RELIABILITY IMPROVEMENT OF GRID CONNECTED DISTRIBUTED GENERATION SYSTEM FOR VARIOUS LOAD CONDITIONS

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Abstract: Modern society generally expects high reliability power supply. Electricity interruption may cause high damage to consumers. Most of load interruptions are due to voltage and load fluctuation in distribution systems. To be reliable distribution system, load fluctuation can be reduced by equalling the fluctuated load and generated power from the renewable energy sources. To improve the reliability of existing distribution network, the renewable energy sources with control techniques are applied Industrial Zone 1 in Mandalay to control supply and demand power. In this paper, one of these grid connected distribution system was presented to full fill the demand power by using real time switching power management. The simulation for the proposed reliable distribution system is demonstrated by MATLAB in various loads condition and the simulation results are analysed for a case of fluctuated industrial loads in Myanmar. In the study area, reliability efficiency is 0% when breakdown condition. According to the results, the stability is greatly improved by 54.79%. The proposed model and methods are applicable to not only Industrial zone which have conventional distribution system but also emergency load condition in which priority consumer loads.

Key words: Photovoltaic System, Biomass Generation System, Municipal Solid Waste (MSW) Renewable Energy Sources(RES) Real radiation data, Synchronizing Technique, Demand side management

1. INTRODUCTION:

Renewable energy technologies are utilized throughout the world for "clean energy" as the concerns for the impact of non –renewable energy extraction and the use on the environmental increases. The size and clean energy technology, renewable energy sources can be installed in close proximity to end-use consumers [1]. Therefore, the installation and maintenance costs for generation and transmission facilities can be significantly reduced. In addition, because a portion of energy consumption of end-use consumers can be supplied by the local renewable energy sources, energy losses in transmission and distribution networks can be significantly improved. Grid connected distributed generation system based on renewable energy sources is challenging due to large number of design options and uncertainty in key parameters such as load size and future fuel price. In this case study, we have considered the Industrial Zone 1 from Mandalay, which not access efficient electricity supply only from the utility grid. The total daily load average is 281MWh day. The peak load requirement decides the size of the system. Here peak load consumption is 20 MW. Industrial Zone is importance to get electricity in every time as they have priority loads. Renewable energy sources coordination to distribution system increases the penetration ratio of green energy and minimizes the CO_2 emission. In this research, the photovoltaic and biomass generation system is used as renewable energy sources. Fig.1 is the single line diagram of the Industrial Zone 1 and the proposed system. The proposed system is investigated to reliability improvement of the Industrial Zone 1 with daily load changing in this research. It can also improve efficiency; reliability and power quality are the other benefits. Due to nature of onsite generation transmission losses are very less so customizing the quality of the power supply to meet the customer request to be flexible and reliable.

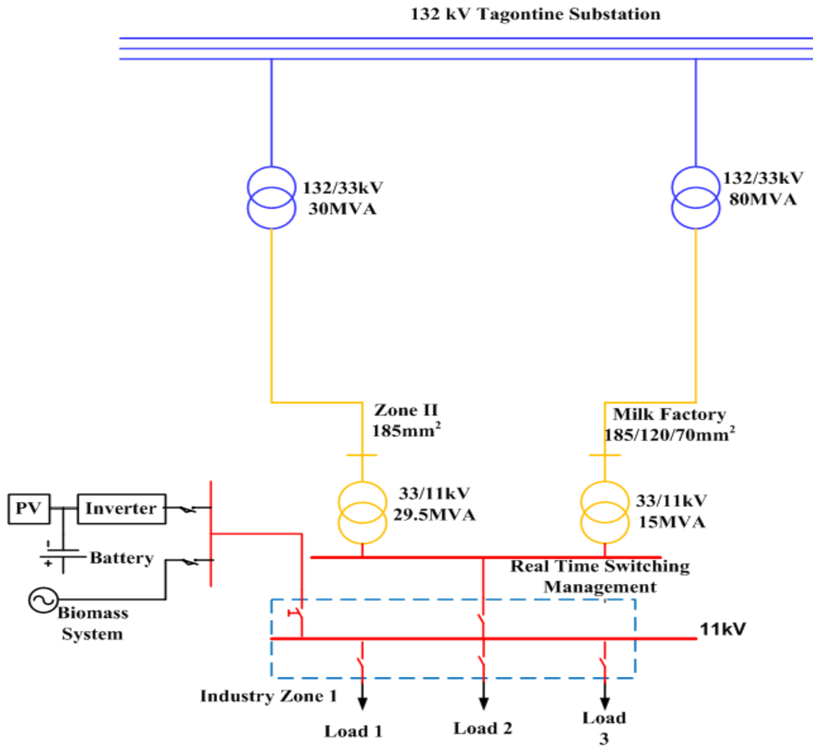


Fig.1. Single-line Diagram of Proposed System

2. SUBSYSTEMS OF THE GRID CONNECTED DISTRIBUTED GENEATION SYSTEM:

In the grid connected distribution system, two renewable energy sources namely photovoltaic and biomass generation system will be considered with national grid supply.

2.1 Photovoltaic Generation System:

A photovoltaic generator is the device that generates electrical energy as a result of the photovoltaic effect that is the electrical potential developed between two semiconductor materials when their common junction is illuminated with radiation of photons. The basic building element of a photovoltaic (PV) generator is the PV cell, also referred as solar cell [4].

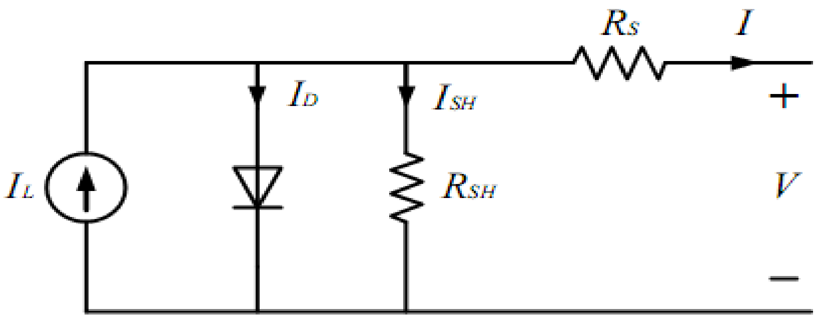


Fig.2 The equivalent circuit of a solar cell

Source:[4]

An ideal solar cell may be modelled by a current source in parallel with a diode; in practice no solar cell is ideal, so a shunt resistance and a series resistance component are added to the model. The resulting equivalent circuit of a solar cell is shown on the Fig. 2.

2.2 Biomass Generation System:

As mentioned earlier, biomass comprises of wood chips and wastes from wood industry, agricultural and forest residues, animal wastes, kitchen wastes and energy crops if available. Biomass undergoes anaerobic fermentation to produce biogas in community scale or household scale biogas digesters. Biogas is used as fuel to generate power from engine-generator set. The average biomass available in study area is 450 tons per day and monthly available average biomass resource is shown in Figure 3. In this paper, biomass generator is using municipal solid waste [3]. Figure 4 shows the pathways of Waste to Energy Technologies.

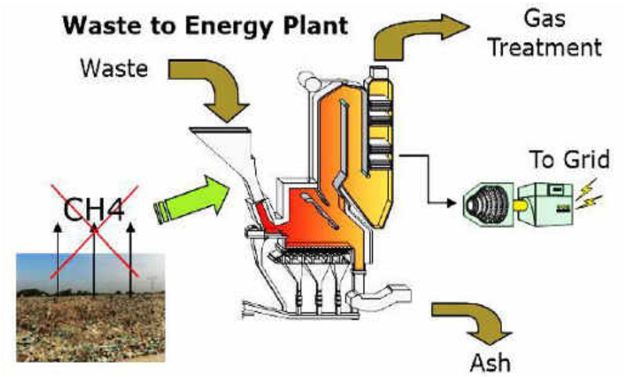


Fig.3 Pathways of Waste to Energy Technologies
Source:[3]

3. SIMULINK MODEL OF THE PROPOSED SYSTEM:

In the proposed system, energy required per day is 281.4MWh, total energy supply from utility grid per day is 185MWh and needed renewable energy is 96MWh.Renewable energy sources: photovoltaic and biomass generator using municipal solid waste coordination to the distribution system. In this model, switched filters, inverters, battery, synchronization controller, auto transfer switch are used to match the instantaneous power supply and demand power. To be correspondence with the local standard, the operation frequency is selected as 50Hz and operation voltage of the system is 11kV in distribution level. Figure 4 shows the Simulink Model for the proposed grid connected distribution system.

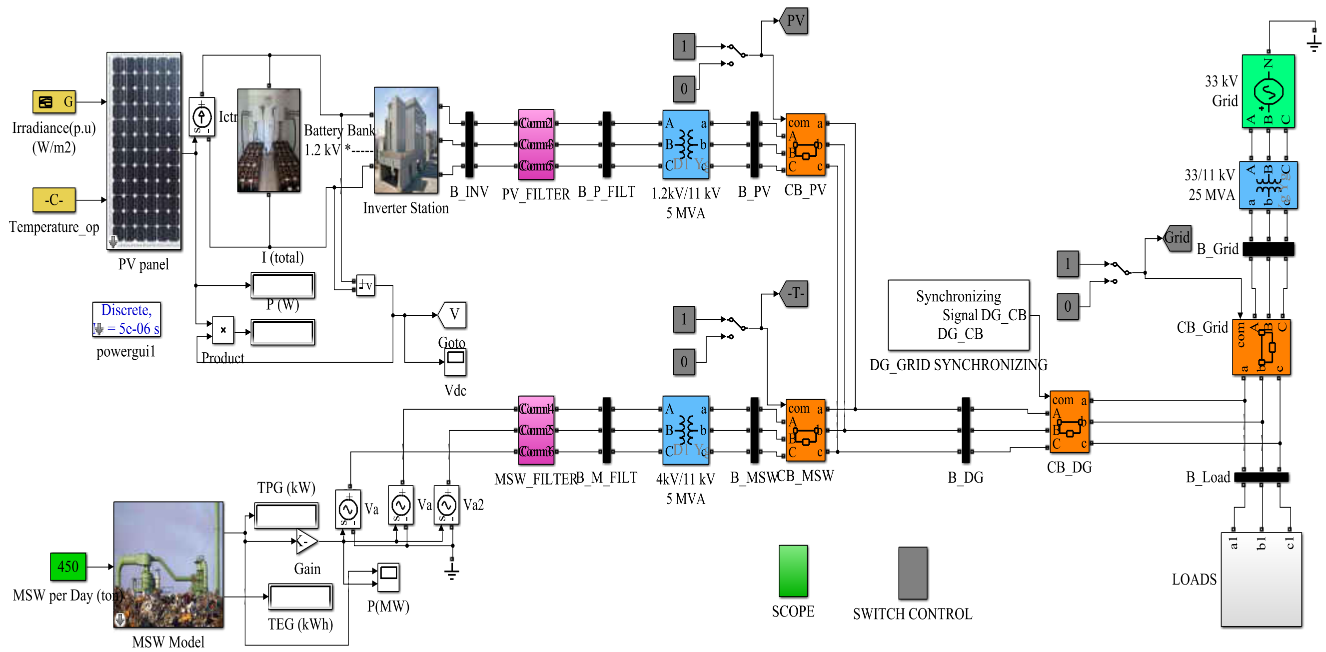


Fig.4 Simulink Model for the Proposed System

3.1 Simulink Modelling of PV Module:

For the modelling of PV module, Matlab /Simulink software package is utilized. In this proposed model, photovoltaic generation system generated 4MW. A 60kW PV module uses in this array. The array consists of 25strings of 3 series connected modules connected in parallel. If the irradiation changes this moves the operating point towards the new intersection between the I-V curves of the array .The Simulink model is shown in Figure 6. In the Simulink modelling, the simplicity and accuracy is taken as primary concern.

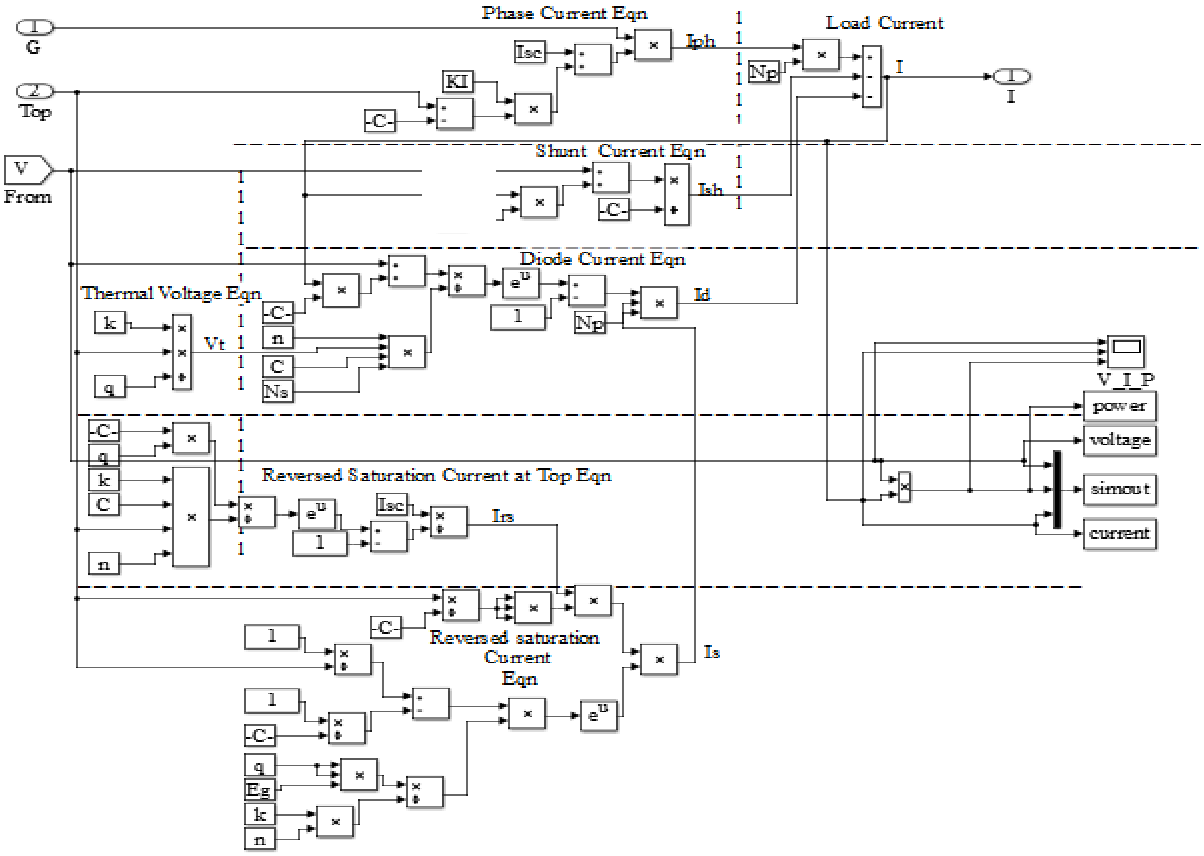
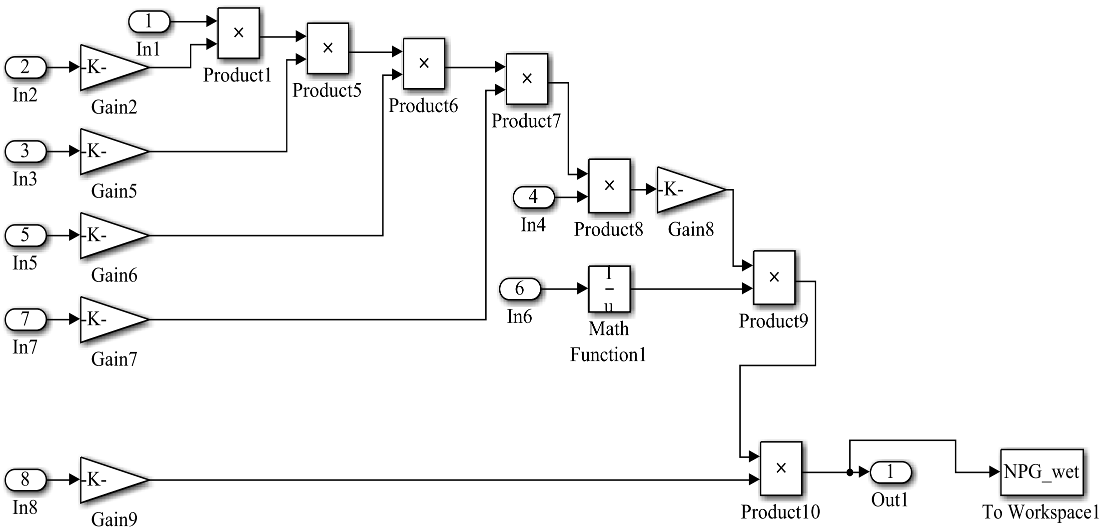


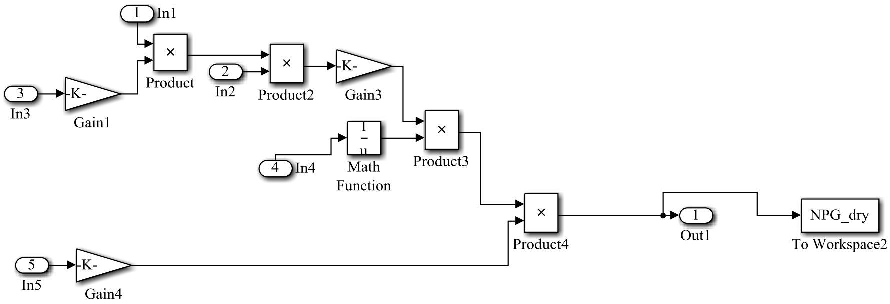
Fig 5. Simulink Model for Selected for PV Module

3.2 Simulink Modelling of Biomass Generation System:

For the modelling of biomass generation system using municipal solid waste, Matlab /Simulink software package is utilized. There are two types of MSW to generate energy. They are (i)Dry solid waste and (ii) Wet solid waste. Both of them can generate electricity but their efficiencies differ depending on their components. The Simulink model for selected biomass generation system is shown in Figure 6.



(a) Subsystem Structure of MSW



(b) Subsystem Structure of MSW (DRY)

Fig 6.Simulink Model for Selected Biomass Generation System: (a) Subsystem Structure of MSW (WET) (b) Subsystem Structure of MSW (DRY)

3.3 Synchronizing Technique for achieving Criteria:

The manual and auto synchronization has four devices are normally used voltage relay synchronizing relay and automatic synchronizer. Zero crossing method is used for synchronizing criteria due to simple structure and accurate but it has some disadvantages it produce more noise ,harmonics and also wait for long measurement. A new synchronizing technique contains detecting signal for synchronizing criteria, signal conditioner, and zero phase angle difference estimation. This method help to reduce harmonics and noises also gives instant and precise phase angle difference [7]. The intelligence electronic device made up of new synchronizing method is responsible for measuring synchronizing criteria also control static transfer switch. In Figure 7, Intelligence Electronic Device (IED) sense the three phase voltages of both sides and calculate the frequency, phase and magnitude of voltage for synchronizing criteria both sides are compare results send to controller through network.

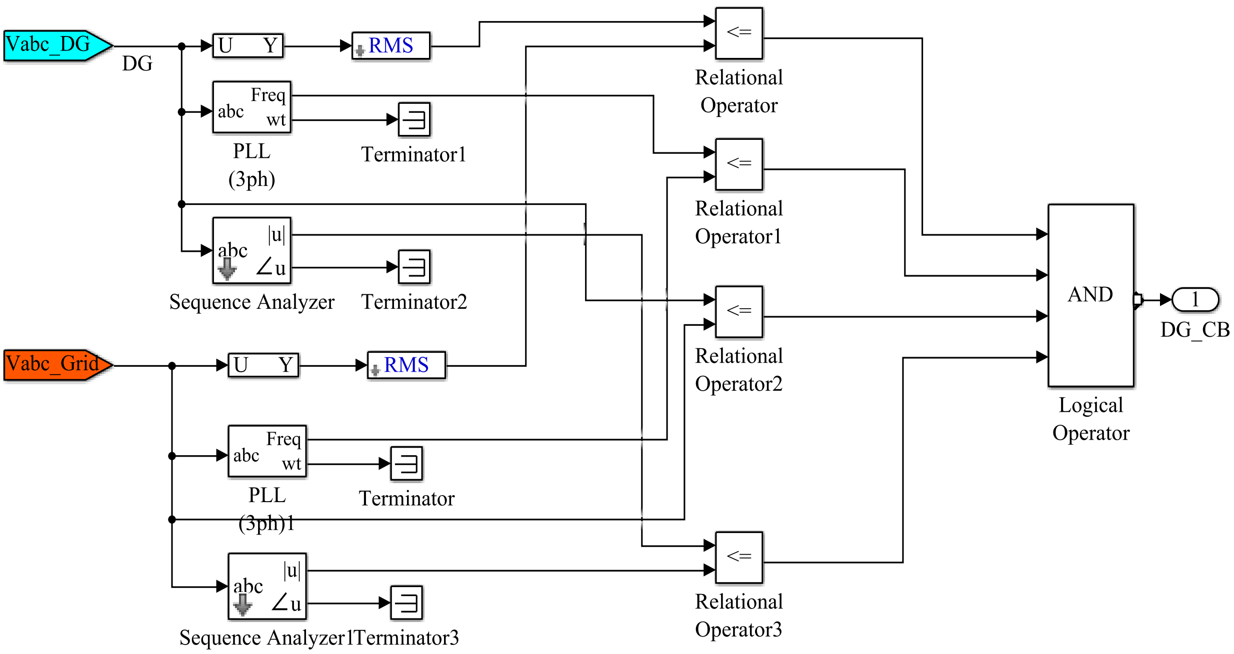


Fig.7 Control Structure of Grid and Distributed Generator Synchronizing System

4. SIMULATION RESULTS:

To evaluate the performances of the supporting renewable energy sources coordination to distribution system, three operations are created as follows:

[1] Grid Connected Distribution System for Optimal Load Condition

[2] Grid and Renewable Energy Sources Coordination for Peak Load Condition

[3] Grid and Renewable Energy Sources Coordination for Minimum Load Condition

4.1 Simulation Result of the proposed system in Optimal Load Condition:

The function of grid connected distributed generation system is to provide the demand power of the load. Figure 8 shows the daily load curve for Industrial Zone one in Rainy Season. In this Fig, peak load consumption is 14.6 MW, minimum load consuming is 8.3MW. As mentioned before, the distribution system is to operate at 11kV, 50Hz.

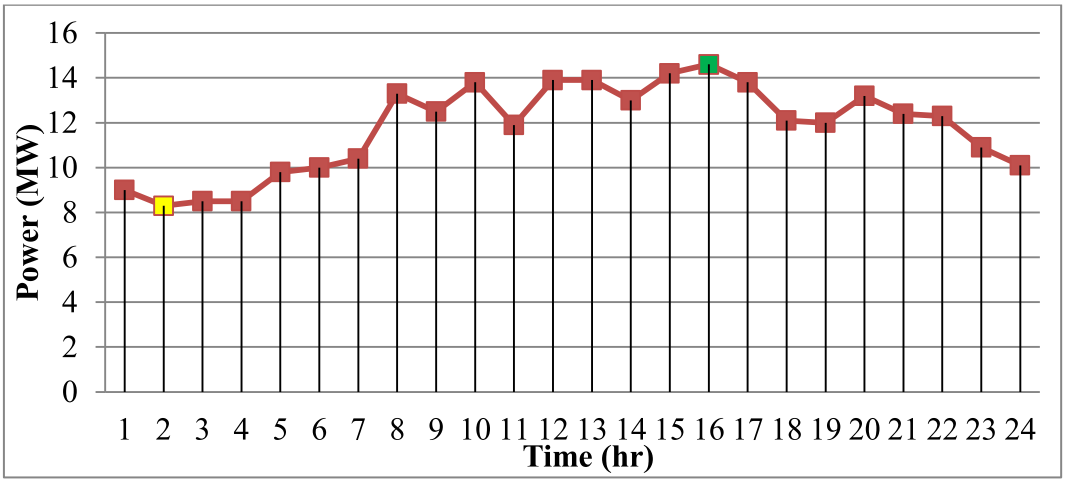


Fig. 8 Daily Load Curve for Zone 1in Rainy Season
Selected Date: 2.6.2015

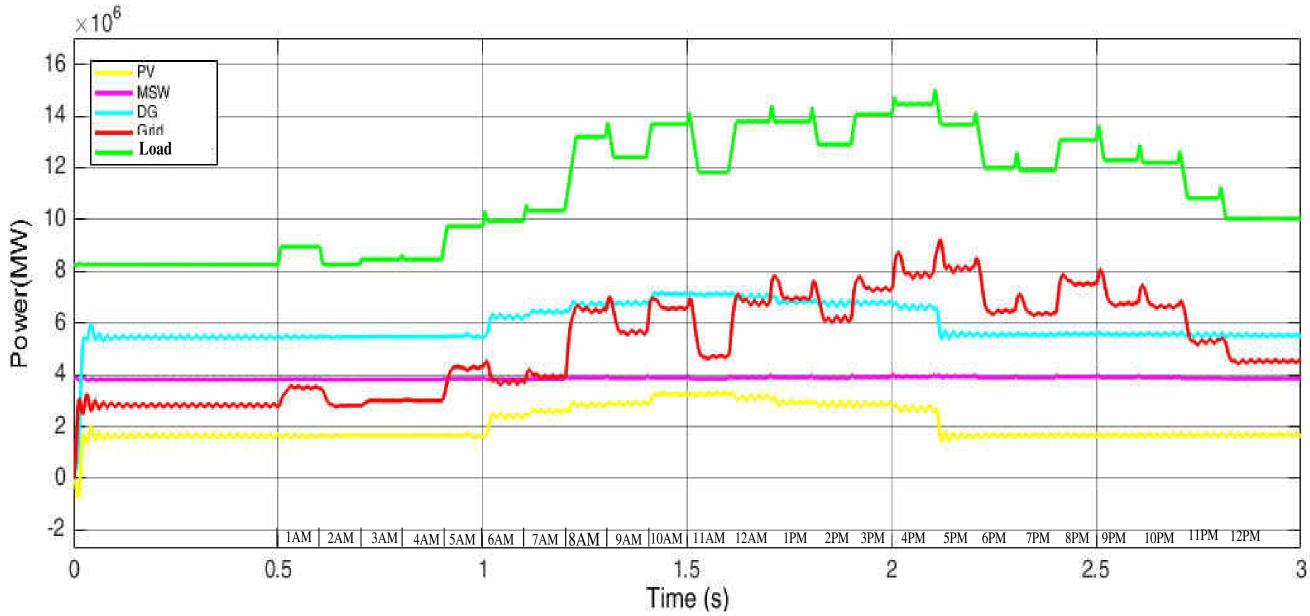


Fig.9 Simulation Results of the Proposed System Supply Power

The active power measurement for grid and renewable energy sources distribution system for optimum condition is shown in Fig 9. The power development by biomass supply system is 4MW.The power development by photovoltaic generation system supply is depending on solar irradiance changing in 24 hours. Within 0s to 0.5s, the active power consumed by the load is 8.3MW, the power development by biomass supply system is 4MW, the photovoltaic supply is 2MW and grid supply is 2.3MW.This is based power for the priority load of Industrial Zone 1. Within 2 sec to 2.1 sec (4PM),load consumed power is 14.6 MW, biomass system is supplied 4MW,photovoltaic supplied is 2.607MW and another needed demand power 7.959MW is supply by grid. In this Simulink model, grid connected distributed generation system is supplied power to match Instantaneous supply power and demand power by using real time switching power management system as time (24hr) as time duration (from 0.6 sec to 2.9 sec).

4.2. Simulation Result of the proposed system in Peak Load Condition:

The function of grid connected distributed generation system is to provide the demand power of the load. Figure 10 shows the daily load curve for Industrial Zone one in summer. In this Fig, peak load consumption is 19.6 MW, minimum load consuming is 11.6MW. As mentioned before, the distribution system is to operate at 11kV, 50Hz.

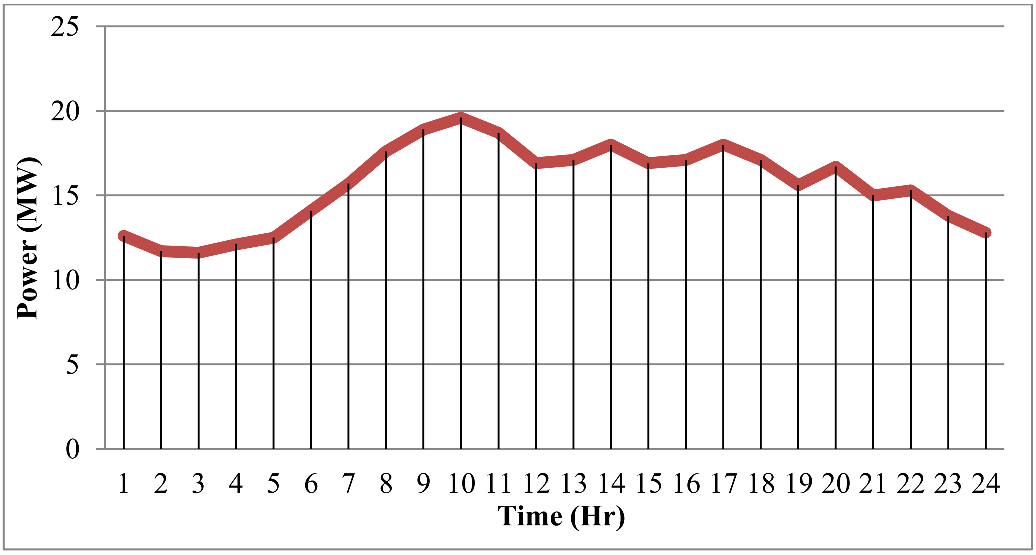


Fig. 10 Daily Load Curve for Industrial Zone One in Summer
Selected Date: 30.4.2015

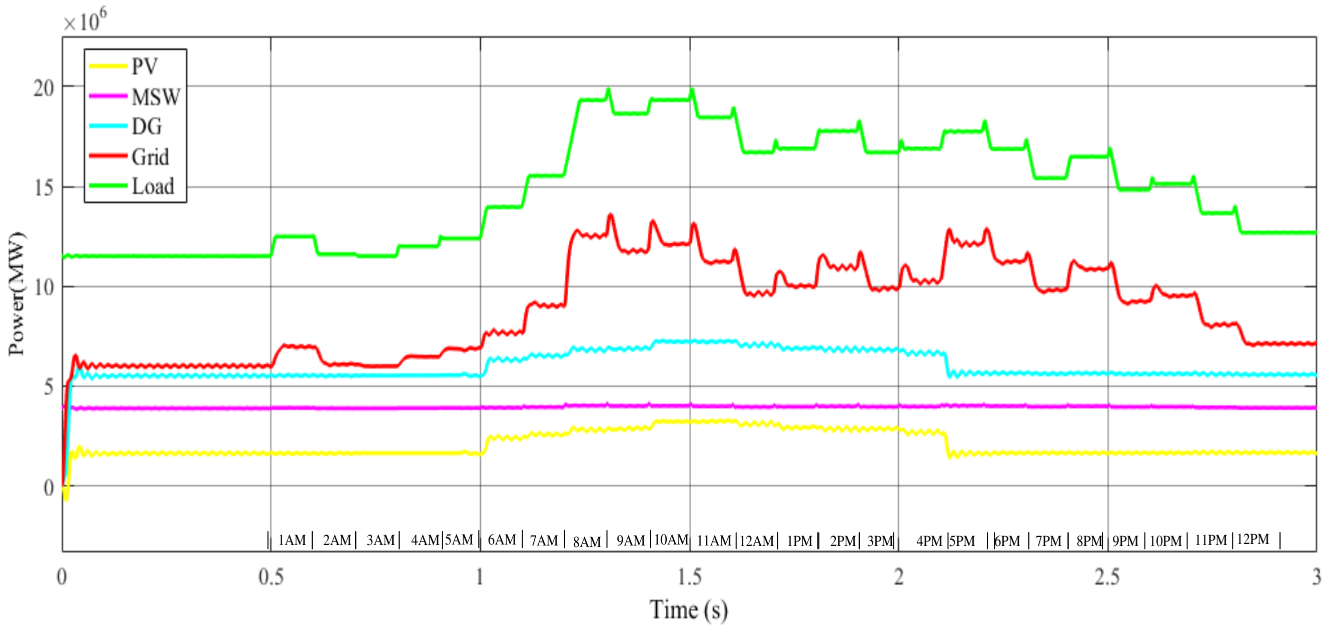


Fig.11 Simulation Results of the Proposed System Supply Power

The active power measurement for grid and renewable energy sources distribution system for optimum condition is shown in Fig 11. The power development by biomass supply system is 4MW.The power development by photovoltaic generation system supply is depending on solar irradiance changing in 24 hours. Within 0s to 0.5s, the active power consumed by the load is 11.6MW, the power development by biomass supply system is 4MW, the photovoltaic supply is 2MW and grid supply is 3.6MW.This is based power for the priority load of Industrial Zone 1. Within 1.4 sec to 1.5 sec (10AM),load consumed power is 19.6 MW, biomass system is supplied 4MW,photovoltaic supplied is 3.202MW and another needed demand power 12.14MW is supply by grid. In this Simulink model, grid connected distributed generation system is supplied power to match Instantaneous supply power and demand power by using real time switching power management system as time (24hr) as time duration (from 0.6 sec to 2.9 sec).

4.3. Simulation Result of the proposed system in Minimum Load Condition:

The function of grid connected distributed generation system is to provide the demand power of the load. Figure 10 shows the daily load curve for Industrial Zone one in summer. In this Fig, peak load consumption is 19.6 MW, minimum load consuming is 11.6MW. As mentioned before, the distribution system is to operate at 11kV, 50Hz.

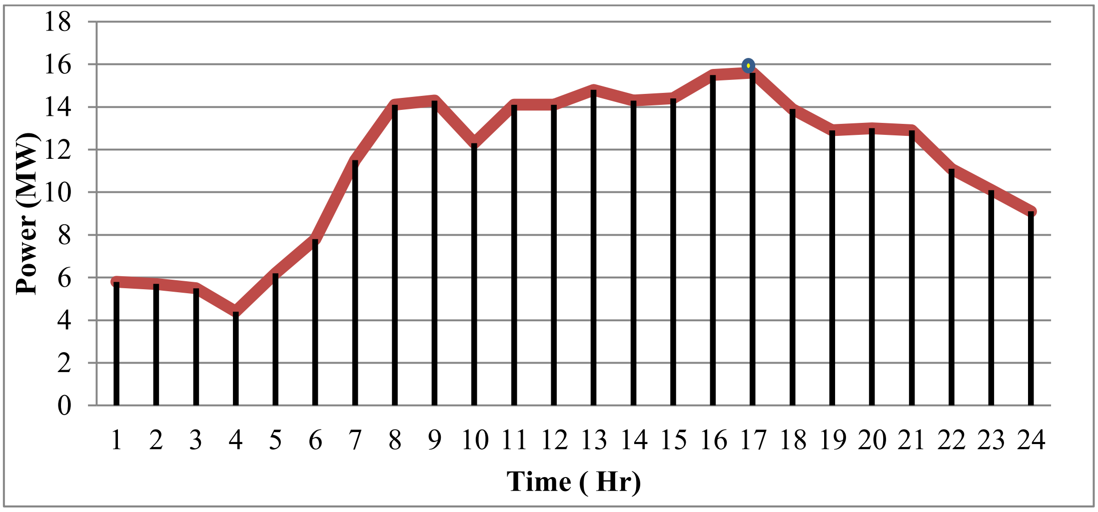


Fig.12 Daily Load Curve for Industrial Zone One in Winner
Selected Date: 30.12.2015

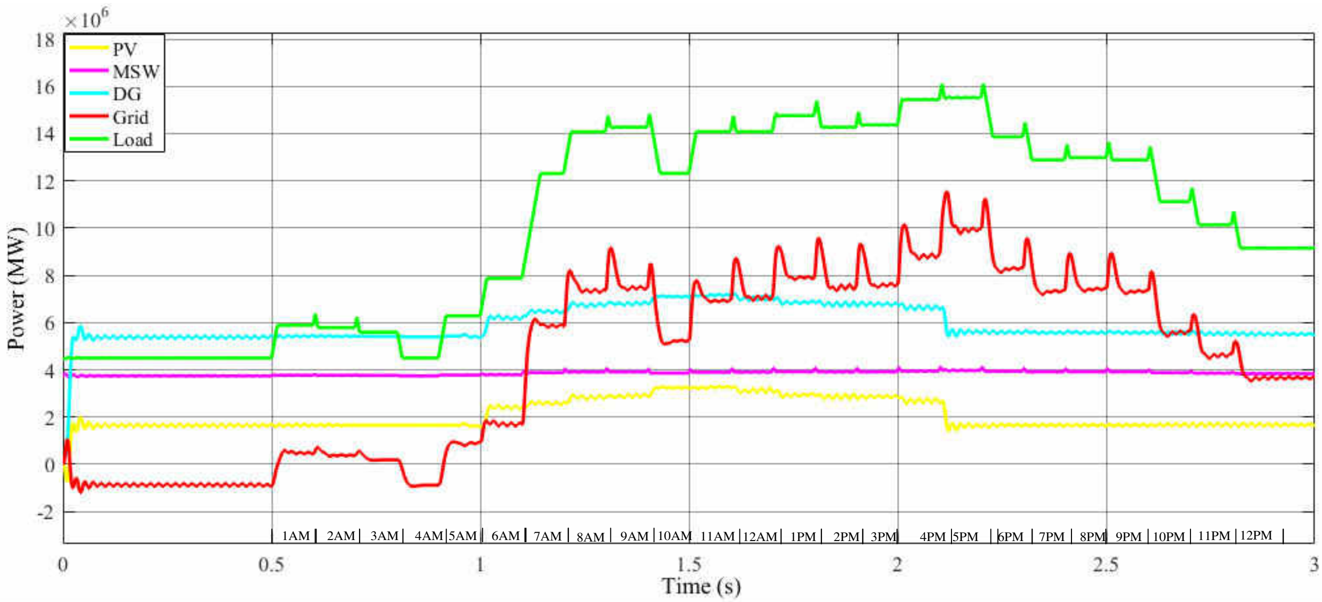


Fig.13 Simulation Results of the Proposed System Supply Power

The active power measurement for grid and renewable energy sources distribution system for optimum condition is shown in Fig 11. The power development by biomass supply system is 4MW.The power development by photovoltaic generation system supply is depending on solar irradiance changing in 24 hours. Within 0s to 0.5s, the active power consumed by the load is 4.4MW, the power development by biomass supply system is 1.5MW, the photovoltaic supply is 1.5MW and grid supply is 1.5MW.This is based power for the priority load of Industrial Zone 1. Within 2.1 sec to 2.2 sec (5PM), load consumed power is 15.6 MW, biomass system is supplied 4MW, photovoltaic supplied is 1.582MW and another needed demand power 9.984MW is supply by grid. In this Simulink model, grid connected distributed generation system is supplied power to match Instantaneous supply power and demand power by using real time switching power management system as time (24hr) as time duration (from 0.6 sec to 2.9 sec).

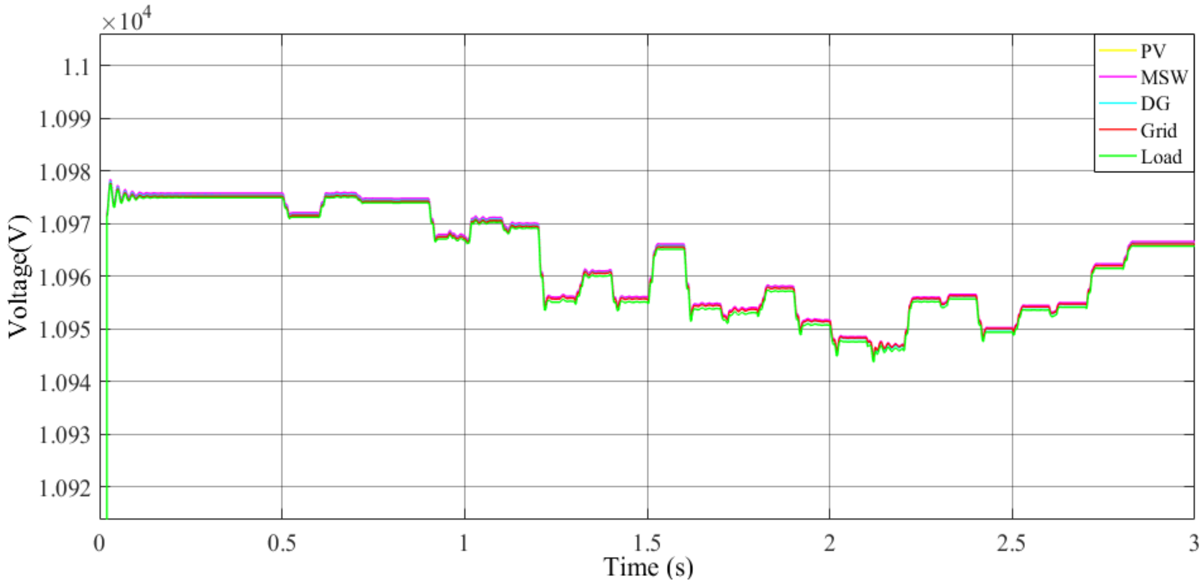


Fig.14 Simulation Results of the Proposed System Supply Voltage

In the voltage measurements at all conditions, the generation bus exhibits 11kV and the load bus shows 11kV in Fig14.

4.4. Reliability Indices

A distribution system is one of the main three parts of a power system, responsible for transferring electrical energy to the end users compared with generation and transmission parts. However, analysis of the customer failure statistics of most utilities indicates that the distribution system makes the greatest individual contribution to the unavailability of supply to a customer In order to reflect the severity or significance of system outages, customer indices are evaluated.

$$\text{SAIFI} = \frac{\text{total number of customer interruptions}}{\text{total number of customer served}} = \frac{\sum \lambda_i N_i}{\sum N_i} \text{ f/customer/yr} \quad (1)$$

$$\text{SAIDI} = \frac{\text{sum of customer interruption duration}}{\text{total number of customer}} = \frac{\sum U_i N_i}{\sum N_i} \text{ hr/ customer /yr} \quad (2)$$

$$\text{CAIDI} = \frac{\text{sum of customer interruption duration}}{\text{total number of customer interruptions}}$$

$$= \frac{\sum U_i N_i}{\lambda_i N_i} \text{ hr/customer/yr} \quad (3)$$

$$ASAI = \frac{\text{Customer Hours Service Availability}}{\text{Customer Hours Service Demands}} \quad (4)$$

$$= = \left[1 - \frac{\sum U_i N_i}{Ni \times Ti} \right] \times 100$$

by using historical outage data recorded in distribution outage reports. This is important so that utilities know how their systems are performing, but is less useful when the specific impact of various design improvement options wish to be quantified and compared. To make such comparisons, a model must be developed which is capable of predicting reliability measures based on system topology, component reliability data, and operational da ta. Where $L_{a(i)}$ is average load demand at load I and U_i is outage time at load point i. Reliability indices are useful for determining what a customer can expect in terms of interruption frequencies and durations. Reliability indices are typically computed by utilities at the end of each year. In this Industrial zone has a total of 7,000 customers. Power Outage hours per year is 133.52 hours and the total number of customers interrupted is 205. Therefore, the reliability indices for Industrial Zone 1 is shown by without Renewable Energy Sources (RES) and with Renewable Energy Sources (RES)in table 1.

Table I Reliability Indices of Industrial Zone One

	Industrial Zone One	
	Without RES	**With RES**
SAIDI	9,211.2 min per customer	198.1543 min per customer
SAIFI	1	0.4285
CAIDI	9,211.2 min per interrupted customer	4,623.6min per interrupted customer
ASAI	89.98%	99.99%

5. CONCLUSION:

As expected, the ability of grid connected distributed system in improving the reliability of power distribution networks is much depending on the ratio of their generation and load demand. The power produced by renewable based grid connected distributed generation system normally depends on the environmental condition. In addition, the load demand also changes with factors such as hourly and seasonal customer activity. This study refers to investigate the grid connected distributed generation system based renewable energy sources by using the MATLAB/ Simulink program. In this paper, the simulated results show the simulation models and results of distribution system with or without renewable energy systems by the daily load profile of Industrial Zone 1.In various load condition, grid connected distributed generation system is supplied to fulfil needed of demand power by real time switching power management system. It is own supply system that it is reduce SAIDI from 9,211.2 min per customer to198.1543 min per customer and reduce CAIDI from 9,211.2 min per interrupted customer to 4,623.6min per interrupted customer.As a result, this provides much more accurate estimation of reliability indices in grid connected distributed generation system based on renewable energy sources.

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