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Implementation of the Micro- Grid Concept And Balancing Massive Energy Production from Renewable Sources

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Abstract:- Demand-side management, along with the integration of distributed energy generation and storage, are considered increasingly essential elements for implementing the Micro-grid concept and balancing massive energy production from renewable sources. This paper reviews on a micro- grid concept in which the demand-side comprises traditional users as well as users owning some kind of distributed energy sources and/or energy storage devices. Optimization process regulated by an independent central unit reduces the monetary energy expense by producing or storing energy rather than just purchasing the energy needs from the grid. This paper gives simulation results of PV-and battery, Hybrid system for emergency load.

Keywords:- Micro-Grid, Distributed Generators, Renewable energy sources Optimization process.

I. INTRODUCTION

There has been increasing interest in the use of applications of renewable energy that can reduce the impact of CO2 emissions. However, generically, the level of electric power from renewable energy, e.g., wind generation (WG), tends to fluctuate with meteorological changes, and also photovoltaic (PV) cells generate power only in daylight hours. On the other hand, the volume of the load demanded tends to vary with how the loads are used. Therefore, when we use power from renewable energy, we depend on utility power to balance generation and demand. However, there are limits which utility power can accept. Economic, technology and environmental incentives are changing the face of electricity generation and transmission. Centralized generating facilities are giving way to smaller, more distributed generation partially due to the loss of traditional economies of scale.

Distributed generation encompasses a wide range of prime mover technologies, such as internal combustion (IC) engines, gas turbines, Micro-turbine, photovoltaic, fuel cells and wind-power. These emerging technologies have lower emissions, and have the potential to have lower cost, thus negating traditional economies of scale [1]. The applications include power support at substations, deferral of T&D upgrades, and onsite generation. A better way to realize the emerging potential of distributed generation is to take a system approach which views generation and associated loads as a subsystem or a “micro-grid”. During disturbances, the generation and corresponding loads can separate from the distribution system to isolate the micro-grid’s load from the disturbance (and thereby maintaining high level of service) without harming the transmission grid’s integrity. Intentional islanding of generation and loads has the potential to provide a higher local reliability than that provided by the power system as a whole. The size of emerging generation technologies permits generators to be placed optimally in relation to heat loads allow for use of waste heat [2]. Such applications can more than double the overall efficiencies of the systems. One of the main differences between conventional vertically integrated systems and restructured systems is the presence of DG units in the latter. Fig. 1 presents a schematic for the two different systems.

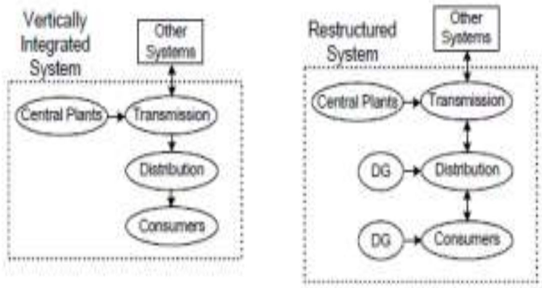

Fig. 1 conventional vertically integrated systems and restructured system

Micro-grid consists of a group of radial feeders, which could be part of a distribution system or a building's electrical system. There is a single point of connection to the utility called point of common coupling. Some feeders, (Feeders A-C) have sensitive loads, which require local generation.

II. MICRO GRID SYSTEM SCHEMATIC AND COMPONENT

Micro-grid has two critical components, the static switch and the micro-source. The static switch has the ability to autonomously island the micro-grid from disturbances such as faults, IEEE 1547 events or power quality events. After islanding, the reconnection of the micro-grid is achieved autonomously after the tripping event is no longer present. This synchronization is achieved by using the frequency difference between the islanded micro-grid and the utility grid insuring a transient free operation without having to match frequency and phase angles at the connection point [3]. Each micro-source can seamlessly balance the power on the islanded Micro-grid using a power vs. frequency droop controller. This frequency droop also insures that the Micro-grid frequency is different from the grid to facilitate reconnection to the utility. In the paper a small grid is form to meet the emergency of 200W/d and 46W peak load.

A .UNIT POWER CONTROL CONFIGURATION

In this configuration each DG regulate the voltage magnitude at the connection point and the power that the source is injecting, P. as shown in Fig. 2

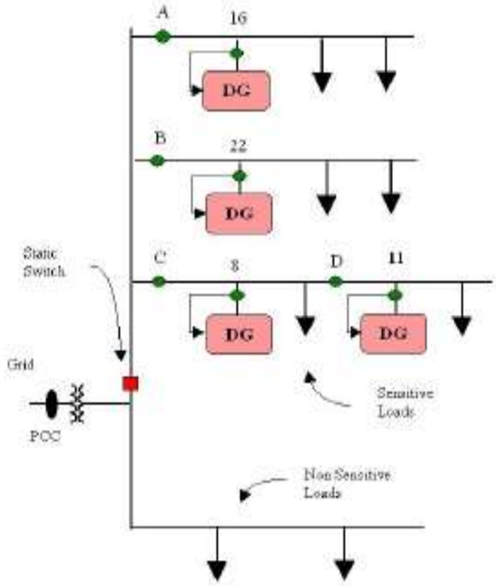

Fig. 2 micro-grid concept

With this configuration, if a load increases anywhere in the micro-grid, the extra power come from the grid, since every unit regulates to constant output power. This configuration fits CHP applications because production of power depends on the heat demand. Electricity production makes sense only at high efficiencies, which can only be obtained only at high efficiencies, which can only be obtained only when the waste heat is utilized.

B. FEEDER FLOW CONTROL CONFIGURATION

In this configuration, each DG regulate the voltage magnitude at the connection point and the power that is flowing in the feeder at the points A, B, C and D in Figure 2. With this configuration extra load demands are picked up by the DG showing a constant load to the utility grid. In this case, the micro-grid becomes a true dispatch able load as seen from the utility side, allowing for demand-side management arrangements. When the system islands the local feeder flow vs. frequency droop function insures the power balance with the loads.

C. MIXED CONTROL CONFIGURATION

In this configuration, some of the DGs regulate their output power, P, while some others regulate the feeder power flow, F. The same unit could control either power or flow depending on the needs. This configuration could potentially offer the best of both worlds: some units operating at peak efficiency recuperating waste heat, some other units ensuring that the power flow from the grid stays constant under changing load conditions within the micro-grid.

III. DISTRIBUTED GENERATION

A .DEFINITION

Distributed generation, is the process of generating electricity from many small energy sources and connecting it directly to the distribution network or on the customer's side of the meter. It can also be called as onsite generation, dispersed generation, decentralized generation, decentralized energy or distributed energy. From the definition, the DG includes those generating units that cannot supply reactive power and are located close to the customer or the end user. However, there is no specific defined capacity for the DGU. Distributed Generation (DG) is a small generator spotted throughout a power system network, providing the electricity locally to load customers [10]. DG can be an alternative for industrial, commercial and residential applications. DG makes use of the latest modern technology which is efficient, reliable, and simple enough so that it can compete with traditional large generators in some areas [4]. Placement of DGs is an interesting research area due to economical reason. Distributed generation systems (such as fuel cells, combustion engines, micro-turbine, etc) can reduce the system loss and defer investment on transmission and distribution expansion. Appropriate size and optimal locations are the keys to achieve it [13].

In the proposed system PV cell of 1 KW and battery having rating of 6V, 225 AH, 1.35kWH is considered to meet the demand of the load.

There are many differences between DG and the conventional central power stations. These differences include, but are not limited to Location: DG units are located near loads and connected to distribution networks, unlike the central plants, which are far away and, therefore, connected to load centres via transmission networks;

- Generation capacity: The generation capacity of DG units is much smaller than that of the massive central plants;
- Technology used: New cleaner technologies, including renewable energy sources, are used as DG units;
- Ownership: DG units can be owned by utilities, customers or a third party.

B. BENEFITS OF DISTRIBUTED GENERATION

Consumer advocates who favour DG point out that distributed resources can improve the efficiency of providing electric power. They often highlight that transmission of electricity from a power plant to a typical user wastes roughly 4.2 to 8.9 percent of the electricity as a consequence of aging transmission equipment, inconsistent enforcement of reliability guidelines, growing congestion. At the same time, customers often suffer from poor power quality variations in voltage or electrical flow that results from a variety of factors poor switching, operations in the network, voltage dips, interruptions, transients and network disturbances from loads.

C. TECHNOLOGIES

DG can be divided into two main groups: renewable DG and fuelled DG. Most fuelled DG technologies use fossil fuels as their primary energy resource to generate electricity, or as a means to produce alternative fuels. Fuel-based technologies include conventional steam and combustion turbines, internal combustion (IC) engine generators, micro-turbine (MT), and fuel cells (FC).[5] Renewable energy resources are becoming more important due to fossil fuel resource depletion, price associated risks, and environmental concerns. On the other hand, renewable energy resources are sustainable and environmentally friendly. Renewable resource-based technologies include photovoltaic cells (PV), wind turbines (WT), and small-scale hydro-generation.

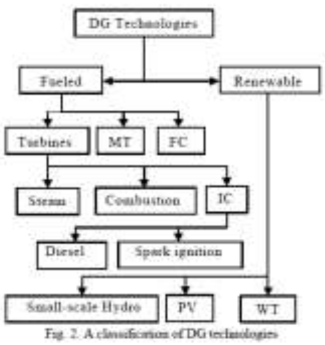

Fig. 3 DG technology

IV. ENERGY SOURSES

A. ENVIRONMENTAL CONCERNS

DG technologies have a wide range of emission levels, from emission free (PV & wind) to moderate (diesel). For fossil fuel DG technologies, the authors in [6] identified two areas of concern: nitrogen oxide effects on local air quality and the global greenhouse gas emission effects on climate change.

Although most DG technologies have lower nitrogen oxides (NOx) emissions compared to coal-fired power stations, they have higher emissions than combined-cycle gas turbines with emission controls. This situation imposes a serious limitation on DG in areas where NOx emissions are of concern. Similarly, except for CHP operation, DG greenhouse gas emission rates are generally lower than those of coal fired plants but higher than those of combined-cycle gas turbines with emission controls, for most of fossil fuel technologies. The authors recommend using economic measures to encourage DG owners to reduce emissions. As an example, carbon emission trading would give DG owners an incentive to minimize emissions [6].

B. ENERGY SECURITY

The large penetration of DG in the system can affect energy security. This effect can appear in two forms: primary fuel diversification and power system reliability. Although renewable technologies (e.g., PV and WT) help diversifying the primary fuel of electrical energy, most other DG technologies uses natural gas, directly or indirectly, as a primary source of energy. Therefore, the overall effect on fuel diversity in the power system is expected to be limited [6]. The increased demand and dependency on one major primary fuel, natural gas, reduces energy security. An exception to this effect is the CHP, where higher fuel efficiency, lower fuel consumption; hence, enhanced energy security could be achieved. DG could enhance power system reliability by integrating the available standby DG resources. It has been reported that the availability of standby generation helped in reducing blackout risks during California's 2001 electricity crises [7]. Moreover, DG can enhance system reliability by relieving distribution network congestion and reducing the demand flowing over transmission lines by using locally generated power. In addition, since DG units are much smaller than central power plants, lower capacity margin is needed to operate the system with the same reliability compared to a system with conventional large plants. The main reliability concern for DG in this context is the fact that most DG units are non-dispatchable due to natural or operational unpredictability. In such cases, DG might not be able to respond to demand variations and this in turn reduces the system ability of providing reserve power when needed

V. RENEWABLE ENERGY SOURCES

A. WIND RESOURCE

Wind mills are used for various reasons is a practice for several years. Now many nations recognize the shortage of fossil fuels and importance of wind energy. The wind energy has re-emerged as an important source of sustainable energy resource worldwide. The energy available in the wind depends on the density and velocity. The density changes with the temperature and pressure. The need to integrate the renewable energy like wind into power system is to make it possible to minimize the environmental impact on conventional plant. As the ratio of installed wind capacity to the system load increases, the required equipment needed to maintain a stable AC grid increases, forcing amount of wind power in a given system. [9].

B. DIESEL ENGINES

Diesel generators and combustion engines are mainly used for off-grid generation. Low installed capacity, high shaft efficiency, suitable for start-stop operation, and high exhaust heat are some of the advantages of combustion engines. These engines convert heat from the combustion into work via rotation of shaft. The shaft is directly coupled to the generator and electricity is produced. They run at a speed defined by the frequency of supply grid [9].

C. PHOTO VOLTAIC (PV)

Photovoltaic systems convert energy from the sun directly into electricity. They are composed of photovoltaic cells, usually a thin wafer or strip of semiconductor material that generates a small current when sunlight strikes them. Multiple cells can be assembled into modules that can be wired in an array of any size. Small photovoltaic arrays are found in wrist watches and calculators; the largest arrays have capacities in excess of 5 MW. Photovoltaic systems are cost-effective in small off-grid applications, providing power, for example, to rural homes in developing countries, off-grid cottages and motor homes in industrialized countries, and remote telecommunications, monitoring and control systems worldwide. The PV plant is connected to grid via DC/AC inverters of different technology. PV have explosive growth rate, which is still less than one tenth of wind. The solar resource data for Gujarat is obtained from NASA surface meteorology and solar website [10].

The approximate location of the site used is 23.3000 latitude and 73.230090 longitude from the data daily solar radiation with respect to horizontal is obtained.

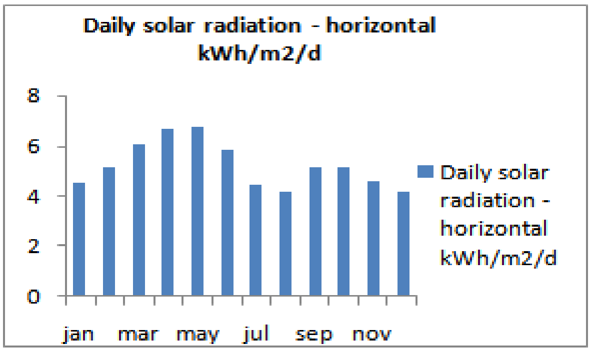

Fig 4 **solar rediation for gujarat state**

Ideally Cost curve of PV cell (where replace cost zero)is as shown Fig 5. The proposed model uses 0.1KW of PV cell having cost curve as shown in Fig. 6

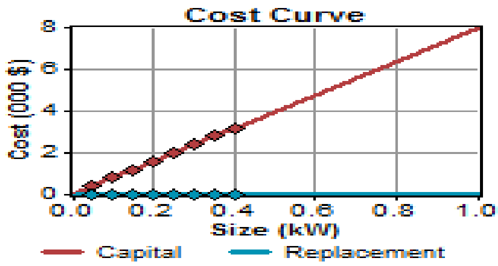

Fig. 5 **cost curve for ideal PV cell**

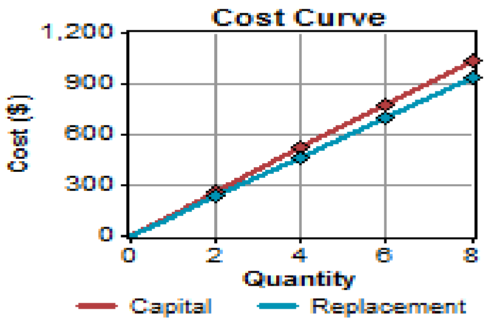

Fig. 6 **cost curve for PV cell**

D. BATTERY SOURCE:

There's a promising new entry in the race to build cheap batteries for storing energy from solar panels and wind turbines. The technology is a cross between a flow battery and an experimental type called a lithium-sulphur battery. In a flow battery, positive and negative liquid electrolytes are stored in swimming-pool-size tanks. The batteries are attractive because the amount of energy they store can be increased simply by expanding these tanks, without increasing the size of the electronic connections and other battery parts needed to extract the energy. But they require expensive ion membranes and large amounts of material.

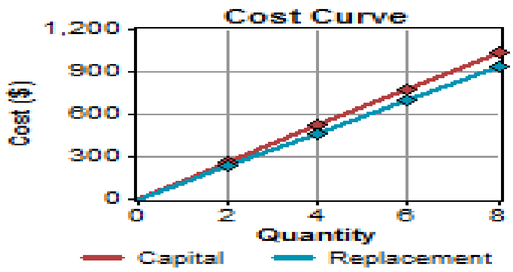

Fig. 7 **cost curve for battery**

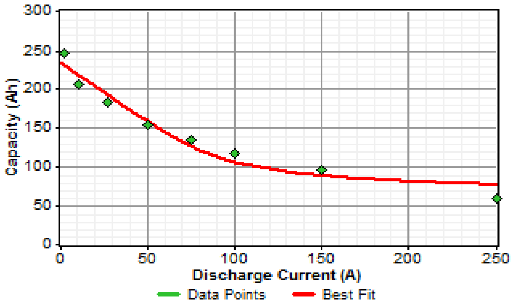

Fig. 8 **characteristics of battery**

The battery size is of 6V, 225 AH, 1.35kWH. The cost curve is as shown in Fig.7

VI. MODELLING and RESULTS

Table 1. System Architecture:

PV Array	0.1 kW
Battery	2 Trojan T-105

Table 2. Cost summary of Sources:

Total net present cost	$ 1,239
Cost of energy	$ 1.479/kWh
Operating cost	$ 15.6/yr

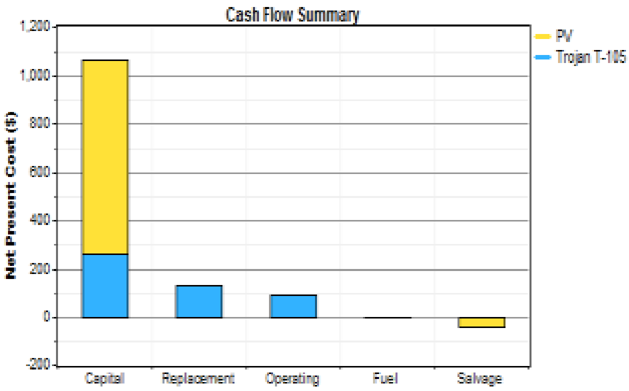

Fig. 9 **cash flow summary of sources**

Table 3. Electrical characteristics

Component	**Production**	**Fraction**
	(kWh/yr)	
PV array	158	100%
Total	158	100%

The Load size of 0.2 KWh/d and peak load of 48W is considered as a model.

Table 4. Load Profile:

Load	**Consumption**	**Fraction**
	(kWh/yr)	
DC primary load	73	100%
Total	73	100%

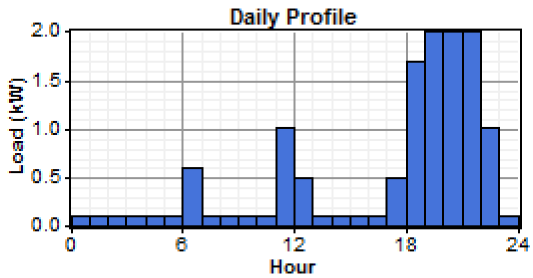

Fig. 10 **variation of load during a day**

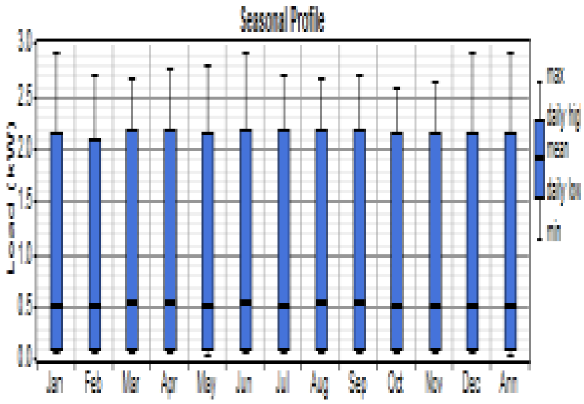

Fig. 11 Monthly Load Variation Considered

Load size varies from 0.2kWh/d to 1 kWh/d. The result shows the optimal system. The following graph shows that PV/battery systems are optimal for most of that sensitivity space.

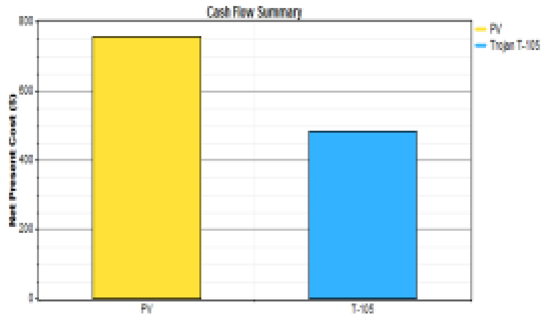

Fig. 12 Cash flow summary for PV and Battery

The battery selected has following characteristics

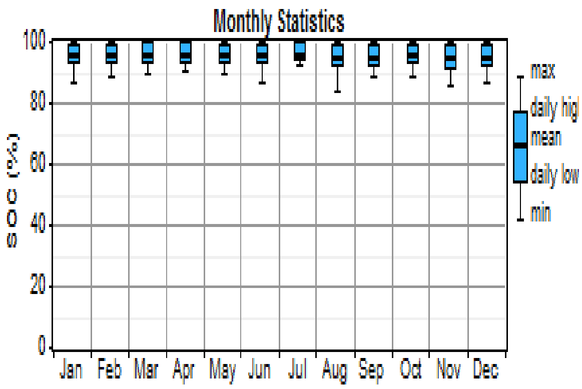

Fig. 13. Monthly statistics of battery

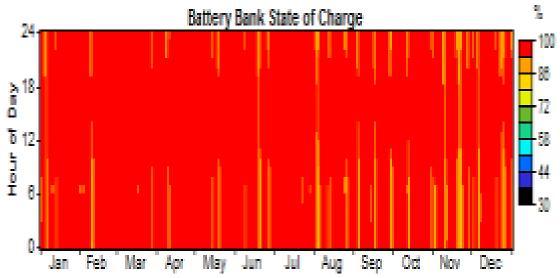

Fig.14. charging states of battery

The excess generation is 75%.

Table No.5 Excess Energy generation

Quantity	**Value**	**Units**
Excess electricity	74.9	kWh/yr
Unmet load	0.00	kWh/yr
Capacity shortage	0.00	kWh/yr
Renewable fraction	1.000	

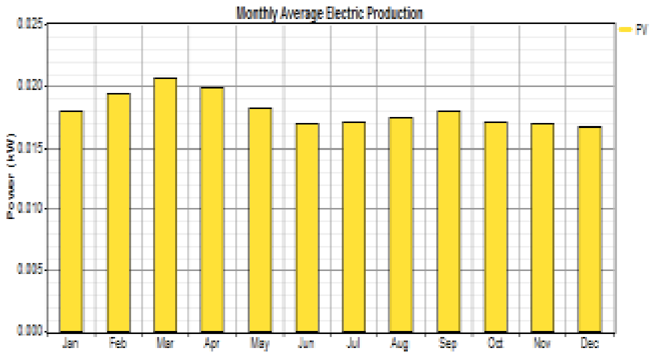

Fig. 13 Monthly Average Electricity Generations with PV

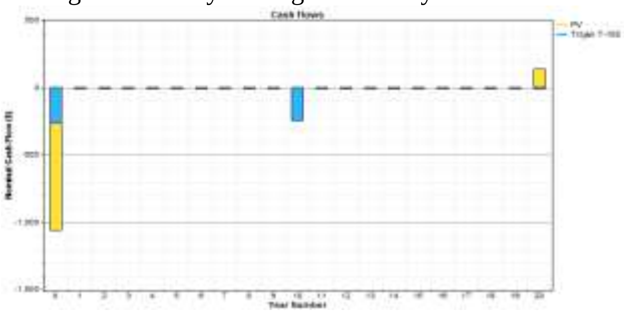

Fig. 14 Comparison of Cash Flow (PV /Battery)

The system is environment friendly. The emission is given the Table 6

Table No.6 carbon emission

Pollutant	**Emissions (kg/yr)**
Carbon dioxide	0
Carbon monoxide	0
Unburned hydrocarbons	0
Particulate matter	0
Sulphur Dioxide	0
Nitrogen oxides	0

VII. CONCLUSIONS

The results are simulated using HOMER software. Modelling shows that the cost summary, cash flow summary, electrical production or emissions and cost of PV and Battery hybrid system are feasible.
Total Net Present Cost is $1239. From the optimal system type it is clear that except rainy season PV cell is optimum, during day time. The charges during day time during Sun set hours battery is configuration is feasible. This Model can be modified with Wind sources. At higher wind speeds, PV/Wind/Battery configuration will show optimum results. If the wind speed is high, use of PV and Battery may reduces.

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