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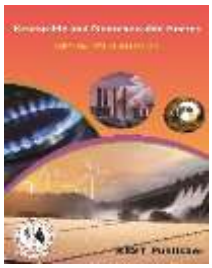

Design & Analysis of Grid Connected Hybrid PV-Diesel Power System

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***Abstract*:** *The use of renewable energy in power plant is starting to be developed and continually added capacity in parallel with the existing diesel. The combination of solar power photovoltaic (PV) and diesel generator hybrid is to be installed. The combination of renewable energy and the existing diesel power system is related with hybrid configuration due to the operating system. Further Study to evaluate the existing configuration and provide the results the meteorological data is required. To configure this project the technical and financial performances of the hybrid system will be simulated as per the industry requirements. (1) Studying the load demand for every month in a year, (2) Calculating the maximum, minimum and the average load demand, (3) Introducing the solar data in HOMER/MATLAB any other contemporary design & simulation software, (4) Designing the hybrid model. Grid connected system is compared with standalone hybrid power system.*

Keywords: *Hybrid Energy system (HES), photovoltaic system (PV),DG set.*

1. INTRODUCTION

Energy plays a vital role in modern world. As a matter of fact electricity use has become a barometer of level of development and quality of life. Human Development Index (HDI) rises sharply with increase in energy consumption up to around 5000kWh per capita. Beyond this level HDI reaches a maximum saturation level. We have to cover a lot of ground from the present level of around 800 kWh per capita to reach 5000 kWh per capita. The energy demand is increasing day by day due to increase in population, urbanization and industrialization. The world's fossil fuel supply viz. coal, petroleum and natural gas are depleting at alarming rate, with in short span of time fossil fuels will be exhausted. The demand for energy is increasing mainly due to usage machinery, these machines are consuming energy mainly in two forms(1) electrical form and (2) fossil fuel form. for generation of electricity we are using fossil fuels. Ultimately we are relying on depleting fossil fuels . This is right time for the world to think of alternate sources which are not depleting like solar energy. Renewable energy sources are needed to pay much attention at technological prospective as it at infantry stage.

2. LITERATURE REVIEW

Pragya Nema[1] explainedHybrid Energy Systems, Hybrid energy systems combine two or more energy conversion devices, or two or more fuels for the same device, that when integrated, overcome limitation in either. A hybrid energy system is a combination of two or more energy sources with fossil fuel powered generator to provide electric power where the electricity is either fed directly to grid or to batteries for energy storage.

Pragya Nema, SayanDutta [2] explained main reasons of integrating renewable energy sources in a hybrid system is primarily to save fossil fuel (diesel). Therefore a diesel generator is mainly used as a backup. Hybrid system can be configured in three different ways: grid connected off-grid with distribution system and for direct supply. The first configuration is able to rely on grid if the hybrid system has problems. Similarly feeding the power to the grid, thereby, boosting the voltage and minimizing power cuts strengthens the grid. For off-grid configurations, the hybrid can either be connected to many load centre's or can act

as a source of supply for one or two loads, thus avoiding the need of a distribution system. An isolated off-grid system is usually used to charge batteries or supply power to small rural industry/households, . Hybrid systems can address limitations in terms of fuel flexibility, efficiency, reliability, emissions and / or economics.

Brig.M.R.Narayaoan, D.V.Gupta, R.C.Gupta & R.S.Gupta[3]the hybrid system configuration is the configuration of the bus used in the operation of the hybrid system. On the application of renewable energy, there are three kinds of bus: dc bus, ac-dc bus and ac bus. Dc bus is called the generating unit (renewable energy and diesel) as well as the load served by one type of bus, the dc bus. Including the configuration of diesel gen-sets using dc voltage output. The ac-dc bus is used in dc bus related to renewable energy, while the diesel generator is connected to the ac bus. To serve the load, from the dc bus through the inverter is converted into ac power. When used from energy storage, the power of the network can be taken to charge the batteries, so it requires a bidirectional inverter. The ac bus in this case is the energy produced from renewable energy including PV converted through an inverter to the ac bus to serve the load, as well as electricity from diesel generators connected to the incoming ac bus, and all the loads connected to the ac bus. When used for energy storage, even this equipment is connected on the ac bus, so we need a bidirectional converter for battery charge or burden to serve the load.

3. HOMER

Md. Tauseef Riasat, Muntasir Anik Ahmed explained aboutNational Renewable Energy Laboratory (NREL)'s, Hybrid Optimization Model for Electric Renewable (HOMER version 2.19) has been used as the sizing and optimization software tool. HOMER is a micro power optimization software used in evaluating designs of both off-grid and grid connected power systems for a variety of applications. Analysis with HOMER requires information on resources, economic constraints, and control methods. It also requires inputs on component types, their numbers, costs, efficiency, longevity, etc. Sensitivity analysis could be done with variables having a range of values instead of a specific number. HOMER, the micro power optimization model, simplifies the task of evaluating designs of both off-grid and grid-connected power systems for a variety of applications [3]. This software has been developed by United States (US) National Renewable Energy Laboratory (NREL) since 1993. It simulates the operation of a system by making energy balance calculations in each time step of the year. For each time step, it compares with the electric and thermal demand in that time step to the energy that the system can supply in that time step, and calculates the flows of energy to and from each component of the system. For systems that include batteries or fuel-powered generators, HOMER also decides in each time step how to operate the generators and whether to charge or discharge the batteries[3].

A. Standalone power system:

Yang. Mi1, Y. Fu1, J. B. Zhao explained the stand alone power system is one which has no access to grid. The stand-alone power generation systems are utilized by many communities and remote area around the world that have no access to grid electricity [2]. The renewable energy in hybrid power independent system is growing due to rising fuel prices and environmental warming and pollution.

B. Grid connected power system:

Grid connected system is one which is connected to grid by utilising the services of transformer and two way converter inverter system. the main intension of grid connection to improve the reliability of the system.the reliability of the system is improved by utilizing grid power when solar power is not available in night time .and by supplying the excess electricity generated during day time to the grid which might be utilized somewhere .the grid connection is to synchronized so that there will be no damage occur to the system ,for this purpose the voltage and frequency must be same for both sides i.e. on sending end side receiving end side.

C. Solar energy:

K.R. Ajao, O.A.Oladosu explained Solar energy is the most promising of the renewable energy sources in view of its apparent unlimited potential. The sun radiates its energy at the rate of about 3.8 x 1023 kW per second. Most of this energy is transmitted radially as electromagnetic radiation which comes to about 1.5kW/m2 at the boundary of the atmosphere. After traversing the atmosphere, a square metre of the earth's surface can receive as much as 1kW of solar power, averaging to about 0-5 over all hours of daylight. Although solar radiation intensity appears rather dilute when compared with the volumetric concentration of energy in fossil fuels. Nigeria receives 5.08 x 1012 kWh of energy per day from the sun and if solar energy appliances with just 5% efficiency are used to cover only 1% of the country's surface area then 2.54 x 106 MWh of electrical energy can be obtained from solar energy [7]. This amount of electrical energy is equivalent to 4.66 million barrels of oil per day. Typical of such applications are in drying, cooking, heating, distillation, cooling and refrigeration as well as electricity generation in thermal power plants. In solar photovoltaic applications, the solar radiation is converted directly into electricity. The most common

method of doing this is by the use of silicon solar cells. The power generating unit is the solar module which consists of several solar cells electrically linked together on a base plate. On the whole the major components of a photovoltaic system include the arrays which consist of the photovoltaic conversion devices, their interconnections and support, power conditioning equipment that convert the dc to ac and provides regulated outputs of voltage and current; controller, which automatically manages the operation of the total system; as well as the optional storage for standalone[7] (non-grid) systems.

D. Wind energy:

The energy available in the wind depends on the density and air velocity. The density, as any other gas, changes with the temperature and pressure which varies with the high level of the sea. The energy of a mass of air which is displaced is determined by the Kinetic Energy (K.E) when wind move across the wind turbine, the static pressure drops to a lower pressure than the atmospheric pressure. As the air follows its trajectory, it takes its atmospheric value again, inducing an extra wind deceleration. By this way, in a distance between upstream of the turbine and downstream, behind the turbine, there is no change in static pressure, but there is a reduction in kinetics energy. Wind is a natural phenomenon related to the movement of air masses caused primarily by the differential solar heating of the earth's surface. Seasonal variations in the energy received from the sun affect the strength and direction of the wind. The ease with which wind turbines transform energy in moving air to rotary mechanical energy suggests the use of electrical devices to convert wind energy to electricity. Wind energy has also been utilized, for decades, for water pumping as well as for the milling of grains.

E. Biomass energy:

Biomass refers to the mass of biological material produced from the living processes, such as plants, trees, agriculture crops, household waste and wood. These are used traditional technology for day-to-day needs such as heating water and cooking. In developed countries wood is used for generating electricity.

F. Tidal and geothermal energy:

Tidal energy and geothermal energy sources are the ones which do not originate from the sun. In tidal energy, the kinetic energy of water from a higher altitude to a lower altitude is made use to rotate turbine to generate electricity. In geothermal energy, the heat energy prevailing inside the earth is utilized to produce steam by pumping in water thereby generating electricity.

G. .Objective:

previous discussion reveals that the C.O.E (cost of energy) of isolated photovoltaic-diesel power is higher, as we are utilizing diesel as fuel for operation of diesel generator which is fossil fuel, the combustion of fossil fuel releases pollutants in atmosphere. suppose large capacity solar plant co exists with DG (diesel generator) during day time it will it may produce excess to the requirement, for storing excess electrical energy we may use battery banks, but the storage has limitations, we are unable to store huge quantities of energy, the conversion of electrical energy into chemical energy and chemical energy to electrical energy may not be efficient in relative comparison with direct usage of solar energy or usage of power from the grid.

For getting maximum benefits from the hybrid system grid connection is right choice, we if connect H.E.S (hybrid energy system) to grid we can buy as well we can sell when excess production. By doing so we can reduce cost of energy, pollutants can be minimized, reliability can be maintained, economy can be improved.

4. SIMULATION WORK

Simulation of PV-diesel grid connected hybrid system, HOMER software is used as tool. For simulating, the monthly daily average solar radiation data is provide as input to software, as solar resources. The simulation circuit diagram is designed in homer window by adding appropriate system components. The added components here are solar PV system, diesel generators of two, an inverter, primary load component, andgrid.

There two buses appears ,one bus on ac side other on dc side, inverter will in between the two buses which dual in nature i.e. it can convert ac to dc and dc to ac. By clicking each icon of the circuit the input values are given to them, we have to enter solar data for PV system ,and for diesel gen sets we have provide fuel cost, etc.,. For inverter we have to provide the ratings after providing all the values we have to simulate the system to get results.

A. *SIMULATION CIRCUITDIAGRAMS:*

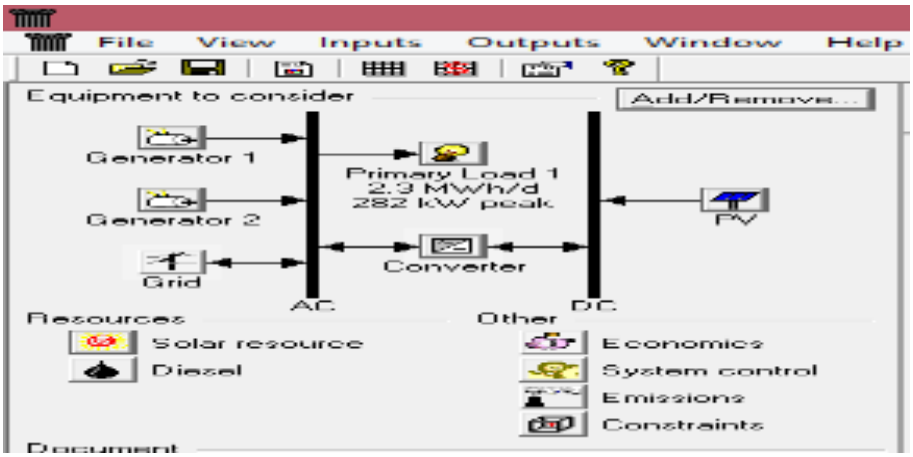

FIGURE 1. Grid connected hybrid power system Circuit Diagram.

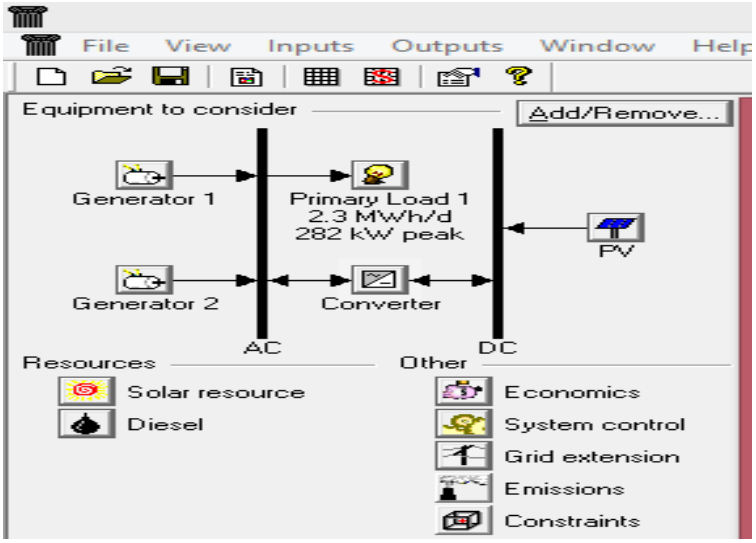

FIGURE 2. Standalone hybrid power system Circuit Diagram

TABLE 1. Daily Average Solar Radiation in Different Months

Month	Clearness index	Daily Radiation (kWh/m2/d)
January	0.658	5.436
February	0.689	6.259
March	0.681	6.802
April	0.644	6.796
May	0.595	6.359
June	0.484	5.147
July	0.453	4.812
August	0.460	4.894
September	0.503	5.102
October	0.562	50237
November	0.583	4.909
Dec	0.615	4.901

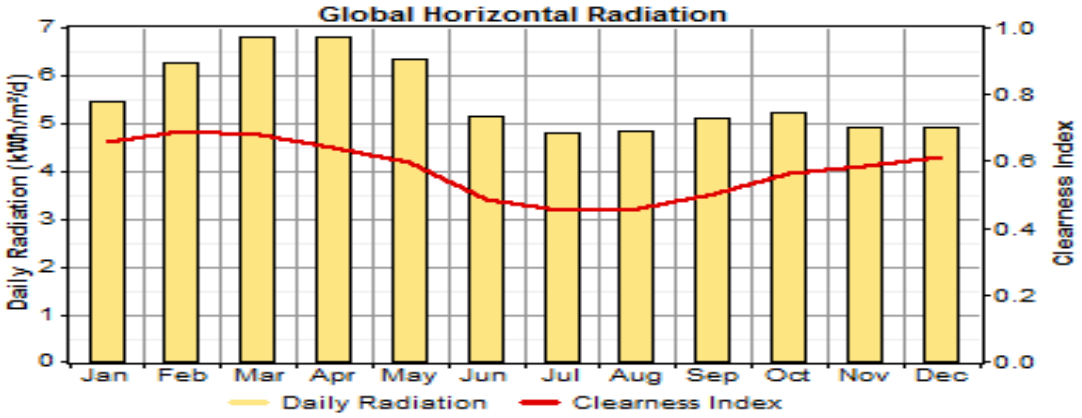

FIGURE 3. Daily Average Solar Radiation In Different Months

TABLE 2a. Diesel Generator Sets Name Plate Details

Kva Rating	140 Kva
Kw	112
Current	195amperes
Voltage	415volts
R.P.M	1500
Frequency	50hz
Power Factor	0.8
Ambient Temperature	40 Centigrades

TABLE 2b. Field Excitation Details

Voltage	55volts
Current	2.5amperes
Machine No	Ddac0672
S1duty To Is	4722-1992
Fuel Consumption	20litres Per Hour

TABLE 3. Standard Test Data For Solar Pv Panel 250watt

Parameters	Value
Peak Power Watts-PMAX (Wp)	250
Power Output Tolerance-PMAX (%)	0/+3
Maximum Power Voltage-VMP (V)	30.5
Maximum Power Current-IMPP (A)	8.20
Open Circuit Voltage-VoC (V)	37.8
Short Circuit Current-ISC (A)	8.90
Module Efficiency mη (%)	15.3

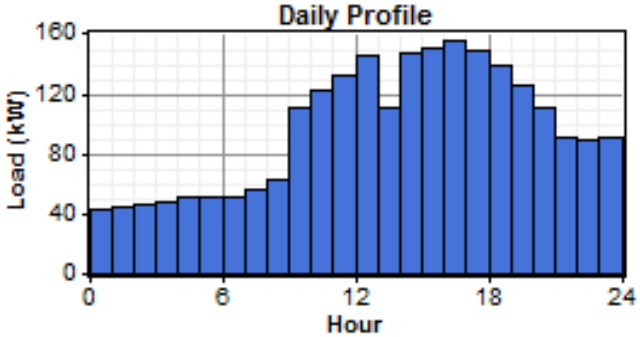

FIGURE 4. Load Profile Hourly Variation

5. RESULTS AND DISCUSSIONS

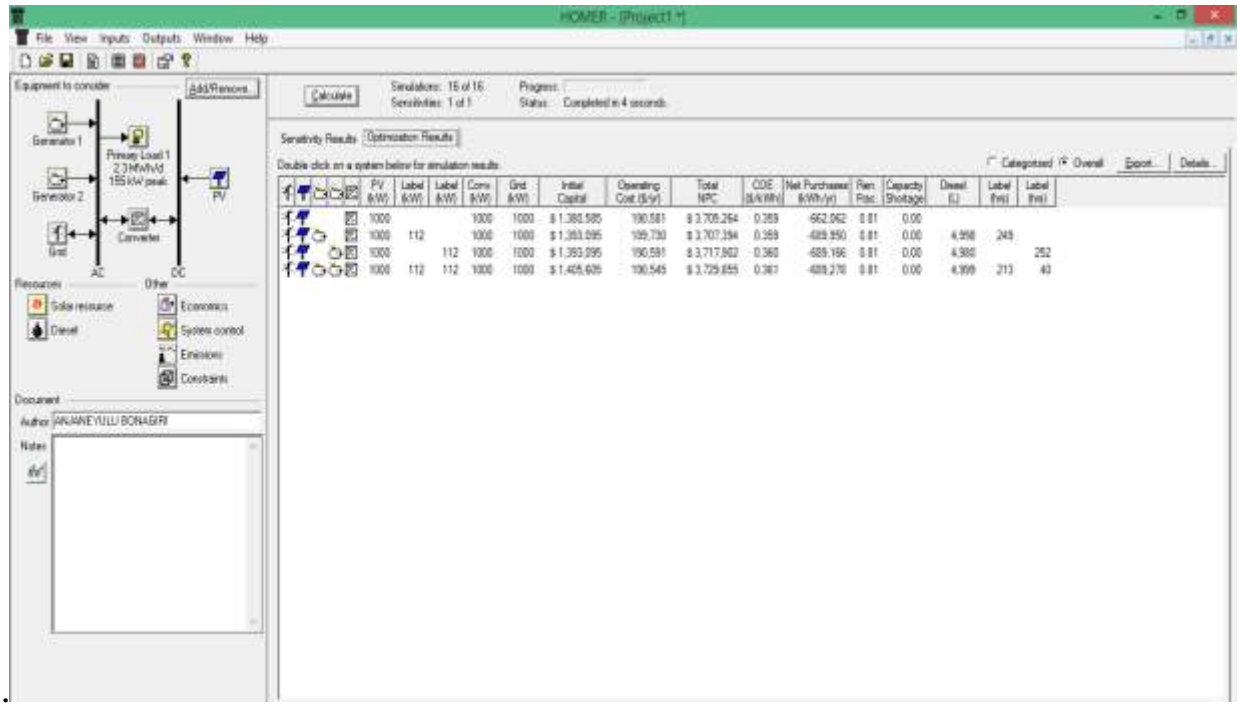

FIGURE 5. Optimization Results of grid connected system

FIGURE 6. Load Sharing Between PV and Grid

FIGURE 7. Power Production from Hybrid grid connected.

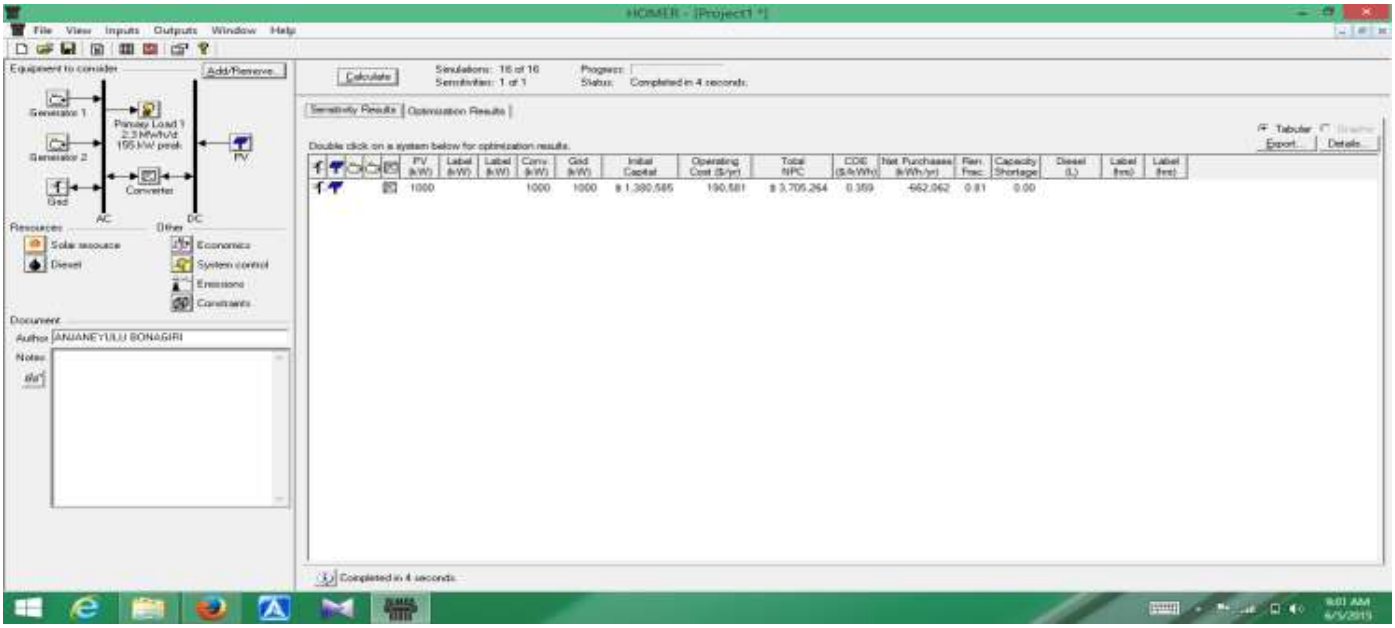

FIGURE 8. Optimization results of standalone system.

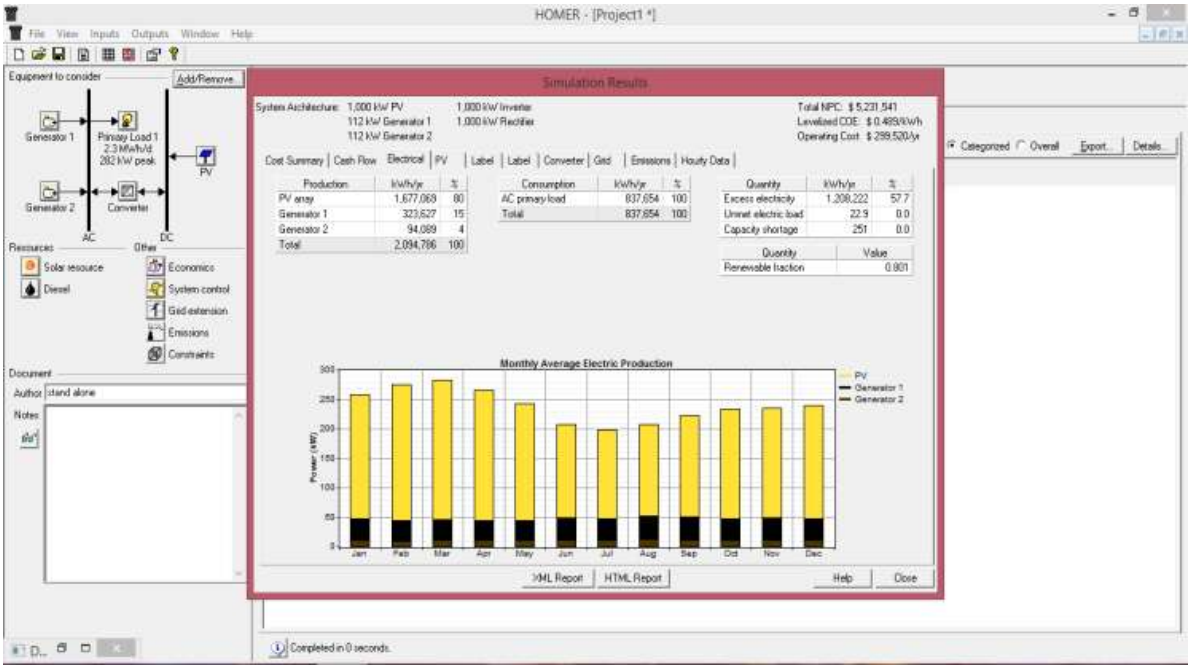

FIGURE 9. Electrical power production from pv and diesel system.

Summary of grid connected system:

PV array produced units=1677069 kw-hr/yr.
Generator 1 produced units=6234 kw-hr/yr.
Generator 2 produced units=3058 kw-hr/yr.
Purchased units from grid=380829 kw-hr/yr.
Total no of units produced from above system=2067190 kw-hr/yr.
No of units consumed or supplied to ac primary load=838041 kw-hr/yr.
Remaining units left for sales to grid=1,052,499 kw-hr/yr.
As per Andhra Pradesh Electricity Regulatory Commission (APERC).
Unit cost of energy =Rs13.50.
Diesel cost per liter=Rs59.10 (on 14 April 2015)
Sell back rate to grid per unit cost is approximately=Rs9.50.
Estimated returns from grid =106144 kw-hr/yr.*Rs9.5=Rs10083718.
From the same figure it is shown that cost of energy C.O.E=$0.176/kw-hr.
Cost of energy in rupees=0.176*62.28=10.96/ kw-hr.
Renewable fraction =0.811.
Operating cost=$33,669/yr.
Here for calculation purpose 1$ value is taken Rs 62.28. (Day by day dollar rupee value is changing so i chose this value on april14, 2015).

SUMMARY OF STAND ALONE SYSTEM

PV array produced units=1677069 kw-hr/yr.
Generator 1 produced units=323627 kw-hr/yr.
Generator 2 produced units=94089 kw-hr/yr.
Total no of units produced from above system=2094786 kw-hr/yr.
No of units consumed or supplied to ac primary load=838041 kw-hr/yr.
Excess electricity=1208222 kw-hr/yr.
As per Andhra Pradesh Electricity Regulatory Commission (APERC).
From grid unit cost of energy =Rs13.50.
From the same figure it is shown that cost of energy C.O.E=$0.489/ kw-hr.

Cost of energy in rupees=0.489*62.28=30.45/ kw-hr.
Renewable fraction =0.811.
Operating cost=$299520/yr.
Here for calculation purpose 1$ value is taken Rs62.28.(day by day dollar rupee value is changing so i chose this value on april14 ,2015).

6. CONCLUSION

simulation was done using HOMER software tool, separately on grid connected and on standalone pv diesel hybrid power system, from simulation results it was found that the cost of energy, operating and maintenance cost of grid connected hybrid power system is much lesser, when compared with standalone hybrid PV diesel power system .By utilizing grid connected hybrid system we can reduce fossil fuel usage for electricity generation, which will reduce pollutants released into the atmosphere. From results it shows that cost of unit energy is Rs10.96for grid connected pv-diesel hybrid power system. whereasstand alone system is Rs30.45 which is approximately three times of grid as well as grid connected hybrid. The initial capital needed for this kind of hybrid energy system is the only disadvantage but only in the beginning. In the long run this hybrid energy system will be more profitable and as well as environment friendly solution.

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