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Study of Solar, Biogas and Wind Micro-Grid at Sanjeevan Socio-Medical Foundation, Nagpur

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***Abstract*: -- In India, most of the electricity is produced by the thermal power plant and many of them are located in central India. Thermal power plants use coal as a fuel, which will release sulphur dioxide in the environment during combustion, also the land after extraction of coal will become infertile and of no use, hence in this region use of clean energy is require immediate attention. Power generated by the solar, biogas and wind which are renewable and cause zero pollution, from this renewable resources we can form a microgrid which will be able to generate enough power for the small regions with battery and loads. In central India, the intensity of sunrays is good for the generation of electricity by using solar panels. This paper presents the study of such type of microgrid which is installed at Sanjeevan socio-medical foundation near Nagpur (central India) which consists of the solar plant which generates 2KW, biogas plant which generates 12 KW and wind plant which generates 1 KW.This microgrid is connected to the main power grid and it is self-dependent in almost every season. The area of the foundation is also lit by using solar street lights. This type of microgrids should be installed in central India in more numbers because of the advantages like no fuel cost, predictable 24/7 power, no pollution and global warming effects.**

***Keywords:* - Micro grid, solar, photovoltaic, biogas, wind, battery, solar controller, wind controller.**

I. INTRODUCTION

In recent years, pollution situation increasingly worse in India, Red warning, as top level warning, has been triggered for serious air pollution in over 20 cities, including Delhi. Air quality index has been "exploded" in many cities. The coal extraction in central India is done at Nagpur, Umrer, chandrapur, Ballarpur, Manjri, Wani, Waninorth(Maharashtra), Pench, Kanhan(Madhya Pradesh), Pathakhera (Madhya Pradesh). The biggest coal consumer is thermal power plant. The thermal power plant is really the chief offender. Coal will release sulphur dioxide during combustion and due to which many people near the thermal power plant get diseases like asthma, skin allergy etc. The land after extraction of coal is of no use and also became infertile, So here loss of local people is observed. Hence, we should move towards use of clean energy. Use of clean energy is imperative. For large scale utilization and development of solar energy, biogas energy and wind energy which are regenerative, pollutant free, green and clean energy, the best way to generate power and connect to power grid for distributed energy is to develop micro-grid. Wind energy and solar energy generated amongst micro-grid will be stored in energy storage unit and the energy generated using Biogas will be directly distributed to the loads. This micro grids can be installed at any place and are very efficient and produce no pollution and gives pure electricity to the consumer. Application of such micro grids will definitely decrease the load on the main grid and also by some means reduce the nearby pollution level.

II. STUDY OF MICRO-GRID

MICRO-GRID:

A micro-grid is a group of interconnected loads and distributed energy resources (DERs) within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. Micro-grid can be classified as grid connected or isolated. In isolated micro-grid it acts as a small power system with its all part (generation, transmission, and distribution). The main driver for isolated micro-grid is the availability of local energy resources. Hybrid Renewable energy system (HRES) is a combination of one or more renewable resources such as solar Photo Voltaic (PV) and wind turbine (WT) with other technologies such as batteries to supply electric power systems. Solar and wind are clean energy sources with enormous potential to alleviate grid dependence.

3.1.1 TYPES OF MICRO-GRID :-

There are several types of micro-grids for different applications. As markets, technology, and regulation changes, the types of micro-grids will continue to evolve. Military Micro-grids the ability to reliably incorporate solar PV and energy storage into military energy systems is a critical objective for the United States DOD. Reliance on diesel fuel in remote regions in the world is a weak point in military operations, and the results can be costly and deadly due to the challenge of transporting fuel through hostile regions. Additionally, the use DOD recognizes climate change as a driver of increasing instability, resulting in internal and

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external pressure to reduce emissions. Campus Micro-grids could refer to corporate campuses, university campuses, and military campuses. They are often CHP / Combined Heat and Power. Community Micro-grids could be considered community solar 2.0. In the developing world, community micro-grids can be used to achieve electrification for the first time. In the developed world they are often used to help communities achieve renewable energy targets. Island Micro-grids are attractive due to the high cost of importing liquid fuels. While traditionally run off diesel, small and large islands around the world are incorporating renewables and energy storage into their energy systems. Examples of island micro-grids.

Remote Micro-grids create energy access beyond the grid. Like island micro-grids, remote micro-grids were traditionally dominated by diesel but are rapidly incorporating solar plus storage. Utility Micro-grids are done by incumbent electric utilities.

3.1.2 ON-GRID AND OFF-GRID MICRO-GRIDS :-

On-grid micro-grids means your system is tied to your local utility company's system. This is what most residential homes will use because you are covered if your system under or over-produces in regard to your varying energy needs. This entire means for you is that your utility system acts as your battery space. If you are producing more energy with your solar panels or wind mill than you are using, the excess energy is sent to your grid's power company, allowing you to build credit that you can cash out with at the end of the year, in a process called net metering. Being grid-tied is beneficial because you don't have to buy an expensive battery back-up system to store any excess energy. Off-Grid micro-grid:-Being off-grid means you are not connected in any way to your grid's power system or utility company. This is appealing because you are 100% self-sustaining your energy use.

3.2 SOLAR PANELS:-

3.2.1 DEFINITION:-

Solar panels absorb the sunlight as a source of energy to generate electricity or heat. A photovoltaic (PV) module is a packaged, connect assembly of typically 6x10 photovoltaic solar cells. Photovoltaic modules constitute the photovoltaic array of a photovoltaic system that generates and supplies solar electricity in commercial and residential applications. Each module is rated by its DC output power under standard test conditions (STC), and typically ranges from 100 to 365 Watts (W). The efficiency of a module determines the area of a module given the same rated output – an 8% efficient 230 W module will have twice the area of a 16% efficient 230 W module. There are a few commercially available solar modules that exceed efficiency of 22% and reportedly also exceeding 24%.A single solar module can produce only a limited amount of power; most installations contain multiple modules. A photovoltaic system typically includes an array of photovoltaic modules, an inverter, a battery pack for storage, interconnection wiring, and optionally a solar tracking mechanism.

3.2.2 TYPES OF SOLAR PANELS :-

MONO-CRYSTALLINE :-

To make solar cells for mono-crystalline solar panels, silicon is formed into bars and cut into wafers. These types of panels are called "mono-crystalline" to indicate that the silicon used is single-crystal silicon. Because the cell is composed of a single crystal, the electrons that generate a flow of electricity have more room to move. As a result, mono-crystalline panels are more efficient than their polycrystalline counterparts

POLYCRYSTALLINE:-

Polycrystalline solar panels are also made from silicon. However, instead of using a single crystal of silicon, manufacturers melt many fragments of silicon together to form the wafers for the panel. Polycrystalline solar panels are also referred to as "multi-crystalline," or many-crystal silicon. Because there are many crystals in each cell, there is to less freedom for the electrons to move. As a result, polycrystalline solar panels have lower efficiency ratings than mono-crystalline panels.

MONO VS. POLY SOLAR PANELS:- COMPARISON TABLE:-

	Mono-crystalline	Polycrystalline
Cost	More expensive	Less expensive
Efficiency	More efficient	Less efficient
Aesthetics	Solar cells are a black hue	Solar cells have a blue-ish hue
Longevity	25+ years	25+ years
Major manufacturers	Canadian Solar Sun power LG Hyundai Solar World	Hanwha Kyocera Hyundai Solar world Trina

Mono vs poly solar panels comparison table.

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3.2.3 THEORY AND CONSTRUCTION:-

Photovoltaic modules use light energy (photons) from the Sun to generate electricity through the photovoltaic effect. The majority of modules use wafer-based crystalline silicon cells or thin-film cells. The structural (load carrying) member of a module can either be the top layer or the back layer. Cells must also be protected from mechanical damage and moisture. Most modules are rigid, but semi-flexible ones are available, based on thin-film cells. The cells must be connected electrically in series, one to another. Externally, most of photovoltaic modules use MC4 connectors type to facilitate easy weatherproof connections to the rest of the system.

Modules electrical connections are made in series to achieve a desired output voltage and/or in parallel to provide a desired current capability. The conducting wires that take the current off the modules may contain silver, copper or other non-magnetic conductive transition metals. Bypass diodes may be incorporated or used externally, in case of partial module shading, to maximize the output of module sections still illuminated. Some special solar PV modules include concentrators in which light is focused by lenses or mirrors onto smaller cells. This enables the use of cells with a high cost per unit area (such as gallium arsenide) in a cost-effective way.

3.2.7 CHARGE CONTROLLERS:-

DEFINITION:-

A charge controller, charge regulator or battery regulator limits the rate at which electric current is added to or drawn from electric batteries. It prevents overcharging and may protect against overvoltage, which can reduce battery performance or lifespan, and may pose a safety risk.

SOLAR CHARGE CONTROLLER:-

A solar charge controller is fundamentally a voltage or current controller to charge the battery and keep electric cells from overcharging. It directs the voltage and current hailing from the solar panels setting off to the electric cell. Generally, 12V boards/panels put out in the ballpark of 16 to 20V, so if there is no regulation the electric cells will damaged from overcharging. Generally, electric storage devices require around 14 to 14.5V to get completely charged. The solar charge controllers are available in all features, costs and sizes. The range of charge controllers are from 4.5A and up to 60 to 80A.

TYPES OF SOLAR CHARGER CONTROLLER:-

There are three different types of solar charge controllers, they are:

1) Simple 1 or 2 stage controls
2) PWM (pulse width modulated)
3) Maximum power point tracking (MPPT)

DESCRIPTION:-

1) Simple 1 or 2 Controls: It has shunt transistors to control the voltage in one or two steps. This controller basically just shorts the solar panel when a certain voltage is arrived at. Their main genuine fuel for keeping such a notorious reputation is their unwavering quality – they have so not many segments, there is very little to break.
2) PWM (Pulse Width Modulated): This is the traditional type charge controller, for instance anthrax, Blue Sky and so on. These are essentially the industry standard now.
3) Maximum power point tracking (MPPT): The MPPT solar charge controller is the sparkling star of today's solar systems. These controllers truly identify the best working voltage and amperage of the solar panel exhibit and match that with the electric cell bank. The outcome is extra 10-30% more power out of your sun oriented cluster versus a PWM controller. It is usually worth the speculation for any solar electric systems over 200 watts.

BATTERY:-

Batteries in wind and solar applications have to meet the demands of unstable grid energy, heavy cycling (charging and discharging) and irregular full recharging. There's a variety of battery types fitted for these unique requirements. Considerations for choosing a battery include cost, cycle life and installation and maintenance.

So we use **Lead acid batteries for this use:-**

Deep-cycle, lead-acid batteries have been employed in renewable energy and reliably used in off-grid applications globally for decades.

COST: Typical deep-cycle, lead-acid batteries cost significantly less than lithium-ion.

CYCLING: Valve-regulated lead-acid (VRLA) batteries include absorbed glass mat (AGM) and gel models. Many AGM batteries available in the market are primarily built for dual-purpose or standby applications like emergency backup, but not deep cycling. However, new deep-cycle AGM designs have increased performance and total energy output making them a good choice for renewable energy applications at a lower price point than gel batteries.

REPLACEMENT/MAINTENANCE: Many factors including initial design and ongoing maintenance influence battery life so it's difficult to put a time frame on when the batteries will need replacement. Flooded lead-acid batteries have to be refilled regularly because the electrolyte that fully submerges the battery plates evaporates during charging. The battery

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enclosure needs ventilation to keep hydrogen gas from accumulating to dangerous levels.

WIND MILL :-

Wind power is the use of air flow through wind turbines to mechanically power generators for electric power. Wind power, as an alternative to burning fossil fuels, is plentiful, renewable, widely distributed, clean, produces no greenhouse gas emissions during operation, consumes no water, and uses little land. The net effects on the environment are far less problematic than those of nonrenewable power sources.

Wind farms consist of many individual wind turbines which are connected to the electric power transmission network. Onshore wind is an inexpensive source of electric power, competitive with or in many places cheaper than coal or gas plants. Off shore wind is steadier and stronger than on land, and offshore farms have less visual impact, but construction and maintenance costs are considerably higher. Small onshore wind farms can feed some energy into the grid or provide electric power to isolated off-grid locations.

Wind power gives variable power which is very consistent from year to year but which has significant variation over shorter time scales. It is therefore used in conjunction with other electric power sources to give a reliable supply. As the proportion of wind power in a region increases, a need to upgrade the grid, and a lowered ability to supplant conventional production can occur. Power management techniques such as having excess capacity, geographically distributed turbines, dispatchable backing sources, sufficient hydroelectric power, exporting and importing power to neighboring areas, or reducing demand when wind production is low, can in many cases overcome these problems.In addition, weather forecasting permits the electric power network to be readied for the predictable variations in production that occur.

3.3.1 WIND CHARGE CONTROLLER:-

Wind power charge controllers that are compatible with most wind power systems and batteries. These charge controllers will protect and prolong the life of battery by controlling the amount of current that charges it.

3.4 BIOGAS :-

Biogas typically refers to a mixture of different gases produced by the breakdown of organic matter in the absence of oxygen. Biogas can be produced from raw materials such as agricultural waste, manure, municipal waste, plant materials, sewage green waste or food waste. Biogas is a renewable energy source. Biogas can be produced by anaerobic digestion with anaerobic organism, which digest material inside a closed system, or fermentation of biodegradable materials.[1]

Biogas is primarily methane (CH4) and carbon dioxide (CO_2) and may have small amounts of hydrogen sulfide (H 2S), moisture and siloxanes. The gases methane, hydrogen and carbon monoxide (CO) can be combusted or oxidized with oxygen. This energy release allows biogas to be used as a fuel; it can be used for any heating purpose, such as cooking. It can also be used in a gas engine to convert the energy in the gas into electricity and heat. Biogas can be used for electricity production on sewage works in a CHP gas engine, where the waste heat from the engine is conveniently used for heating the digester; cooking; space heating; water heating; and process heating. If compressed, it can replace compressed natural gas for use in vehicles, where it can fuel an internal combustion chamber or fuel cells and is a much more effective displacer of carbon dioxide than the normal use in on-site CHP plants.

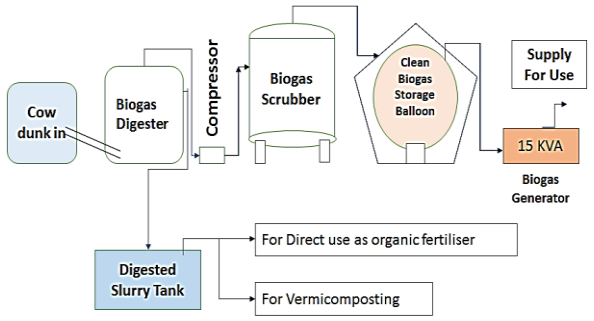

Fig 3.4 :- Block diagram of biogas plant

3.4.1 COMPOSITION

The composition of biogas varies depending upon the substrate composition, as well as the conditions within the anaerobic reactor (temperature, pH, and substrate concentration Landfill gas typically has methane concentrations around 50%. Advanced waste treatment technologies can produce biogas with 55%–75% methane,which for reactors with free liquids can be increased to 80%-90% methane using in-situ gas purification techniques. As produced, biogas contains water vapor. The fractional volume of water vapor is a function of biogas temperature; correction of measured gas volume for water vapor content and thermal expansion is easily done via simple mathematics which yields the standardized volume of dry biogas. In some cases, biogas contains siloxanes. They are formed from the anaerobic decomposition of materials commonly found in soaps and detergents. During combustion of biogas containing siloxanes, silicon is released and can combine with free oxygen or other elements in the combustion gas. Deposits are formed containing mostly silica (SiO2) or silicates and can contain calcium, sulfur, zinc, phosphorus. Such white mineral deposits accumulate to a surface thickness of several

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millimeters and must be removed by chemical or mechanical means. Practical and cost-effective technologies to remove siloxanes and other biogas contaminants are available. For 1000 kg (wet weight) of input to a typical biodigester, total solids may be 30% of the wet weight while volatile suspended solids may be 90% of the total solids. Protein would be 20% of the volatile solids, carbohydrates would be 70% of the volatile solids, and finally fats would be 10% of the volatile solids.

3.4.2 APPLICATION

Biogas can be used for electricity production on sewage works in a CHP gas engine, where the waste heat from the engine is conveniently used for heating the digester; cooking;
space heating; water heating; and process heating. If compressed, it can replace compressed natural gas for use in vehicles, where it can fuel an internal combustion engine or fuel cells and is a much more effective displacer of carbon dioxide than the normal use in on-site CHP plants.

3.4.3 BIOGAS GAS-GRID INJECTION

Gas-grid injection is the injection of biogas into the methane grid (natural gas grid). Injections includes biogas until the breakthrough of micro combined heat and power two-thirds of all the energy produced by biogas power plants was lost (the heat), using the grid to transport the gas to customers, the electricity and the heat can be used for on-site generation resulting in a reduction of losses in the transportation of energy. Typical energy losses in natural gas transmission systems range from 1% to 2%. The current energy losses on a large electrical system range from 5% to 8%. Before being injected in the gas grid, biogas passes a cleaning process, during which it is upgraded to natural gas quality. During the cleaning processtrace components harmful to the gas grid and the final users are removed.

IV. MICRO GRID PARAMETERS

4.1 DATA COLLECTION:

1) Solar panels rating, Area i.e their Length breadth, no of cells, Mono-crystalline info,
2) Battery specifications, connections (parallel), wire size.
3) Solar controller ratings.
4) Windmill ratings.

4.1 MICRO-GRID:-

Capacity :- 15 KW
Area :- 03 Acre
Type :- Off-grid

4.2 SOLAR PANELS:-

No. of solar Panels :- 08 Panels
Type :- Mono-crystalline
No. of cells :- 60 (6*10)
Cell vendor :-LG
Cell dimension :-156 x 156 mm^2/6 x 6 in2
Dimensions :- (L x W x H) 1640 x 1000 x 35 mm
Capacity :- 250 watts
Voltage :- 12v
Efficiency :-18.3%

4.3 CHARGE CONTROLLER :-

Type :- MPPT charge controller (Increase Output by 30%)
Make :- CS-30
Voltage input (Max.) :- 530v
Voltage Output :- 12V
Current :- 40 A

4.4 POWER INVERTER:-

Capacity :-1300 VA
Voltage :- 12V
Current :- 10A

4.5 BATTERY:-

No. of batteries :- 04
Make :- SF Sonic Stan Red-350
Type :- Lead-Acid Battery.
Rating :- 12v (100Ah)
Connections :- Parallel Connection

4.6 WIND MILL:-

RATING OF AXIAL FLUX PM GENERATOR (USED IN WIND MILL):-

SR NO.	PARAMETER	UNITS	SPECIFICATIONS
1	Rated power	KW	5
2	Rated speed	RPM	100
3	Rated voltage	V	380VAC
4	Rated Current	A	7.6
5	Efficiency		>85%
6	Resistance (Line-Line)	Ω	-
7	Winding type		Y
8	Insulation Resistance		100Mohm Min(500V DC)

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9	Leakage level		<5 ma
10	Start torque	N/M	<0.5
11	Phase		Three phase
12	Structure		outer rotor
13	Stator		coreless
14	Rotor		Permanent magnet type (outer rotor)
15	Gen. Diameter	mm	765
16	Gen. Length	mm	406
17	Gen. Weight	Kg	165
18	Shaft. Diameter	mm	98
19	Housing Material		Aluminum (Alloy)
20	Shaft Material		Steel

TABLE. 4.6.1 RATING OF AXIAL FLUX PM GENERATOR (USED IN WIND MILL)

4.7 BIOGAS :-

Plant Capacity :- 25 m^3/day
Internal Diameter of Digester :- 23 m
External Diameter :- 23.7 m
Internal height of digester :- 6 m
Wall thickness of digester :- 0.3 m
Clean Biogas Balloon capacity :- 45 m^3
Clean Biogas Balloon material :- Rubber

4.7.1 BIOGAS COMBUTION ENGINERATING :- 15 KVA(WATER COOLED)

- 12v starter
- Radiator with and water pump
- Lub oil filter
- Flywheel suitable for Genset (Heavy)
- Panel with charging Ammeter, Oil Pressure Gauge, Water temperature gauge and starting switch
- Battery charging Alternator
- Air/ Gas mixture regulator
- Heavy Duty Air Filter
- Industrial Silencer

Biogas Combution Engine type :- 4 Stroke (110x125 110x120 110x120110x120 110x120)
Biogas Engine RPM :-1500
Combution Engine cylinder :- 02
Make :- Prakash India

4.7.2 BIOGAS GENERATOR:-

Rating :- KVA-15 KVA
RPM :-1500
Phase :- 3 phase (AC)
Voltage :-415 V
Current :-21 Amp
Excitation Voltage :-120V Excited
Frequecy :-50 Hz
Power factor :-0.8 pf
Generator output :-12 kw
Make :-Prakash India

4.2 DETAILS :

Our disc coreless PMG have advantage in low Rated speed, Low starting wind speed, Small volume, Energy Small, Light weight, Compact structure, High efficiency etc. Inner or outer rotor all available, and we can do customize generator accordingcustomer request magnetic levitation , Coreless, an hysteresis, slot less, have low starting torque. No iron loss, have high efficiency over 98% Adopt unique coreless precision winding technology design precision coil Adopt the rare earth permanent magnet, which is multipole, mean gap, high power density and high output power. Low speed direct driving, no torque fluctuations Compact structure, high ratio of power to volume No iron loss, low calorific value, small temperature rise Simple structure, easy to install The brushless structure, free maintenance.

V. CONCLUSIONS

This micro-grid is implemented currently in Sanjeevan foundation, The micro-grid consist of Solar plant, Wind Plant and Biogas plant whose collective generation capacity is 15 KW. Depending on the requirement of solar, wind and biogas energy sources can be utilized in micro-grid or it can be operate individually. Solar plant consist of 16 solar panels each of capacity 250 watt and 9 solar street lights , making the capacity of 2 KW. Wind mill had a capacity of 1 KW, which consist of AFPMG (axial flux permanent magnet generator) whose rated capacity is 5 KW. This types of micro grids can definitely reduce the pollution level and wastage of land as well retain there fertility. In central India this types of initiatives are needed in order to prevent environment and human health in the future. Making such institutes free from main grid will make them self dependent and after expansion they can provide their extra generated energy to the main grid also.

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