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Analysis of a Micro Grid Connected Low Voltage Distributed Generation System

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Abstract: **With the continuous development of economy and social progress, the social requirement of power network is more and more high. This paper, as a basis research of distributed generation, proceed mainly from the impact of distributed generation on power grid, detailed fine analysis of the influence of all kinds of distributed generation on power network adverse, including power system stability, power quality, power supply reliability effect. In order to avoid these adverse effects, we combining the distributed grid technology and smart micro grid, put distributed generation as a branch of the micro grid that can be ideal to connect grid and can avoid most of the problems mentioned above. Distributed intelligent micro grid system uses variety of new energy supply, it is a comprehensive model of power electronic technology, distributed generation, renewable energy power technology and energy storage technology .The paper provides a reference for the use of future distributed power generation. Technological advancements in the field of renewable energy power generation are made it possible to think of micro grids. This technology is providing to be beneficial in making localized areas self-sufficient in power management. Being at low voltage (440 V Line-to-Line (L-L)-11kv) for Three Phase and 230 V for single phase networks, the micro grid can deliver needs of domestic as well as small scale industries (SSI) which together consume a few kilo watts (KW) of power. This paper focuses on single phase grid connected system catering the needs of few domestic as well as small scale industries. Solar energy coupled with a storage system is considered here so that the reliability of the system is improved. MATLAB R2015 a Simulink is used to simulate the model.**

Key words: **Grid -Connected System; Micro-Grid; Battery Management; Small Scale Industry (SSI); Solar Photo-Voltaic Cell And Renewable Energy;**

I. INTRODUCTION

Distributed generation (DG) refers to power in the range of tens of kilowatts to tens of mega watts, modular, distributed load near the clean and green power generation facility to the economic, efficient and reliable power generation. Distributed generation is different from the traditional centralized power generation, long-distance transmission, power generation in the form of large interconnected networks. Distributed generation has the advantages of low investment, small occupied area, short construction period, energy saving, environmental protection and other features, for the peak of the power load more economical and effective than centralized power, so it can be supplied useful supplement for centralized power. As a standby power, distributed power generation can be used as backup power to provide electricity for peak load and improve reliability; can supply power for users in remote areas, commercial and residential; can be used as a local power saving of power transmission and transformation construction cost and investment, improve energy structure and promote the sustainable development of electric energy. The application of distributed generation and energy, technology development, environmental protection and electricity market liberalization have relations, impact analysis, the grid application on the traditional power system control and protection etc. the far reaching, further may cause the change of electricity market, the user side management and other aspects.

The advantages of distributed generation that can fully develop and utilize the various available dispersed energy sources, including fossil fuels and renewable energy can be conveniently obtained locally, and improve energy efficiency. Distributed power supply usually accesses the medium or low voltage distribution system, and will have a far-reaching influence on distribution system. Traditional distribution system is designed only with the function of the distribution of electricity to the end of user, and the future distribution system is expected to evolve into a media of exchanging power, it can collect power and transmit them to any place, and distribute them at the same time. Therefore, in the future it may not be a distribution system but a power delivery system. Distributed generation has the characteristics of dispersion and randomness, access to a large number of distributed powers, will greatly influence the safe and stable operation of power distribution system. Traditional distribution system analysis methods, such as the power flow calculation, state estimation, reliability evaluation, fault analysis and restore the power supply and soon, are due to varying degrees by the impact of distributed generation and the need to improve and perfect.

Around the world, the country of the higher energy efficiency and better environmental protection keener support for the development and application of distributed energy source technology, and support policy more clearly. Such as Denmark, Holland, Japan on distributed power Sources have taken a series of policies to encourage; after "911 incident", taking into account the power security, the developed countries accelerate the pace of construction of distributed power, so far, Britain has more than 1000 seat distributed power station, even the queen of England's Buckingham Palace, Prime Minister of the 10 Downing Street residence, all use of gas turbine distributed energy Station; the United States has more than 6000 seats distributed power station, there are more than 200 seats distributed energy station in university campus. In the many countries, Denmark is by the worlds recognized the model, to realize the sustainable development of the country. Over the past 20 years, Denmark's GDP over one time, but the energy consumption is not increased, environmental pollution has not increased, and the secret lies in the Danish actively the development of cold, Heat and electricity cogeneration, advocate scientific use of energy, support distributed energy, by enhancing the development efficiency of energy use in support of national economy. At present, Denmark did not have a thermal power plant is not heating, nor a heating boiler room is not power, they put the production of cold, heat and electricity become high-tech cogeneration of cold, heat and power, so that science and technology become true positive productivity.

According to reports in the literature, before 2010, about 25% to 30% of global new generation capacity is distributed generation electric. USA is the world's developed the most countries of new energy and renewable distributed energy generation, is the world's the main provider of commercial distributed power supply equipment. In 2004, the total capacity of USA distributed generation is 67 GW, accounting for about 7% of America domestic total generating capacity, reached the average level of the world, according forecasting of USA electric power scientific institute research, 25% of new generating capacity in 2010 American will use the distributed power, while National Gas Foundation estimated as high as 30%, by 2020 more than half of the new commercial or office buildings use distributed power supply, the existing building at the same time to 2020 15% by the distributed power supply. The European distributed generation resources develop in the leading level of the world; in 2000, in the EU area DG installed capacity of 74 GW, while the 2004 the total power generation of Denmark, Holland, Finland DGRs accounted for the total domestic electricity generating capacity of 52%, 38% and 36%, the EU forecasts 2020 will reach 195 GW, power generation capacity will reach a total generating capacity of 22%. In our country, ensure an adequate supply of electricity for sustained economic development will play a decisive role, in based on the established central power plant and the power grid, it will be the inevitable future development trend to develop DG technology. The current research on distributed energy system in China has already started, some research institutions, research universities have invested human and financial resources into the distributed energy system. University of Shanghai for Science and Technology in Capstone C60 Micro Gas Turbine Company production as the core, combined with the after burning waste heat boiler, staged combustion absorption refrigerating machine, Cold storage and heat storage system and construction of demonstration type energy island, for the study of distributed energy system. Xi'an Jiao tong University using 100kW gas turbine as the core, set up the distributed energy to the hotel for the application object System. Institute of Engineering Thermo physics and there are a lot of distributed advanced energy system mode and related evaluation system Study on the price of the. North China Electric Power University energy clean and focus on the use of laboratory, established a dual source reversible heating (air conditioning) system experimental platform. Overall, the distributed energy system research in advanced western countries has achieved fruitful results, the research field of distributed energy systems from a single run to just the rise of distributed energy systems and near join a large grid, has extensive experience in distributed energy system operation. While in China, the research of the distributed energy system is still in its early stages, the large-scale use of distributed energy system is still a long way to go. Domestic on research of the independent operation of the distributed energy system research much more, mainly the economic evaluation and the evaluation standard of distributed energy system with various grid.

II. LITERATURE

2.1 The Defects of Distributed Generation:

The power system of centralized power, long-distance power transmission and large power grid interconnection is the main mode of the production of electric energy, transportation and distributing, is to supply power to more than 90% of the world's electric power load. But it also has some malpractices.

There are mainly:

(A) In large-scale power grid local accident easily spread, small disturbance fault at any point of the generated will be greater impact on the whole power, resulting in a large area power outage, or even the whole network collapse, while The larger power system, the higher the probability of the accident .

(B) Large power grid vulnerable to destruction of war or terrorist forces, serious will endanger state security.

(C) Changes in large power grid cannot be flexibly tracked of power load change, such as a surge of air conditioning load in summer causes power supply short deficiency, in order to short-term peak load to build power plants and transmission facilities huge cost, very low economic benefit, with the continuous increase of load peak valley difference, load rate is decreased year by year; the use rate of power facilities has a downward trend.

Therefore, we need to study the combination of mixed system of large power systems and distributed power generation systems, not only can save investment, reduce energy consumption, but also can improve the safety and flexibility of the system.

2.2. THE ADVANTAGES OF DISTRIBUTED GENERATION

(A) ***Energy saving***

In the current background of building a conservation minded society and promoting energy-saving environmental protection, distributed generation can be said to be a bright star of electric power industry, once the face of international development in distributed generation can be seen: the country of the higher energy efficiency and better environmental protection keener support for the development and application of distributed energy source technology, and support policy more clearly. There are two obvious difference between the traditional power grid and distributed power supply: first, the distance of traditional large power grid and electricity load is very far, usually to input to give user remote, especially in China, large power distribution is extremely uneven, electricity consumption of long-distance transmission is very considerable, and distributed power supply is closer to the user site, thus the net loss decreased significantly; second , the form of the traditional great power supply mode is single, and distributed power supply can provide various forms of energy, typically cold, heat and power cogeneration can achieve three energy cascade utilization. In line with the "temperature counterparts,

Cascade utilization" principle, thus greatly improves the overall efficiency of energy use.

(B) Reduce air pollution

Air quality is closely linked with our life quality, air pollution is in large part from the various fires power station, in our country at present, and the efficiency of thermal power generation in the world is not high. Raw material of distributed power generation is using natural gas, oil and other clean energy and wind power, hydro, tidal, geothermal and other renewable energy, to reduce carbon dioxide, carbon monoxide, sculpture and nitrogen compounds and other harmful gases emissions, at the same time, because the voltage class of distributed energy system power is relatively low, the electromagnetic pollution is much smaller than traditional set Chinese generation.

(C) Increase the economy of power grid

Using the technology of distributed generation, the demand of the new centralized power plants and long-range transmission lines will be reduced less. First of all, the large of new load will meet by distributed generation; secondly, because the distributed may cut a peak and fill valley load, balancing power, the use rate of existing power generation and transmission facilities will be greatly improved, the some utilization rate is extremely low, only to meet the need of the peak load generation and transmission facilities will no

Longer have the necessary construction. Thus greatly enhance the network economy. In addition, the distributed generation can also be used as a backup power for peak load Provide power, not only to improve the economy of power network, but also improves the reliability of power grid operation.

(D) Reduce line loss

Because distributed generation can be used as a local power supply, so the transmission and distribution loss is very low, not only saves the construction cost and investment of power transmission, but also can reduce the power consumption of the long distance transmission lines. In addition, we also can real-time monitor the quality and performance of regional electric power, to further reduce the loss and improve power transmission efficiency, very suitable for mountainous rural and pastoral areas, residents, power supply in the development of medium and small cities or commercial district.

(E) High reliability and power quality

In unabated trend of rapid expansion of the large power plants construction, the rapid expansion of power grid brings a great threat to the security and stability of power supply. Once the power plant and transmission route failure occurs, it will lead to large area blackout. Distributed power supply uses the control equipment of advanced performance. Open and stop convenient, simple operation, flexible load regulation, and it can greatly improve the reliability of power supply with large power grid distribution, make up the shortage of its security and stability. When it appears the collapse of power grid and unexpected disaster harm (earthquakes, snowstorms, man-made destruction, and war) it can maintain the power supply of important users. The internal of distributed power supply usually install a local voltage regulation and reactive power compensation, thus ensuring the quality of electric energy. In addition, the investment of distributed power supply relatively compared with large power grids and large power plants is very small, the risk is also smaller, and the construction period is short, is conducive to a short period of time to solve the problem of power shortage.

2.3 Classification and Energy Forms of Distributed Generation

(A) Distributed generation technologies based on fossil fuel

Reciprocating engine technology: reciprocating engine using distributed generation use fire or compression ignition of four stroke point, with gasoline or diesel oil as fuel, is distributed generation method by being used widely at present. But this approach will have an impact on the environment, recently by improving on its technology, has greatly reduced the noise sound and the exhaust emission pollution. Micro gas turbine technology: micro gas turbine is ultra-small gas turbine referring to the power of below hundreds of kilowatts and natural gas, methane, gasoline, diesel oil as fuel. But the efficiency of micro gas turbine is low compared with other power generation technology. The efficiency of the full load operation is only 30%, while in the half load operation, its effect rate is only 10% ~ 15%, so the current use of domestic cogeneration way by using equipment of waste heat to improve its efficiency (up to 75% or even higher). The characteristics of micro gas turbine are small in size and weight .The implementation of cogeneration is light, high power generation efficiency, low pollution, easy operation and maintenance. It is one of the most mature and business competitiveness the distributed power supply. The key technology is mainly the high-speed bearing, high temperature materials, and parts Processing etc.

The diagram below shows the basic building blocks of a small stand-alone off-grid PV power generating system. A grid connected system would not need the battery and MPPT power tracking system. They do however need alternative capacity to come on stream to carry the load during the hours of darkness.

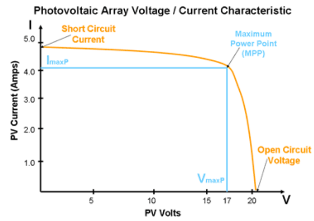


Fig: 1 Photovoltaic Array Voltage/ current Characteristic

The graph below shows that with constant irradiance the output voltage of a cell or an array of cells falls as it is called upon to deliver more current.

Photovoltaic Array Voltage/Current Characteristic Maximum power delivery occurs the voltage has dropped to about 80% of open circuit voltage.

The Fill Factor (FF) is defined as the ratio between the power at the maximum power point and the product of the open circuit voltage and short circuit current. It is typically better than 75% for good quality solar cells.

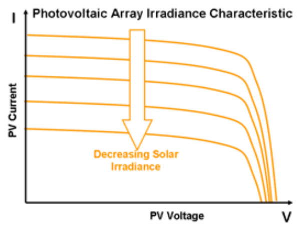


Fig: 2 Photovoltaic Array Irradiance Characteristic

The short circuit (SC) current is directly related to the number of photons absorbed by the semiconducting material and is thus proportional to light intensity.

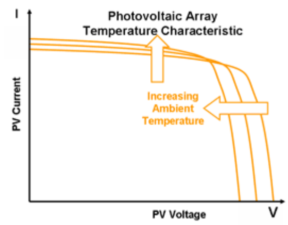


Fig: 3 Photovoltaic Array Temperature Characteristics

The conversion efficiency is therefore reasonably constant so that the power output is proportional to the irradiance down to fairly low levels; however the efficiency is reduced if the cell temperature is allowed to rise.

The open circuit (OC) voltage varies only slightly with light intensity.

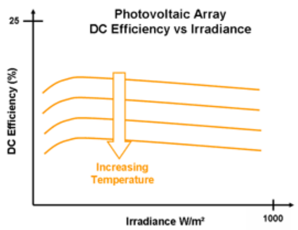
As temperature increases, the band gap of the intrinsic semiconductor shrinks, and the open circuit voltage (Voc) decreases.

At the same time, the lower band gap allows more incident energy to be absorbed because a greater percentage of the incident light has enough energy to raise charge carriers from the valence band to the conduction band. As the temperature is raised however, the internal resistance of the material increases and the electrical conductivity decreases. The increase in the current for a given temperature rise is thus proportionately lower than the decrease in voltage. Hence the efficiency of the cell is reduced.

2.4 Photovoltaic Array Temperature Characteristics

a) Solar Cell Efficiency

The following graphs show the same information as those above but in a slightly different form showing how increased temperature reduces the efficiency.



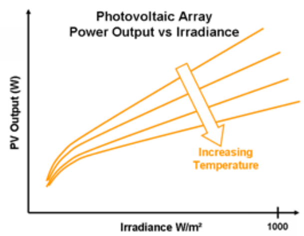


Fig: 4PV Array Efficiency Fig: 5 PV Array Power

Typically, PV cell power output reduces by about 0.5% with every degree Celsius increase in temperature.

In real outdoor conditions the rated peak power Wp is seldom achieved, since module temperature usually is more in the range of 40°C - 60°C. Efficiency can be improved by cooling the cells and some systems have been designed to make use of the heat absorbed by the cooling fluid in solar heating applications

b) Fuel cell technology:

The fuel cell is an electrochemical device that can directly converts the chemical energy into straight current under isothermal state. Fuel cells work does not need to be burned, and no environmental pollution, its power is obtained by electrochemical process. In the anode through a hydrogen rich fuel, a cathode is above through the air, and put the separation of the two substances by electrolyte. In the process of obtaining electric energy, some of the by-product is only heat, water and Oxidation Carbon etc. Hydrogen fuel can be made of various hydrocarbon sources, under the pressure of steam reforming process or by the reaction of oxidation.

(c) The technology of hybrid-type distributed generation

An important direction is multi-objective generation energy supply systems of being mentioned thermo, electric, and cold, usually referred as the distributed energy supply system. In the production of electricity at the same time, it can also provide heat or satisfy heating and cooling requirements. Compared with the power supply system, distributed energy supply system can be integrated with energy cascade of science, thus greatly improving the energy efficiency of thermal economy and reducing environmental pollution, improve thermal economy of the system.

Cogeneration is 2 kinds of circumstances.

Mainly for power generation, using a large capacity units, only a small part of utilization of waste heat, electricity into high voltage transmission network distribution, this should be attributed to the centralized power cogeneration;

To heat determine power, in the premise of satisfying certain heat load demand, to the construction of small heating unit, power digestion by the users themselves, or digestion in the local distribution network in the region.

(d) The technology of distributed generation based on renewable energy solar photovoltaic power generation technology: solar photovoltaic technology is using the photoelectric effect of optoelectronic semiconductor material that may directly convert solar energy into electric energy. Photovoltaic power generation has the advantage of no consumption of fuel, not subject to geographical restrictions, scale

Flexible, non-pollution, safe and reliable, simple maintenance etc... But the cost of this kind of distributed power generation technology is very high, so the solar power generation technologies need improvements in technology at the present stage, to reduce the cost suitable for wide application.

The wind power generation technology is generation technology by converting wind energy into electric energy power generation technology, as the wind power is environmental protection and can be regeneration, the global feasible, low cost and the high scale benefit, has been more and more widely welcome, become the one of new energy of the fastest development. It can be divided into independent and grid connected operation, the former is micro or small wind power generation unit, capacity is 100W ~10kW, the capacity of the latter is usually more than 150kW, usually have more than one larger capacity wind turbine components of wind generator group, called the wind farm (also known as the wind field, wind field), with machine group of large-scale, centralized installation and control characteristics. In recent years, the wind power generation technology is making rapid progress; the technology of stand-alone capacity in the following 2MW has been very mature.4. The Adverse Effects and Solutions of Grid Connected Distributed

III. GENERATION ON POWER NETWORK

3.1. The Adverse Effects of Grid Connected Distributed Generation on Power Network

In recent years, the rapid development of distributed power supply, more and more application, in the enormous energy-saving effect at the same time, there are many bad phenomenon's; the most prominent is the related problem of distributed power grid.

The main problems are as follows:

(A) Large changes of network structure

The distribution system will be a fundamental change: from a radiation type network into a throughout power and user interconnection network networks, somewhat similar to internet. The control and management of the distribution system will become more complex. The introduction of distributed generation will make the operation and planning of the traditional distribution network (such as reactive power compensation and voltage control) completely change; distribution automation and demand side management (DSM) also need to be reconsidered; distributed power between the control and scheduling must be coordinated and laws, regulations and industry standards associated with the distributed power supply also need to be properly formulated.

(B) Setting problem of distribution network relay protection device

The introduction of distributed power supply and uncertainty of the distribution network power flow will cause the distribution network voltage control trapped difficult, cause voltage flicker, lead to disoperation of relay protection, will also have a short circuit current of the power system, relay protection setting and operation value setting increased certain difficulty, need to solve the reliability problem, and especially is the coordination problem of relay protection. DG by 10 kV feeder access to distribution system, and the level of the match electric system generally uses 3 section current protections (instantaneous current quick break protection, timing and limiting current quick break protection, over current protection). DG access may lead to reduce the sensitivity of the protection device, and even refused to move, may also lead induced protective device disoperation, and temporally adjacent line quick break protection device malfunction, lose selectivity.

(C) The introduction of a large number of harmonics, power quality decline

Distributed power grid, due to the large number of power electronic devices used in distributed power supply, so it cannot avoid Free to bring a large number of harmonics to the influence of the system, the harmonic amplitude and order by generating mode and working mode of the converter. At the same time, stability and voltage on the voltage waveforms have different degrees of impact.

(D) The influence of the static stability of power distribution network

Distributed power grid will produce the effect of static stability of the distribution network, the extent of influence depend on the different types of distributed power supply.

For the use of asynchronous generator interface DG, grid connected has a negative effect on static voltage stability of the system, grid position is far from the most weak branch system, the negative impact is on the more small; for the synchronous generator without excitation of the DG interface and with the variable power control unit Heat exchanger as the interface of DG, grid can improve the static voltage stability of the system, grid position is closer to the line the most weak branch, is to improve static voltage stability of the system the more significant.

(E) Other problems

Distributed generation have the problem of covering, the efficiency and of meter. If a distributed power stations construct inside the city, the city is very crowded .Because energy is a two-way flow, such as results the roof installed solar energy, so the day no one is at home without electricity, the electric energy into the distribution network. So these conditions of the ammeter will record all. Now the foreign adoption meter bidirectional measurement. If we do this method, so a great deal of meter should be changed. The problem of efficiency, the efficiency of distributed generation can reach more than 80%,

But sometimes can reach more than 60%. There are problems of environmental protection and fire safety problem.

3.2. The Solution for Grid Connected Distributed Generation Adverse Effects

Micro grid technology is inventing the name by American first. The establishment of micro grid, when there is a fault in a distribution network, it can avoid trip, because the micro grid structure makes contact of the whole grid and distribution network weak. Once there is the failure of words, it can connect to jump off. At the same time, there are many branches of micro grid structure; the less important load put on a branch, when you need cut off, you can cut all the less important branches. The use of micro grid structure, there will be a lot of transformation, relay protection and all control equipment is not the same.

This is the characteristics of micro grid. Putting the distributed generation as a branch of the micro grid, it can be the ideal with grid connected and can avoid most of the problems mentioned above.

Distributed intelligent micro grid system uses variety of new energy supply, it is a comprehensive model of power electronic technology , distributed generation, renewable energy power technology and energy storage technology, the integration of multiple distributed generation units and loads as a separate power grid system, independent supply power to the load or with the city power supply power to the load by the wind light wood electronic system composed of distributed micro grid structure shown in Fig. 1.

Figure 1. The Structure Diagram of Distributed Intelligent Micro Grid System Mode of power supply: solar and wind power generation first storage, when the battery is full, solar and wind power automatic switch energy to grid connected power supply mode, and with an external power grid power to the load (Plant configuration of backflow prevention device). When external power grid appear failure or disaster, the micro grid system automatically cut off the external power grid, independent power supply mode

Automatic will start, by a diesel generator and battery device after the conversion of electric energy to control to the important load power supply. With the development of power electronic technology, computer advanced control technology, communication technology is closely related to micro grid technology, the intelligent micro grid system contain with the following components.

(a) The master control platform. It can be achieved to realize the energy management platform of the whole system, using dual function of the system operation and display platform, is a management tool of intelligent micro grid autonomous operation.

(b) A variety of distributed power supply.

(c) More intelligent load user.

(d) The power network self-healing ability. Composing of a measuring device, a switching device and a communication device, it can realize the functions of fault location diagnosis and isolation, and automatic recovery of power supply.

(e) Reservation extensible interface.

Distributed generation will become the future of an important energy production, it will with micro grid and smart grid with the change in power system network structure and operation mode of low level, and the distributed intelligent microgram system based on intelligent power distribution network as a platform, the effective integration of distributed generation technology and micro network technology, play technology the advantage of them, i.e. the combination of advanced power electronic technology, will be a variety of distributed micro power supply, load, energy storage system and control device combined system unit composed of a single controlled, at the same time alone or with external power grid with the supply of electric power to the users.

3.3 PV Cell as a current source

The working of a photovoltaic cell is a well-known technology. The solar cells are designed to accept the energy present in the sun's rays for a particular wave length range is called visible light.

a) Photo voltage solar panel modeling:

The equation corresponding to the current output from a solar cell can be written as:

$$I = I_{ph} - I_s\left[\exp\frac{q(V+RsI)}{NKT} - 1\right] - \frac{V-R\,sI}{Rsh} \quad ..(1)$$

Where,

I_{ph} is the photocurrent,

I_S is the reverse saturation current of the diode,

Q is the electron charge,

V is the voltage across the Diode,

K is the Boltzmenn's constant,

T is the junction temperature,

N is the ideality factor of the diode, and

R_S and R_{sh} are the series and shunt resistors of the cell respectively.

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The equivalent circuit of Solar Photo- Voltaic can be shown as in Fig: 6

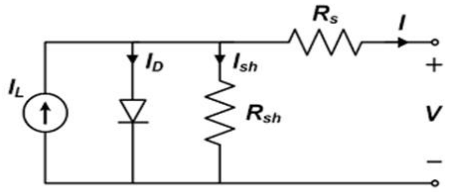

Fig: 6 The equivalent circuit of Solar Photo-Voltaic

b) Solar Radiation Data:

The solar insolation levels for a samle period of one day at a resolution of one second is taken as shown in Fig: 7

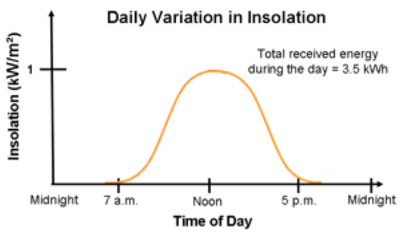

Fig: 7 Solar Irradiation during a day.

The sunrise is taken approximately at 8 AM and has a peak insolation during the noon time, i.e., 1 PM to 2 PM and the sunset is expected to be around 6PM. The Irradiation is expressed as W/m^2.

This data is presented to the solar cell as an input which, according to the above eequation develops current and hence a potential differenc across the terminlas. The outputs of it will be shown in section 6.

3.4 Battery Capacity and Charge Control

A1000 AH battery is taken for the system and the charding and discharging ofit are controlled based on the power flow at the Point of Common Coupling (PCC) of the micrro-grid to the Grid.

The direction of power flow will decide the current injected by the batttery into the system. Hence the battery here is a considered as a current source in parallel with a high resistance acting as a power source. The PCC curent and voltages are continuously monitored. The real power floe is clculated and the direction of flow is taken to be negative if the value goes less than zero. A PI controller is used to calculate the controller signal (the equivalent current signal) input to the battery by comparing the present power flow to the reference value. The battery is also working as a sink for the surplus power produced by the micro-grid, where it it gets charged up. As the cspscity of the battery id set, the Ampere- Hour discharge or charging is hence calculated by a simple integrated circuit and a fraction converting the time signa in seconds to hour. Similarly, the State-of- Charge (SOC) is also calculated.

IV. SINGLE PHASE LV MICROGRID AND LOADS

The Single Phase LV Micrograds being operated at low voltage poses problem related to the efficient power transfer, placement of the generating plants closer to the loads. The present system considered in th paper is powered up bya solar Photo-Voltaic source as the distributed generator supplying a set of domestic loads and a SSI. The voltage across the lines is continuously monitored. The Grid is considered to be finite in nature and hence the magnitude and phase of the grid voltage is not supposed to change even for a variation at the PLL. A three phase set up transformer of 10 MVA, 66 KV/ 6.6 KV is used in the generatin the plant considered in the grid. A pi sectional transmission is considered in the grid of 1km length associated with a three phase load. At the PLL, a three-phase –to- single phase conversion is done using a transformer working on one of the line to line voltage. The power grid is considered is shown in Fig: 10.

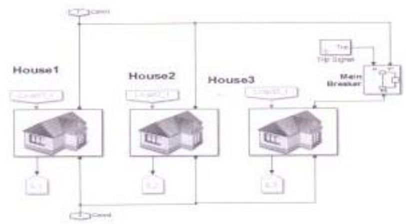

Fig: 8 Domestic Load connected to the grid

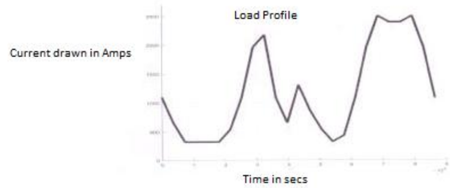

Fig: 9 Load profile considered for each house

A domestic load of three houses is considered. The loads are assumed to consume power at the voltage of the microgrid and depending on the switching on or off the loads in a house,the current consumption changes. Hence the profile of the current is taken as the basis and the loads are designed to be current sources taking the signal of the load profile. The behaviour of the loads is considered as an internal aspect and represented in the load profiling. The load change is calculated on a per minute basis. The domestic loads considered and the current profile are shown in Fig 8 and Fig 9 respectively.The SSI discussed here is considered to have a solar PV plant set up on its roof-top, which is half of the is size of the plant considered previously. This is now represented as half the solar radiationconsidered previously in Fig 7, so that the power output also is half. The load here is approximately five times the power drawn by a house. The industrial load and the solar PV connected are modelled in the simulink as shown in Fig 16

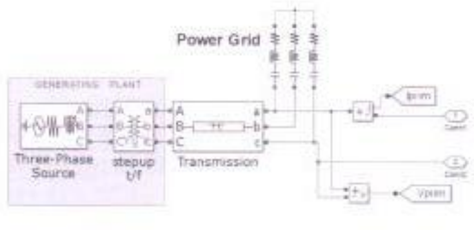

Fig:10 The Power Grid considered for simulation

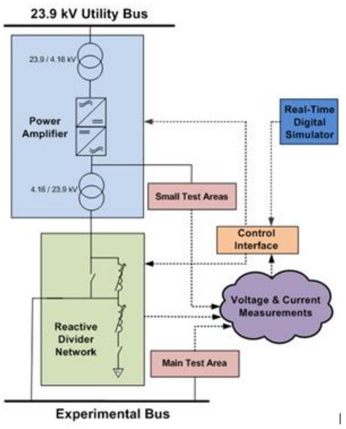

Fig: 11 The grid simulator system

A simplified diagram of the grid simulator system is shown in Figure 11. The system has four main components: power amplifiers, a reactive divider network,

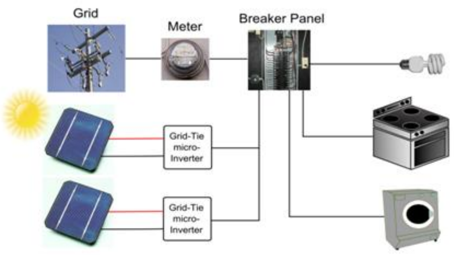

Fig: 12 Diagram of a residential grid-connected PV system

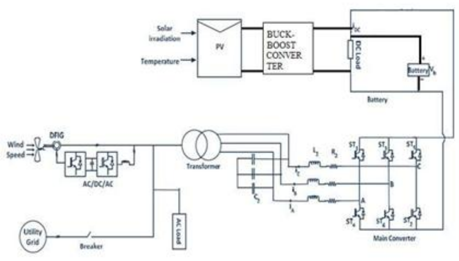

Fig 13: Representation of hybrid micro grid

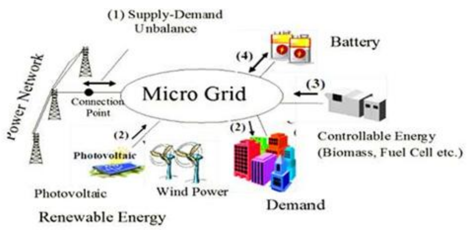

Fig.:14 General representation of hybrid micro grid.

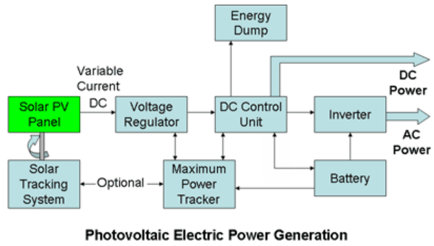

Fig: 15 small Scale Photovoltaic Plants and Domestic Applications

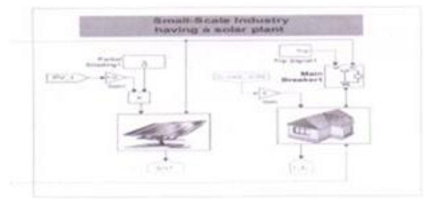

Fig: 16 Load profile considered for SSI

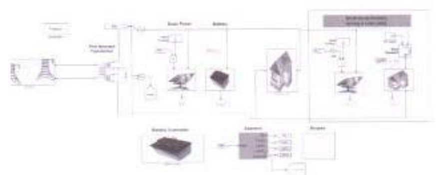

Fig: 17 Simulation diagram for the system considered

V. LOAD SHEDDING

The loads are considered are switched on and off at definite times. The term scheduling here applies to the programmed usage of the loads. In the system considered, one of the domestic loads is switched off suddenly at 8 AM and the SSI I scheduled so as not to consume power between 10 PM to 4 AM in the morning. There is also a partial shading (a factor of 0.3, for a short duration of time) applied on the solar panels due to the cloud cover or the shadowing effects during the day.

VI. TEST SYSTEM DESCRIPTION

The system considered is shown in Fig 17. The micro grid network is configured to be 1phase, AC (200V at 50 Hz). A maximum of 7.5 kW of power generation is available from renewable energy source (PV). The battery (operating at 200V, at 100% SOC, 1000Ah, and at 0.2 C discharge rate), shall also work in a charging mode when there is an excessive power being generated in the micro-grid. This is constrained to the upper limit of 100% SOC. The domestic load consists of three houses consuming power (maximum 2.5 kW) from the micro-grid.

The pole mounted transformer has a transformation ratio defined by the voltages of 6.6 kV/ (2*115 V) on the primary and secondary. Hence a 230 V RMS is available at the PCC from the grid. The solar power is available from 6 AM to 6 PM on a typical day. The peak solar irradiation is available from 2PM to 3PM. The peak value of loads, (which are combination of domestic and industrial consumer power) are occurring at 9AM, then at 7PM to 10 PM.

As the solar energy available is enough to meet the demands during the noon times, the battery remains in off mode and the SOC is maintained during that time as constant.

A small surgical disturbance is created by switching off the domestic load (3rd house) to observe the transient reaction of the grid, so that the real power flow can be studied at the PCC. The results obtained by simulating the above are described below.

VII. SIMULATION RESULTS

The above system (Fig 17) is simulated using MATLAB 2015a. The time period is taken to be 1-day i.e., 24×60×60 seconds. The simulation is carried out in a phasor mode with a frequency of 50 Hz to match the system's requirement of Indian sub-continent. The simulation is carried out with an aim to make the micro-grid self- sufficient I.e., to be able to meet the demand by the distributed sources within the micro-grid. There are four loads (3domestic and one industrial) and two sources (solar PV) and an energy storing element (Battery) in the micro-grid. At the PCC, voltage and currents are measured so that he power exchange between the grid and the micro-grid can be studied. Analysis is specifically made on a few points of interest that are detailed below.

The power generated by the two solar panels during the day and the power delivered/consumed by the battery are shown in Fig: 19. The zero state of the battery power shows that it is idle.

The power generation from solar PV can be seen to be maximum during the noon times. When the solar power generation is not present, the battery is taking over the load during the evenings and mornings.

It is usual practice that ant self-sufficient system will have total power generation equal to the total load on the system. This is the basis on which PI controller is designed to work. The relationship can be mathematically written as:

$P_{Solar\ PV} + P_{Battery} = P_{Load}$…………(2)

Eqn. 2 can be written as

$P_{Solar\ PV} + P_{Battery} - P_{Load} = 0$ ……………… (3)

The system's response to the Eqn. 3 in Fig. 9

The above Fig. shows that Eqn. 3 is almost satisfied, but not during the period 12PM to 6PM. The graph is positive from 12PM to 5.30 PM, because the generation is more than the total demand, while the negative values show that the grid is supplying power to the micro-grid.

The excess power generated by the micro-grid has to be fed to the grid through the PCC. The power monitored at the PCC is observed to match the power transfer at PCC.

If the battery is available all the time, i.e., the controlling on the battery is over looked, then the power balance equation would be satisfied and the battery is seen to be changing from the micro-grid power. There is no exchange of power from the grid, as the PI controller in the battery controller circuit is proving to be effective. The SOC of the battery is also maintained high i.e., 80% -60%. The ampere hour discharge of the battery can be monitored and this can decide the capacity of the battery needed in the system. Here a peak of more than 210Ah is observed as shown in Fig: 21.

An analysis can also be made to estimate the capacity of the solar panel needed for the SSI, so that the micro-grid would still be self-sufficient. An efficient battery management algorithm can be implemented so as to see that the battery SOC would not violate the standard values of 20% -80% at any given point of time in a day.

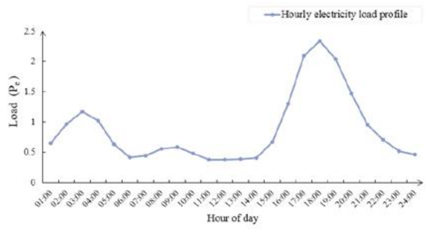

Fig: 18. Potential rural electrical energy load profile

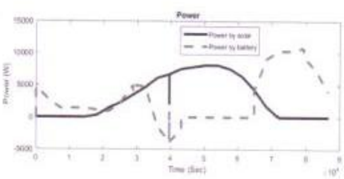

Fig: 19 Load profile considered for SSI

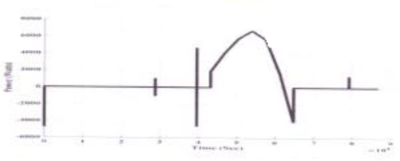

Fig: 20 Representation of the power balance equation

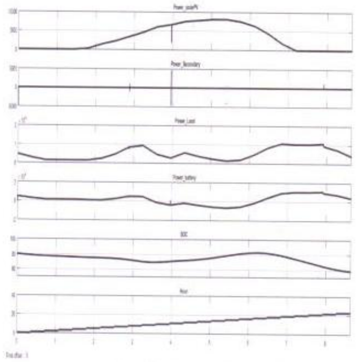

Fig: 21 Illustrates the various values

VIII. CONCLUSION

This paper analyses a single phase micro-grid connected to the grid, under a distributed generation environment and loads considered in the domestic and small scale industrial levels. The efficiency and the self-efficiency of the micro-grid are studied under two different scenarios depending on the control of the battery. The importance of the energy storage system in increasing the reliability of the system is studied. A design which is flexible to determine the capacities of the storage elements and the power sources is framed so as to facilitate future research.

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