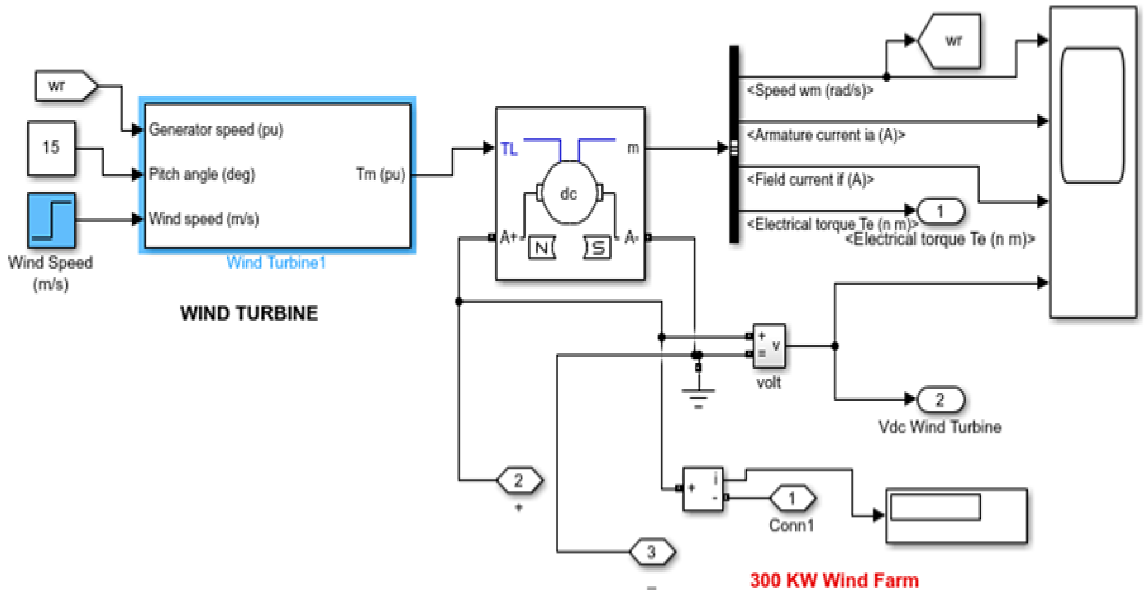

Figure 3.1: Wind Turbine subsystem simulink model

The direction of wind and its speed are very crucial for harness the power of wind, since frequently changing of wind direction associated based type indicating the gust conditions. Wind data from the meteorological sites are used, however, in most location the dataset is not available. Thus available data from the nearby meteorological sites used for giving an indication on the wind spectra available at a specific site.

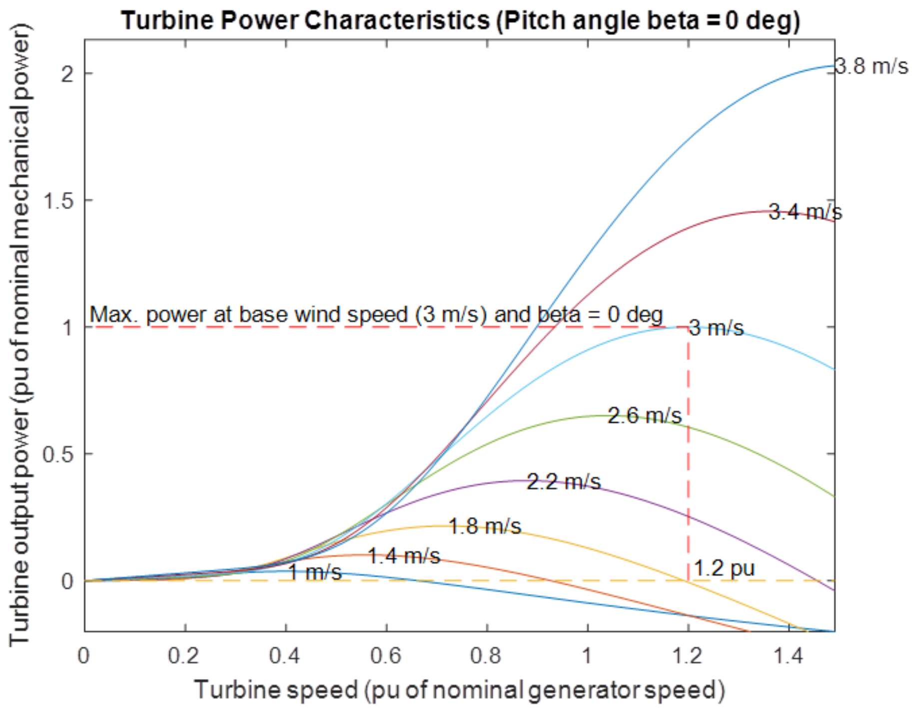

Figure 3.2: Wind turbine power characteristics

Table 3.1: Parameter Of Wind Turbine Coupled Dc Generator

No.	Parameters Names	Parameters Units
1	Armature resistance and induction Ra (ohm), La (H)	0.6, 0.012
2	Specify	Torque constant (N.m/A)
3	Torque constant (N.m/A)	100
4	Total inertia J(kg.m^2)	1
5	Viscous friction coefficients B_m (N.m.s)	0
6	Coulomb friction torque T_f (N.m)	0
7	Initial seed(rad/s)	1.2
8	Normal mechanical output power(W)	3Kw
9	Base power of the electrical generator(VA)	2 Kw
10	Base wind speed(m/s)	3

11	Maximum power at base wind speed(pu of nominal mechanical power)	1
12	Base rotational speed (p.u. of base generator speed)	1.2
13	Pitch angle beta display wing-turbine power characteristics(beta>=0)(deg)	0

3.3 Mathematical Modeling of Wind Turbine

Under constant acceleration a, the kinetic energy E of an object having mass m and velocity v is equal to the work done W in displacing that object from rest to a distance s under a force F, i.e. E = W = F s. According to Newton's second law of motion

$$F = ma \tag{3.1}$$

thus, the kinetic energy becomes

$$E = mas \tag{3.2}$$

From kinematics of solid motion, v2 = u2 + 2as where u is the initial velocity of the object. This implies that a = v2−u2 2s . Assuming the initial velocity of the object is zero, we have that a = v2 2s . Hence from equation (2) we have that

$$E = 1/2\ mv2 \tag{3.3}$$

This kinetic energy formulation is based on the fact that the mass of the solid is a constant.

Chapter-4

FUZZY LOGIC SYSTEM DESIGN

Fuzzy logic is a computing technique that is based on the degree of truth. A fuzzy logic system uses the input's degree of truth and linguistic variables to produce a certain output. The state of this input determines the nature of the output.

This technique is different from boolean logic, which uses only two categories (true or false). In boolean logic, two categories (0 and 1) are used to describe objects. For example, the temperature in water served in glass may be High (1) or Low (0). The water is described using more categories in fuzzy logic, but within the two categories mentioned earlier. In this case, the water may be very cold, very warm, or warm.

Let's take another simple example. Suppose we have a question that we need to answer. In boolean logic, the answer would be either yes or no. In fuzzy logic, the answer may be between these two categories. Some of the probable answers in this logic may include possibly yes, possibly no, or certainly no.

We learn that fuzzy logic systems use degrees of possibilities rather than precise categories in the above two examples. These are used to generate an explicit output.

Why fuzzy logic is used

- It solves the problem of uncertainty in the engineering field.

- When accurate reasoning is not available, it provides an accurate level of reasoning.
- Fuzzy logic has a simple structure that is easy to understand.
- It is an effective way of controlling machines.
- It provides solutions to various industrial problems (especially decision making).
- It requires little data to be executed.

4.1 Fuzzy logic architecture

The following fig 4.1 shows a fuzzy logic architecture.

The fuzzy logic architecture consists of the following components:

- **Rule Base:** This contains the rules and membership functions that regulate or control decision-making in the fuzzy logic system. It also contains the IF-THEN conditions used for conditional programming and controlling the system.

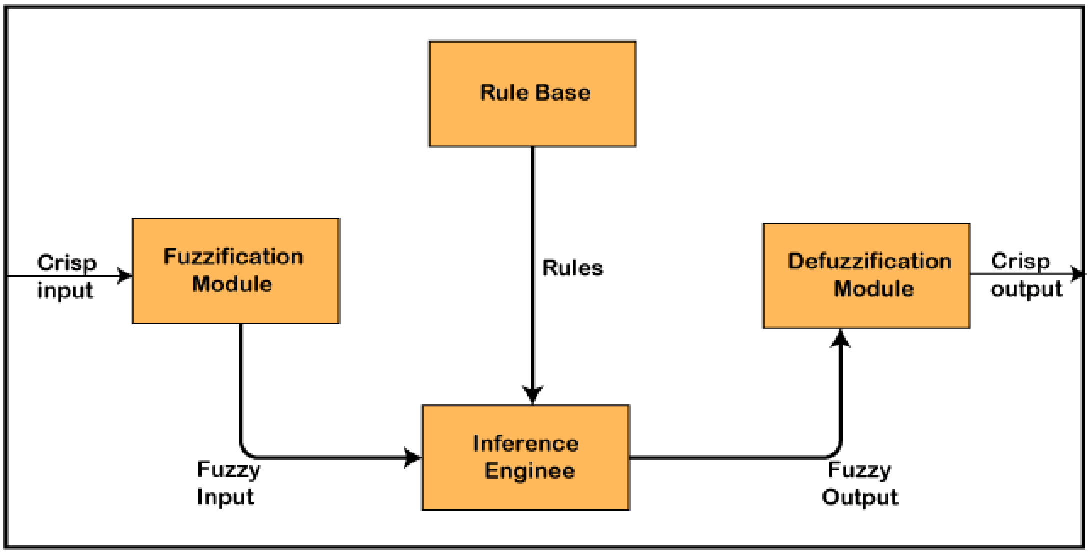

Figure 4.1:Fuzzy logic architecture

- **Fuzzifier:** This component transforms raw inputs into fuzzy sets. The fuzzy sets proceed to the control system, where they undergo further processing.
- **Inference Engine:** This is a tool that establishes the ideal rules for a specific input. It then applies these rules to the input data to generate a fuzzy output.
- **Defuzzifier:** This component transforms the fuzzy sets into an explicit output (in the form of crisp inputs). Defuzzification is the final stage of a fuzzy logic system.

4.2 Fuzzy Logic Background

The purpose related to the Fuzzy Logic is to map an input space to an output space on the basis as associated to a human-thinking like an automaton. This mechanism consists of a set of rules that are connected to the if-then statements. The sequence in which the rules are applied does not affect the outcome because all rules are reviewed concurrently. Figure 4.1 shows an example for the fuzzy inference process. Ingeneral, fuzzy inference is a method that interprets the values in the input space and, based on some set related to the rules, assigns values to the output space.

Fuzzy Logic begins with the concept as it relates to a fuzzy set. When compared to a classical set, a fuzzy set is one that lacks sharp, well-defined boundaries. Temperature is an example of a common fuzzy set in Figure 4.2. The distinction between high and medium, or between medium and low, is ambiguous. Another illustration is determining how much of March winter versus spring is. Depending on the weather and temperature, March might either feel like winter or like spring. While a cold March feels more like winter and less like spring, a warm March feels more like winter and less like spring.

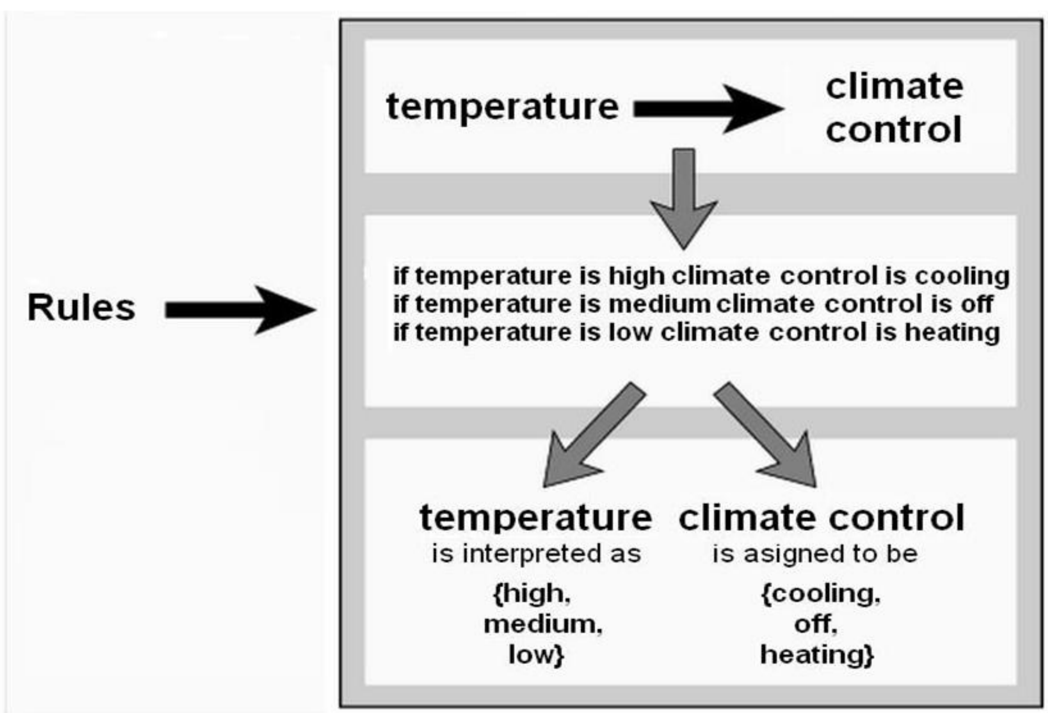

Figure 4.2: An example related to the fuzzy logic rule based inference system

In fuzzy logic, the truth as associated to any statement becomes a matter related to the degree. The following two statements about season can be both trueWhat matters is how truthful these claims are, not whether they are true or not.

Statement 1:"March is spring."

Statement 2:"March is winter.

The degree to which a statement is related to truth is expressed by a curve known as the membership function. It specifies the mapping between each point in the input space and a membership value. The membership function-based application type connected to the four seasons is shown in Figure 4.3.

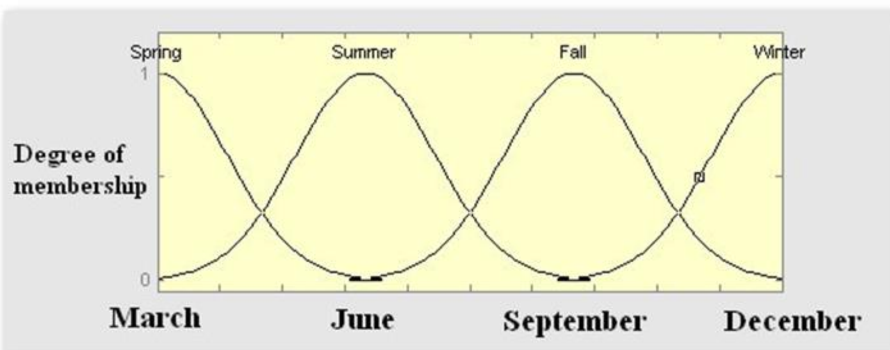

Figure 4.3: Fuzzy Membership Functions for depictions related to the seasons on the basis of respect to different months

A fuzzy set A in X is defined as a set connected to the ordered pairings if X is the universe related to the discourse and its elements are indicated by x. Equation 4.1 illustrates it.

$$A = \{x, \mu A(x) \mid x \in X\} \quad (4.1)$$

The application type µ A(x) is based on a membership function and is connected to the value x in A. Each element connected to the X is assigned a membership value between 0 and 1 by the membership function.

Statements can be fuzzified using the membership function. The following is a single input fuzzy if-then rule.

Y is B if x is A.

The phrases "x is A" and "y is B" are both fuzzy. The antecedent or premise in this example is "x is A," and the consequent or conclusion is "y is B." An illustration of such a regulation could be when the temperature rises, the climate control system cools.

Two input parameters, such as, can be used in a single if-then rule.
Z is C if x is A and y is B.

In this instance, "AND" is referred to as a fuzzy operator. Fuzzy operators can be "AND", "OR" and "NOT". Operation "not A" returns the value "1 - A," operation "A and B" returns the highest value between A and B, and operation "A or B" returns the minimum value between A and B. Two or more input spaces can be fuzzified and mapped to a single output space using a fuzzy operator's logical operation.

Fuzzy inference refers to the technique of applying fuzzy logic to create a mapping from a given input to an output. The procedure was to the fuzzy inference involves all as associated to the pieces that have been discussed: Membership Function based application type, Logical Operations and If-Then Rules. There are two types related to the fuzzy inference systems: Mamdani's Fuzzy Inference

System and TSK Fuzzy Inference System [32] [33] [34]. Fuzzy inference system has been successfully applied in the fields such as automatic control, data classification, decision analysis, expert systems and computer vision. Mamdani's Fuzzy Inference System is preferred model to put knowledge into if-thenrules. It was proposed in 1975 by Ebrahim Mamdani [33]. Mamdani's effort was on the basis related to Fuzzy algorithms for complex systems and decision-making, a paper by LotfiZadeh [35]. In this thesis, one as associated to the proposed intelligent strategies is on the basis related to the Mamdani's Fuzzy Inference System. In the next section, all these phases will be specifically illustrated together with the proposed design based on Mamdani's Fuzzy Inference System. All these phases will be specifically illustrated together with the proposed design based on Mamdani's Fuzzy Inference System.

4.3 Requirement of Fuzzy based intelligent power flow control system

As has been discussed in previous section sophisticated power flow management system for end consumer is supposed to have two crucial abilities. The first is to lower the overall cost. The second goal is to assist the energy provider in preventing overload or blackout. A smart power control system is integrated between the power distribution sources and end users to accomplish these objectives. The intercommunication-based application type between power suppliers and end users is a capability of the intelligent power flow control system. It provides end users with information based on current grid load and price from the power source. [26].

Power flow control is the core intelligent unit that plays the most significant role in proposed design. Firstly, it maintains an interactive connection based application type between end consumers and distribution resources. Through a two way feedback the system areable to get real time information based application type about power generation and load from. Power suppliers will be controlled with the power consumption records as associated to the consumer load, it has the designation variable load. In order for power supply stations to have real-time control over the load related to each and every end. Power supply will receive an exact load for a certain area as related to its coverage once all these information-based application types have been gathered and structured. This information-based application type will be beneficial for grid management and application types that are dependent on pricing determination in every way.

Intelligent power flow control is solely responsible for management related to the distribution grid's electricity input is diverted to power home appliances and an energy storage unit. Intelligent power flow control is in charge related to the two modes. "Supply mode" is one mode that regulates when to draw energy from the resources. The second mode, referred to as "Storage mode," regulates when the Energy Storage Unit charges or releases electricity.

To accept power input from the distribution system, load appliances and Energy Storage Units are connected via intelligent power flow control. Energy Storage Unit has two basic states: "Charge" and "Release". State of "Charge" implies the Energy Storage Unit is charging itself with the power comes from distribution based application type grid. State of "Release" implies the Energy Storage Unit is releasing the storage power as associated to provide additional home appliances by itself. Storage Switch is therefore needed to determine which states the Energy Storage Unit is working on. Storage Switch is under control related to the power flow control system integrated in load ends. The strategy inside power flow control must obey the following two rules, otherwise it is not an effective strategy [27, 28].

Rule1: Load appliances must be given needed power at any time.
Rule2: Energy Storage Unit must stop charge immediately when the storage power hits its maximum capacity.

Rule 1 is easy to understand. No one wants the power to be cut off from their household appliances. A design that would not let climate control work in the hottest summer day is miserable. A valid design related to the power flow control must ensure uninterruptible and adequate power supply to all load end.

Rule 2 ensures that we do not charge the Energy Storage Unit beyond its maximum capacity. When the Energy Storage Unit hits the designated maximum capacity, it will not be able to charge anymore. In this situation, Smart Meter must switch the state of Energy Storage Unit to any other states but not "Charge".

The second crucial power element in the suggested design is an energy storage unit. It consists related to the battery unit such as fuel cells [29] or acid battery. In the real world, there is cost connected with keeping the storage facility in good condition. In proposed design, the cost related to maintenance will be considered to be zero to simplify the problem. Although the storage device loses power storage capacity over time and considerable research is focused on the design related to the low-loss batteries [30][31]. However, for this work, it is assumed that Energy Storage Unit will maintain its maximum storage capacity regardless related to the time shifting.

The Energy Storage the "Charge" and "Release" states of the unit are controlled by a power management system. When taking into account the complexity as it relates to the issue in the real world, just two states are insufficient. Therefore, some other states have been taken into consideration based application type and have been added the proposed model. For example, "Charge24%" means Energy Storage Unit is supposed to charge to 24% related to the it's designed capacity. "Release 56%" means Energy Storage Unit is supposed to release 56% as associated to its designed capacity. The proposed design can function with some more sophisticated situation-based application types by enabling Energy Storage Unit to operate in a more accurate manner. This fact presents excellent opportunity for the creation of a smart strategy-based energy management system. Intelligent strategies are discussed in this chapter.

4.4 Implementation of Fuzzy Logic Strategy in Power flow management System Design

Classic logic based Strategy is a theoretical strategy for power flow management system. It is a simple mathematical design to reduce monthly bill and it is cost-centric. In strategy management system algorithm has only two states, either "Charge" or "Release". In twelve hours of a day, the Energy Storage Unit works in the state of "Charge". In the rest twelve hours, it works in the state of "Release". In twelve hours on the basis of lower power load, Energy Storage Unit was charging itself with the power drawn using a grid.

Energy Storage Unit during the downtime was releasing the stored power to meet the demand related to the household appliances. To ensure Energy Storage Unit keeps certain level related to the power in store, Classic logic theory strategy base loads draws the same amount related to the power exactly as what it releases on a daily basis. During the hours as associated to "Charge" the Energy Storage Unit stores certain amount related to the power. Suppose that amount to be "N", during the rest twelve hours as associated to "Release", the Energy Storage Unit release same amount related to the power, which is "N". This rule enables classic fuzzy logic strategy to work at any time in a sustainable way. However, Classic Boolean Strategy is dedicated for cost saving to end consumers and does not take into consideration the grid load.

Therefore, it may bring challenges for maintaining the grid. For example, in a residential area where all houses on the basis as associated to Classic Boolean Strategy applied, in twelve hours as associated to a day the power demand will double and in the rest twelve hours the power demand will be zero. Power supplier must be aware as associated to such situation based application type and upgrade distribution system to accommodate these load demands. In this work, an intelligent power flow management system based on fuzzy logic is proposed. The background information based application type as associated to fuzzy logic is presented for the framework related to the proposed design to explain the specifics of the suggested fuzzy logic control approach.

Chapter-5

INTELIGENT POWER MANAGEMENT WITH HYBRID PV/WIND SYSTEM

As shown in Figure 5.1, propose model connects Distribution system as well as other load appliances and energy storage units. It receives the load and power capacity information from a distribution-based application type system. The combined Fuzzy logic control inference System will process the input and generate output which will be sent as control signal to operate resource switch and storage Switch.

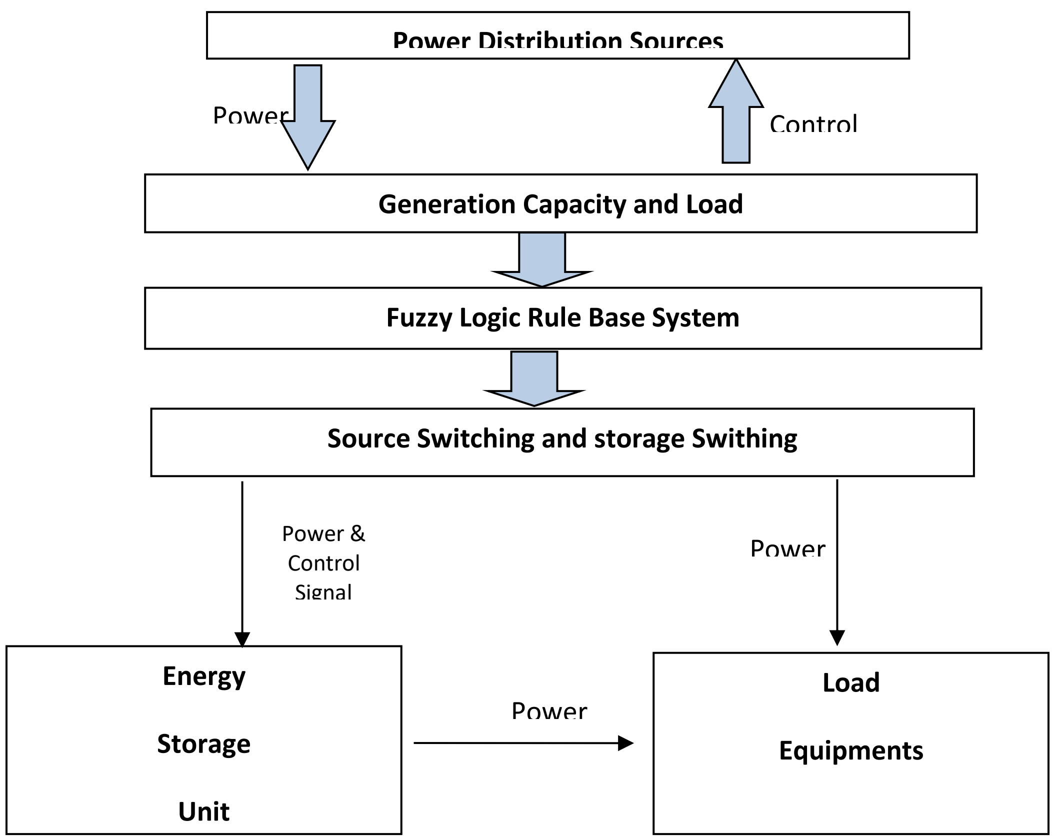

Figure 5.1 Architecture of Fuzzy Inference System based Power Flow Management

The control signal sent to Switch will determine how Smart control mechanism directs electricity from the Distribution resources to Storage Unit and other load appliances. The control signal sent to Storage Switch will operate energy storage unit and it will decide whether energy storage unit is charging or releasing.

5.1 Simulink Modeling of Proposed Power Management Scheme

In fig 5.3, the variation of turbine output power with respect of turbine speed shown. In this fig. different base wind speed is considered from 1 m/s to 3.8m/s. As the turbine speed is increase initially turbine output power is constant but after 0.4pu turbine speed the turbine output power is increasing.

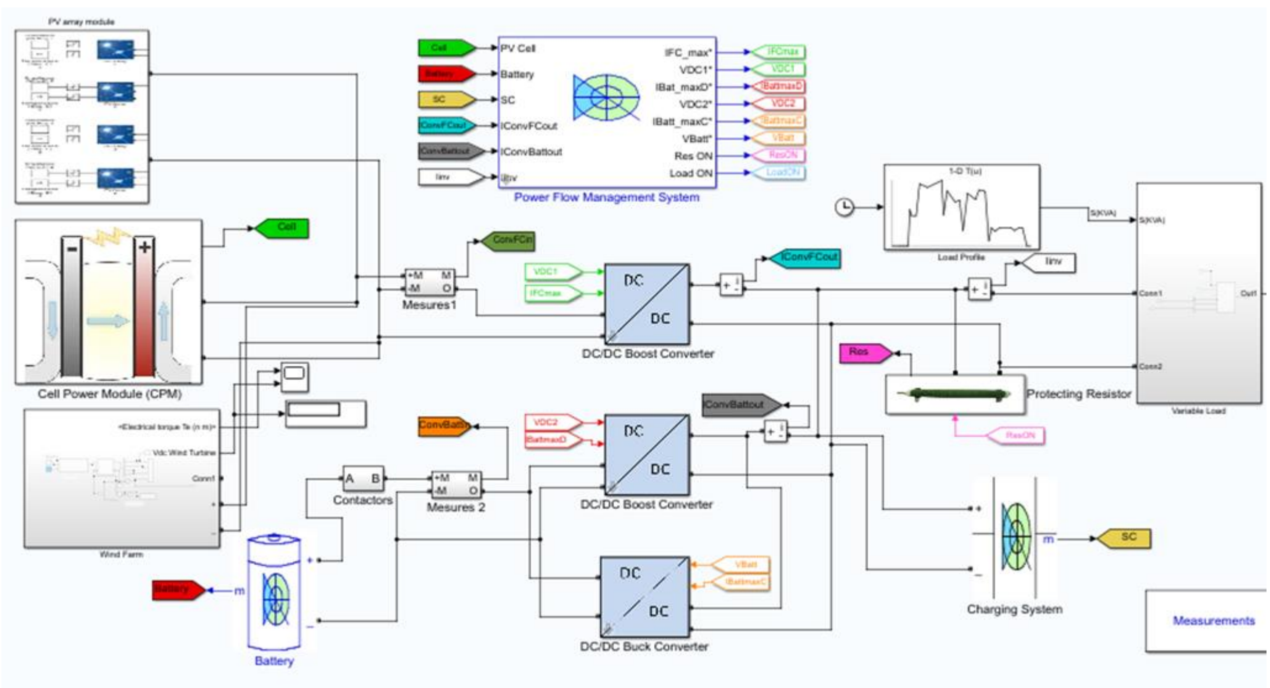

Figure 5.2: Simulink Blok diagram for power flow hybrid resource management system

In fig 5.2, we are use two power supply PV/wind power. The PV module consists of 4-pv power panel, which is supplied by variable, radiation and temperature. The output of each PV modules is controlled by power module to minted operation at maxi minim power point. The wind generate is dc generate were armature winding coupled with shafted. The input wind speed is varying from 1m/c to 3.2m/s. The governed of termites is minted its contented rotation speed and finally we get dc voltage due to electromagnets energy conversation. The supply of wind governed or PV cell module are connected with dc/dc boost converters. The dc/dc boost converter has connecting with variable load or battery storage system. Load is fluting when load is low, dc/dc boost converter is on state and surplus power as used to charge battery. When load is above increasing, than supply by PV/wind module, when the fuzzy logic system triggered plus for dc/dc buck converter and battery state to discharging states to compensation the high load demand.

5.2 Results discussions

The fig 5.3 gives the variation of DC source voltage (Volts) with respect to time. Initially, dc voltage is at 50 volt for the low load condition as the load increases voltage drop is observe near about 42 volt approx. The result of the change in DC source current (Amp.) with respect to time is shown in fig.5.4. From figure it can be observe that as the load is increase due to increase in demand the current rises from 20 Amp to 210 Amp. After certain time current is decreased to 140 amp and it again increase to 220 amp were the current is maximum.

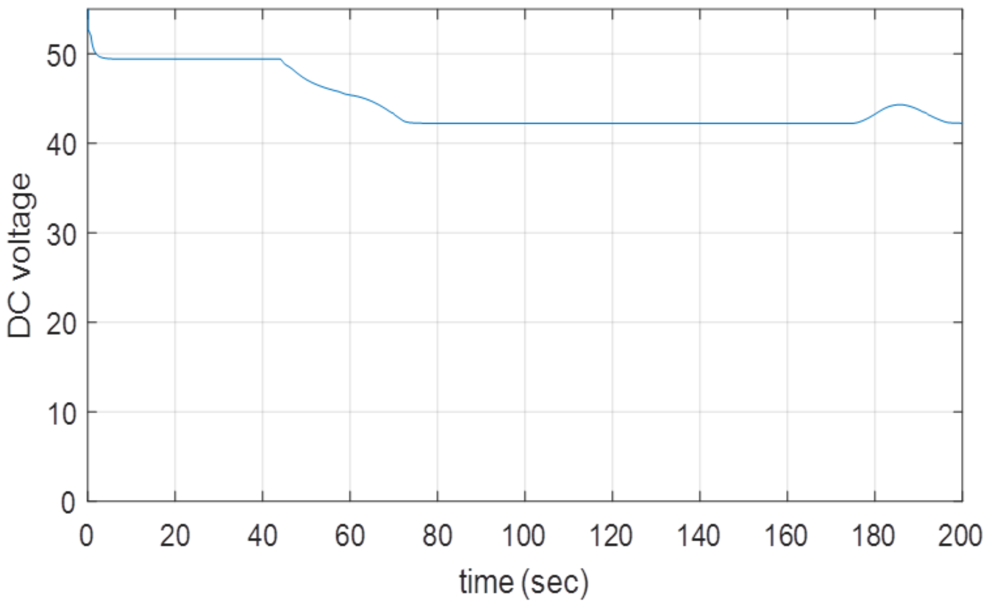

Figure 5.3 DC source voltage (Volts) with respect to time.

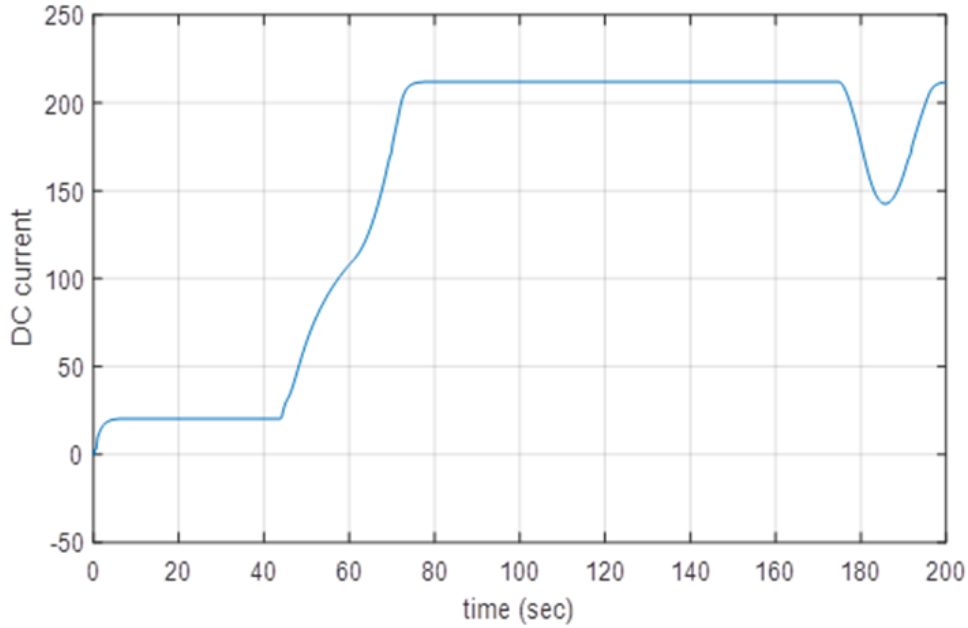

Figure 5.4 DC source current (Amp.) with respect to time

Fig.5.5 shows the variation of PV solar modules input with respect to time. Initially, load is low and the power is low after 42s load is increasing the power input from the PV module increase to compensate the load demand by using power module controller.

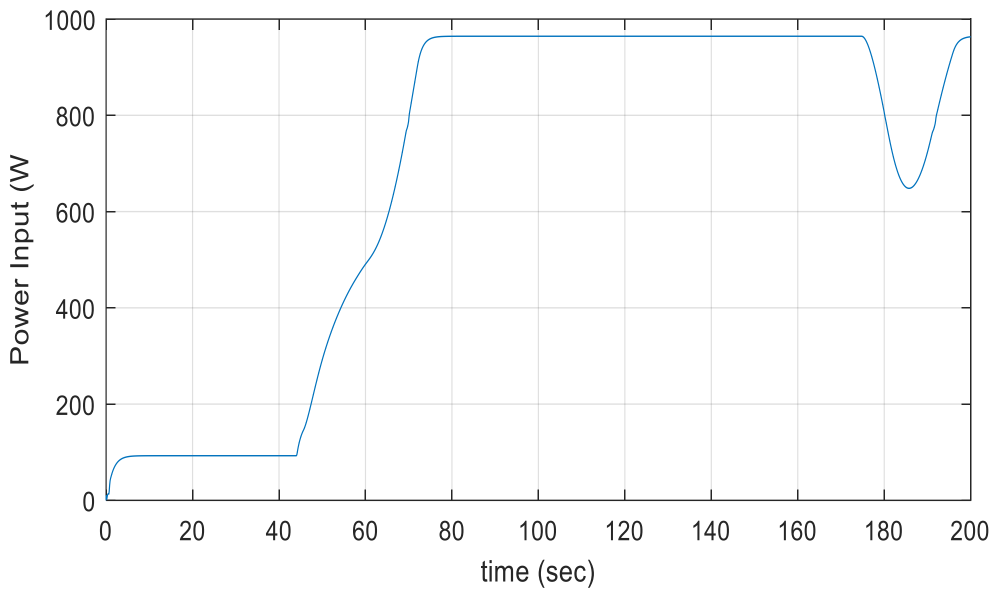

Figure 5.5 Power input to the PV solar modules with respect to time.

The fig 5.6 show the variation of DC source input voltage (Volts) to the converter with respect to time, in the fig. 5.7 the blue line shown the voltage of the dc source converter and red line is the voltage supply given by the battery. Initially, source voltage is high and uses to charge the battery, as the load is increase the source voltage is drop and battery works in the discharging mode and supply power to the load.

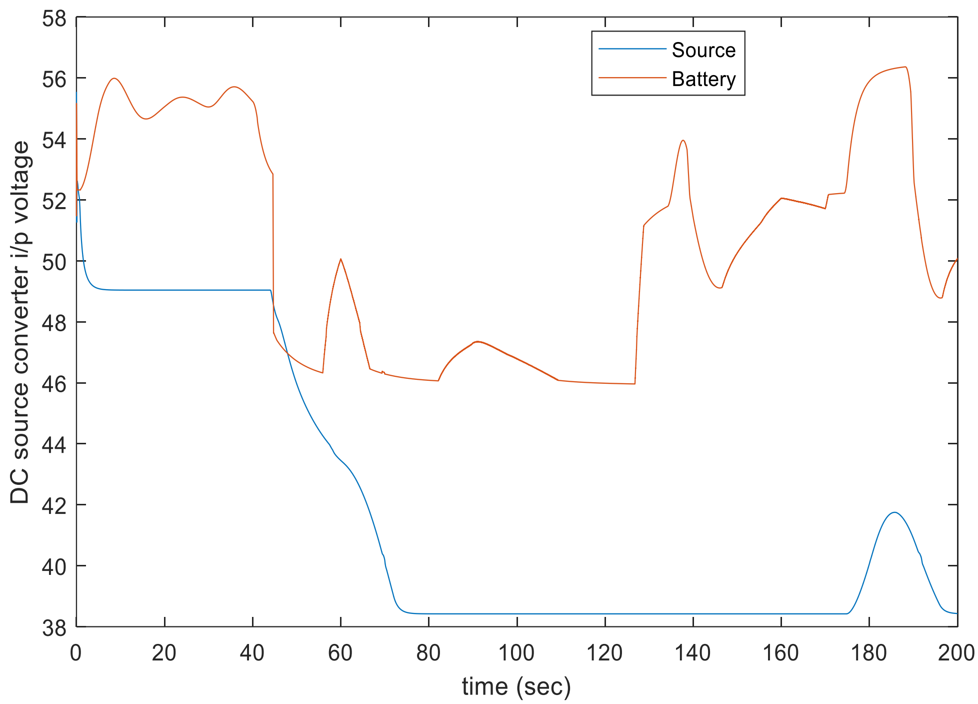

Figure 5.6 DC source input voltage (Volts) to the converter with respect to time.

The charging, discharging pattern with respect to time is shown in fig 5.6 Initially, battery is in charging mode hence current is negative, but as the load demand increase the battery start to discharge to compensate the load demand and current become positive, with pick value about 80 amp. Fig 5.8 gives the variation of battery state of charge ion percentage with respect to time. Basically, it shows the stare of charge of batter in percentage value. Initially, battery is in charging state hence the curve is negative as the load is increases batter switches to the discharging states.

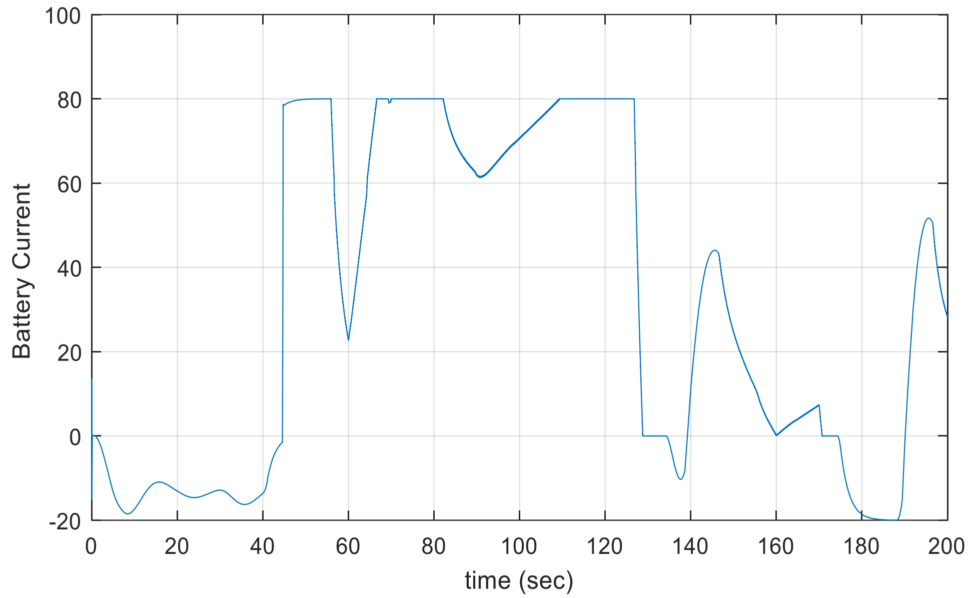

Figure 5.7 Battery current (Ampere) with respect to time.

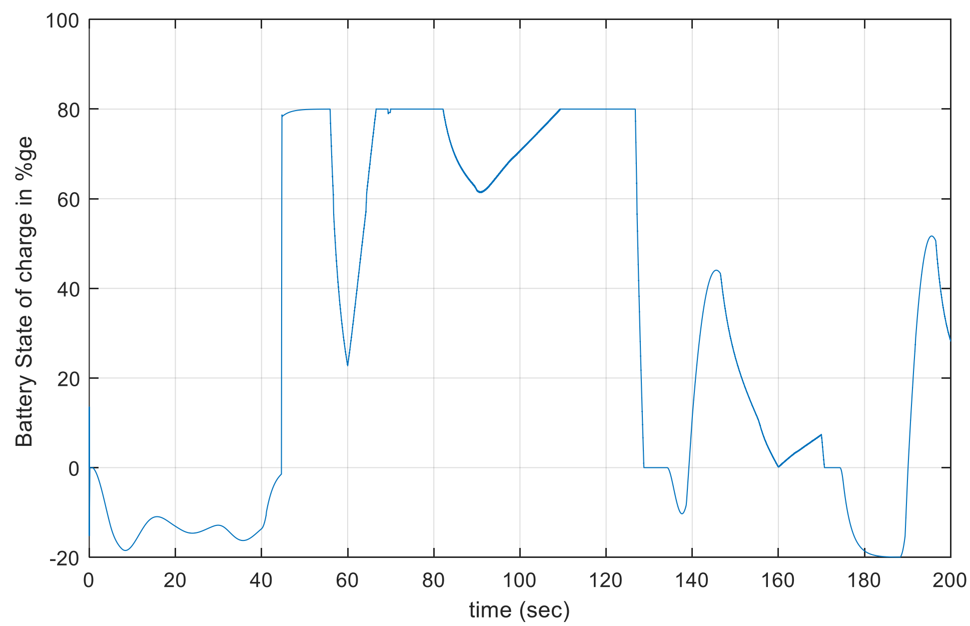

Figure 5.8 Battery state of charge ion percentage with respect to time.

The power flow from different sources, storage unit to load with respect to time is depicted in fig 5.9, in graph the wind power flow is shown in the purple color, battery flow is in yellow color, PV power flow is in red and load variation is shown in blue color. The power output of PV source and wind source is Initially taken to supply the load demand. Furthermore, in this time zone battery is in charging state hence, it consumes extra power. But as the load become high the power output supply of wind is also increased along with PV source. As the load become higher the battery switches to the dissipation mode and total load demand is balanced by PV, wind and battery simultaneously. The table 5.1 gives the detail of power (Watts) supply by different source to the load as per demand.

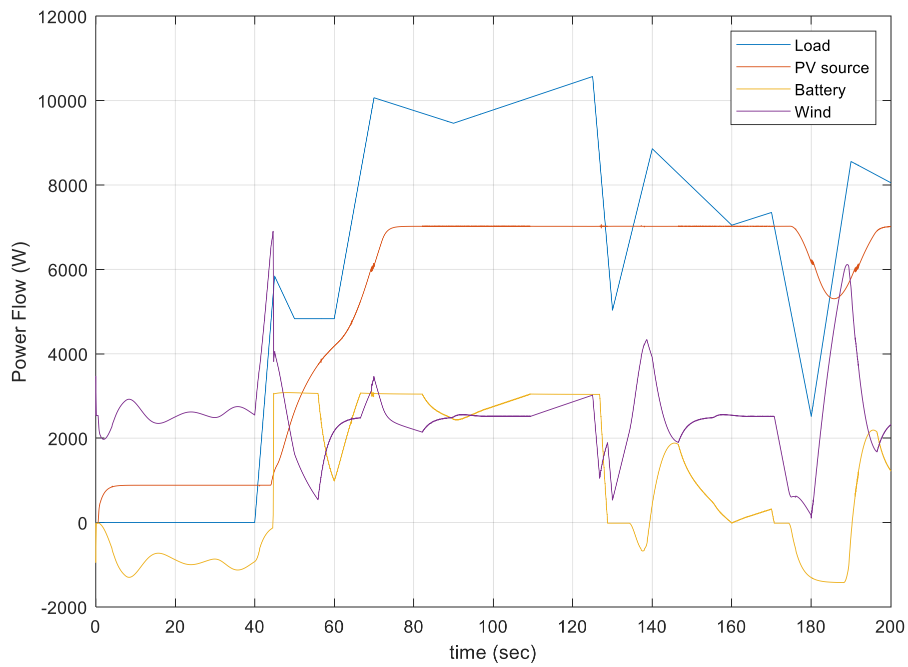

Figure 5.9 Net power flows from different sources, storage unit to load with respect to time.

Table 5.1 power (Watts) flow pattern of different supply source as per the load demand .

Time (se)	Load	PV source	Battery	Wind Source		Time (se)	Load	PV source	Battery	Wind Source
1	1.01	306.1	-14.64	2216.9		105	9933.23	7021.79	2904.85	2513.871
1.81893	1.01	609.4	-88.24	1987.2		105.82	9959.158	7021	2923.31	2522.132

2.63786	1.01	739.8	-225.6	1994.1		106.64	9985.083	7020.66	2952.85	2518.855
3.45679	1.01	808.7	-409.5	2109.2		107.46	10011	7020.79	2975.85	2521.641
4.27572	1.01	844.9	-617.8	2281.2		108.28	10036.92	7020.97	3001.66	2521.574
5.09465	1.01	863.8	-867.5	2511.9		109.1	10062.84	7020.63	3034.11	2515.378
5.91358	1.01	873.8	-1046	2680.6		109.92	10088.75	7020.99	3044.9	2530.147
6.73251	1.01	879	-1169	2798.2		110.74	10114.67	7020.98	3044.16	2556.822
7.55144	1.01	881.7	-1253	2879.2		111.56	10140.59	7020.96	3043.48	2583.434
8.37037	1.01	883.1	-1296	2921.1		112.37	10166.51	7020.93	3042.87	2609.989
9.1893	1.01	883.9	-1283	2907		113.19	10192.43	7020.9	3042.31	2636.493
10.00823	1.01	884.3	-1224	2847.8		114.01	10218.35	7020.87	3041.81	2662.954
10.82716	1.01	884.5	-1135	2759.3		114.83	10244.27	7020.83	3041.34	2689.376
11.64609	1.01	884.6	-1034	2658.1		115.65	10270.19	7020.79	3040.91	2715.766
12.46502	1.01	884.6	-934.9	2558.5		116.47	10296.11	7020.74	3040.51	2742.127
13.28395	1.01	884.6	-847.9	2471.6		117.29	10322.03	7020.68	3040.14	2768.463
14.10288	1.01	884.6	-782.8	2406.5		118.11	10347.95	7020.63	3039.8	2794.78
14.92181	1.01	884.7	-742.7	2366.3		118.93	10373.87	7020.57	3039.48	2821.079
15.74074	1.01	884.7	-726.7	2350.4		119.74	10399.79	7020.5	3039.17	2847.363
16.55967	1.01	884.7	-732.1	2355.7		120.56	10425.7	7020.43	3038.88	2873.635
17.3786	1.01	884.7	-754.2	2377.8		121.38	10451.62	7020.36	3038.61	2899.898
18.19753	1.01	884.7	-787.7	2411.4		122.2	10477.54	7020.28	3038.35	2926.153
19.01646	1.01	884.7	-826.9	2450.6		123.02	10503.46	7020.2	3038.1	2952.402
19.83539	1.01	884.7	-866.3	2489.9		123.84	10529.38	7020.11	3037.85	2978.646
20.65432	1.01	884.7	-903.4	2527		124.66	10555.3	7020.02	3037.62	3004.888
21.47325	1.01	884.7	-938.9	2562.5		125.48	10197.03	7019.96	3037.38	2646.913
22.29218	1.01	884.7	-968.6	2592.2		126.3	9289.854	7020.38	3037.53	1739.2
23.11111	1.01	884.7	-988.7	2612.3		127.12	8382.683	7020.56	2696.77	1172.64
23.93004	1.01	884.7	-997.3	2620.9		127.93	7475.484	7022.61	1387.14	1573.02
24.74897	1.01	884.7	-994.3	2617.9		128.75	6568.339	7019.83	205.846	1849.946
25.5679	1.01	884.7	-981.2	2604.8		129.57	5661.155	7021.26	-14.686	1161.895
26.38683	1.01	884.7	-960.6	2584.2		130.39	5130.19	7021.92	-14.7548	630.3734
27.20576	1.01	884.7	-935.6	2559.2		131.21	5443.577	7022.07	-14.7716	943.6373
28.02469	1.01	884.7	-909.5	2533.1		132.03	5756.965	7022.17	-14.7814	1256.941
28.84362	1.01	884.7	-885.1	2508.7		132.85	6070.352	7022.22	-14.7848	1570.285
29.66255	1.01	884.7	-867.8	2491.4		133.67	6383.74	7022.22	-14.7817	1883.669
30.48148	1.01	884.7	-867.4	2491.1		134.49	6697.127	7022.17	-19.8229	2202.139
31.30041	1.01	884.6	-890.3	2514		135.3	7010.514	7022.03	-155.371	2651.205
32.11934	1.01	884.7	-936.2	2559.8		136.12	7323.901	7021.75	-375.993	3185.469
32.93827	1.01	884.7	-994	2617.6		136.94	7637.288	7021.39	-568.566	3691.769
33.7572	1.01	884.7	-1051	2674.3		137.76	7950.676	7020.97	-673.407	4110.39
34.57613	1.01	884.7	-1095	2718.8		138.58	8264.063	7020.58	-559.411	4310.145

35.39506	1.01	884.7	-1120	2743.7		139.4	8577.452	7020.31	-62.4985	4126.875
36.21399	1.01	884.7	-1122	2746.1		140.22	8851.616	7020.14	483.635	3855.073
37.03292	1.01	884.7	-1103	2726.9		141.04	8777.392	7020.17	901.792	3362.664
37.85185	1.01	884.7	-1067	2690.4		141.86	8703.169	7020.24	1238.47	2951.693
38.67078	1.01	884.7	-1019	2642.7		142.67	8628.946	7020.34	1498.55	2617.296
39.48971	1.01	884.7	-966.8	2590.4		143.49	8554.723	7020.46	1686.46	2355.056
40.30864	164	884.8	-913.5	2700		144.31	8480.499	7020.6	1808.14	2159.022
41.12757	1121	884.9	-740.1	3483.2		145.13	8406.276	7020.73	1870.65	2022.17
41.9465	2077	885	-469.7	4169.2		145.95	8332.052	7020.86	1880.87	1937.607
42.76543	3034	885.2	-313.9	4969.9		146.77	8257.835	7020.41	1823.92	1920.79
43.58436	3991	885.3	-211.9	5824.4		147.59	8183.603	7020.92	1572.34	2097.626
44.40329	4947	956.2	-144.8	6642.9		148.41	8109.372	7021.84	1379.98	2214.841
45.22222	5828	1251	3056	4028		149.23	8035.151	7021.6	1220.82	2300.02
46.04115	5663	1412	3068.3	3689.9		150.05	7960.952	7019.63	1088.63	2359.976
46.86008	5498	1626	3076	3303.2		150.86	7886.718	7020.9	972.505	2400.598
47.67901	5333	1884	3079.3	2876.3		151.68	7812.497	7020.32	865.084	2434.374
48.49794	5168	2148	3079.8	2447		152.5	7738.26	7021.58	773.166	2450.799
49.31687	5003	2399	3078.7	2033		153.32	7664.028	7021.98	682.488	2466.849
50.1358	4838	2626	3076.7	1642.1		154.14	7589.804	7022.05	597.353	2477.687
50.95473	4832	2829	3074.3	1435.6		154.96	7515.593	7021.29	520.261	2481.328
51.77366	4832	3012	3071.7	1256.1		155.78	7441.382	7020.12	425.349	2503.197
52.59259	4832	3177	3069.2	1093.5		156.6	7367.153	7020.81	315.863	2537.764
53.41152	4832	3328	3066.7	945.23		157.42	7292.924	7021.24	225.882	2553.091
54.23045	4832	3466	3064.4	809.34		158.23	7218.688	7022.06	145.436	2558.478
55.04938	4832	3593	3062.4	684.52		159.05	7144.488	7020.14	78.3911	2553.239
55.86831	4832	3709	3060.5	569.66		159.87	7070.259	7020.93	13.32	2543.292
56.68724	4832	3818	2526	995.54		160.69	7064.038	7020.46	11.169	2539.692
57.50617	4832	3917	1976.4	1446.4		161.51	7088.774	7020.8	42.7991	2532.464
58.3251	4832	4002	1573	1764.8		162.33	7113.507	7021.73	76.3899	2522.675
59.14403	4832	4084	1272.5	1982.8		163.15	7138.252	7021.1	103.384	2521.05
59.96296	4832	4164	1036	2140		163.97	7162.987	7021.86	133.914	2514.503
60.78189	5157	4238	1176	2250.7		164.79	7187.728	7021.81	154.517	2518.681
61.60082	5586	4317	1449.3	2327.4		165.6	7212.492	7019.85	184.427	2515.5
62.41975	6015	4409	1738.3	2374.5		166.42	7237.233	7020.06	209.118	2515.341
63.23868	6444	4521	2011.8	2418.2		167.24	7261.95	7021.95	231.064	2516.222
64.05761	6872	4656	2285.9	2437.7		168.06	7286.706	7021.01	259.791	2513.186
64.87654	7301	4811	2540	2457.9		168.88	7311.436	7021.36	278.759	2518.601
65.69547	7730	4988	2775.5	2474.1		169.7	7336.186	7020.73	304.615	2518.124
66.5144	8159	5184	2999	2482.9		170.52	7159.003	7020.35	128.302	2517.641
67.33333	8588	5399	3066.6	2629.4		171.34	6763.139	7021.06	-14.6337	2264.009

68.15226	9017	5630	3063.7	2830.1		172.16	6367.281	7021.29	-14.6672	1867.969
68.97119	9446	5876	3061.2	3015.6		172.98	5971.423	7021.58	-14.7091	1471.88
69.79012	9874	5994	3067.5	3319.7		173.79	5575.565	7021.94	-14.7593	1075.742
70.60905	####	6219	3056.8	3284.8		174.61	5179.707	7022.36	-29.4692	694.1972
71.42798	####	6464	3055	3017.3		175.43	4783.849	7007.52	-332.546	616.2838
72.24691	####	6699	3053.5	2758.9		176.25	4387.991	6939.3	-670.843	626.9584
73.06584	9979	6858	3052.2	2576		177.07	3992.133	6828.37	-908.065	579.2786
73.88477	9955	6939	3051	2471.9		177.89	3596.275	6683.8	-1073.42	493.3676
74.7037	9930	6979	3049.9	2407.7		178.71	3200.417	6511.76	-1186.98	383.1329
75.52263	9905	7000	3049	2363.5		179.53	2804.559	6316.56	-1264.25	259.7678
76.34156	9880	7010	3048.2	2329.3		180.35	2652.177	6210.99	-1316.65	265.3912
77.16049	9856	7015	3047.4	2300.1		181.16	3146.741	6016.73	-1351.75	989.3127
77.97942	9831	7018	3046.7	2273.4		181.98	3641.564	5796.69	-1375.46	1727.874
78.79835	9806	7019	3046.1	2247.9		182.8	4136.386	5610.7	-1391.43	2424.638
79.61728	9781	7020	3045.6	2223		183.62	4631.208	5467.06	-1402.19	3073.837
80.43621	9757	7021	3045.1	2198.3		184.44	5126.03	5368.78	-1409.46	3674.188
81.25514	9732	7021	3044.7	2173.8		185.26	5620.852	5315.71	-1414.39	4226.966
82.07407	9707	7021	3044.3	2149.3		186.08	6115.675	5306.04	-1417.74	4734.775
82.893	9682	7021	2939.5	2229.5		186.9	6610.497	5335.52	-1420.03	5202.373
83.71193	9658	7020	2841.4	2303.5		187.72	7105.319	5403.27	-1421.6	5630.965
84.53086	9633	7021	2753.4	2366.2		188.53	7600.141	5506.17	-1406.63	6007.868
85.34979	9608	7021	2688	2407		189.35	8094.964	5640.95	-1144.96	6106.201
86.16872	9583	7021	2635.1	2435.1		190.17	8554.388	5804.54	-242.156	5499.21
86.98765	9559	7021	2588	2457.2		190.99	8513.153	5991.75	501.939	4526.676
87.80658	9534	7020	2554.3	2466.5		191.81	8472.156	6101.05	1034.45	3843.879
88.62551	9509	7023	2514.6	2479.4		192.63	8430.683	6210.63	1543.68	3183.6
89.44444	9485	7021	2484.8	2486.5		193.45	8389.448	6382.98	1858.9	2654.798
90.26337	9467	7020	2446.6	2506.9		194.27	8348.213	6541.87	2063.04	2250.552
91.0823	9493	7020	2437.6	2541.9		195.09	8306.977	6687.33	2168.82	1958.087
91.90123	9519	7020	2449.4	2555.9		195.91	8265.742	6819.57	2189.28	1764.162
92.72016	9544	7020	2475.9	2555.4		196.72	8224.492	6919.23	2114.42	1698.129
93.53909	9570	7020	2506.8	2550.4		197.54	8183.26	6970.01	1781.95	1938.585
94.35802	9596	7021	2534.9	2547.9		198.36	8142.015	6996.61	1541.76	2110.931
95.17695	9622	7022	2574.5	2533.3		199.18	8100.814	7006.87	1375.12	2226.109
95.99588	9648	7021	2609.4	2525.2		200	8059.572	7013.79	1240.93	2312.134

Chapter-6

CONCLUSION AND FUTURE WORK

6.1 Conclusion

In this dissertation thesis an infrastructure of intelligent power flow management system is proposed. Fuzzy logic based approaches for infrastructure is developed and analysed. Classic Boolean approach has proved to have ability for cost saving to some extent. In this work Mamdani's FIS approach shows better performance than the above mention Classic Boolean approach in most of the circumstance uniformly. This approach is found to be the best and resulted in most efficient during the variation of load under the heterogeneous conditions. Major contribution of this work highlighted is that a novel energy storage system planning has been integrated to household power flow management system. Finally, in this thesis, smart mechanism has been proposed using natural computing and it has been demonstrated that, it is a better strategy than the conventional method for energy saving for end consumer's load.

6.2 Scope for Further Work

Future work will be focusing towards the modern heuristic algorithms on energy saving and power flow planning related to the proposed design, which may will be helpful to best cost saving rates for load consumption end and for better performance in peak demand response for power suppliers and grid connected system.

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