Technical Reconfiguration for Optimal Operation of Integrated Distributed System

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Abstract - The fuel in the earth will be exhausted in a thousand or more years, and its mineral wealth, but man will find substitutes for these in the winds, the waves, the sun's heat, and so forth. Power Sector moving towards deregulation has changed the traditional mission and mandates of power utilities in complex ways, and had large impacts on environmental, social, and political conditions for any particular country. Renewable energy development is of great importance from the point of view of long term energy supply security, decentralization of energy supply particularly for the benefit of the rural population, environmental benefits and sustainability in competitive power market. Renewable energy sources (RES) are environmentally friendly and constitute a basic component of sustainable development, contributing to country's independence in the power energy sector.. In competitive power market the renewable energy sources need more emphasis then in integrated power sector. Presently power industries are moving rapidly towards restructuring from fully regulated conventional set up. In the modern restructured power industry, the role played by generation, transmission and distribution in power sector are independent. In this paper, a distributed generation system consisting of bio fuel wind, solar photovoltaic (SPV) and battery, is proposed. The sources are operated to deliver energy at optimum efficiency. An optimization model is developed to supply the available energy to the loads according to the priority. It is also proposed to maintain a fair level of energy storage to meet the peak load demand together with biomass, wind and SPV, during low or no solar radiation periods or during low wind periods.

Keywords: hybrid energy systems; rural electrification; renewable energy sources; SPV system; biomass; wind energy; wind power; solar energy; solar power; batteries; India; photovoltaic's; energy management.

I. INTRODUCTION

Electricity has been part of our daily life. It has brought many things that surely have made many wonders and life would seem so hard without it. The use of electrical power categorized such as residential sector includes private households and apartment buildings where energy is consumed primarily for space heating, water heating, air conditioning, lighting, refrigeration, cooking, and clothes drying, commercial sector, education sector, transportation etc Distributed generation (or DG) generally refers to small-scale (typically 1 kW – 50 MW) electric power generators that produce electricity at a site close to customers or that are tied to an electric distribution system. Distributed generators include, but are not limited to synchronous generators, induction generators, reciprocating engines, micro turbines (combustion turbines that run on high energy fossil fuels such as oil, propane, natural gas, gasoline or diesel), combustion gas turbines, fuel cells, solar photovoltaic's, and wind turbines.[1]

1.1 APPLICATIONS OF DISTRIBUTED GENERATING (DG) SYSTEMS

There are many reasons a customer may choose to install a distributed generator. DG can be used to generate a customer's en tire electricity supply; for peak shaving (generating a portion of a customer's electricity onsite to reduce the amount of electricity purchased during peak price periods); for standby or emergency generation (as a backup to Wires Owner's power supply); as a green power source (using renewable technology); or for increased reliability. In some remote locations, DG can be less costly it eliminates the need for expensive construction of distribution and/or transmission lines.

1.2 BENEFITS OF DISTRIBUTED GENERATING SYSTEMS

1. Has a lower capital cost because of the small size of the DG (although the investment cost per KVA of a DG can be much higher than that of a large power plant).

2. May reduce the need for large infrastructure construction or upgrades because the DG can be constructed at the load location.
3. If the DG provides power for local use, it may reduce pressure on distribution and transmission lines.
4. With some technologies, produces zero or near-zero pollutant emissions over its useful life (not taking into consideration pollutant emissions over the entire product lifecycle i.e. pollution produced during the manufacturing or after decommissioning of the DG system). With some technologies such as solar or wind, it is a form of renewable energy Can increase power reliability as back-u p or stand-by power to customers.
5. Offers customers a choice in meeting their energy needs.

1.3 CHALLENGES ASSOCIATED WITH DISTRIBUTED GENERATING SYSTEMS

1. There are no uniform national interconnection standards addressing safety, power quality and reliability for small distributed generation systems.
2. The current process for in reconnection is not standardized among provinces.
3. Interconnection may involve communication with several different organizations.
4. The environmental regulation s and permit process that have been developed for larger distributed generation projects make some DG projects uneconomical.
5. Contractual barriers exist such as liability insurance requirements, fees and charges, and extensive paperwork.

II. RESTRUCTURING OF POWER SYSTEM

Based on various renewable resources, this DGS consists of solar PV, wind and biomass biofule power generations, storage devices, power electronic converter devices, energy monitor and management system, loads and transmission lines, etc. See Figure: 1. Each distributed generation unit goes through inverter; filtering and transmission lines into micro-grid central control(MGCC) to manage and allocate the total energy to supply for the local loads directly or into the point of common coupling(PCC) to connect the power grid. Multiple DGSs should go through the distribution management system (DMS) to cooperate and interact together to the whole system for safety and control. [2] Its grid-connection will bring big influence on the power system operating characteristics, power network structure and relay protection and so on. For the purpose of research on their operating characteristics of each generation cell and storage cell, control strategy and the mutual influences with the power system in the grid-connection mode, firstly it will build a detailed stable and transient mathematical model of a DGS to analyze and study. At present, there are many studies of the different distributed generation and power storage modeling at the home and abroad.

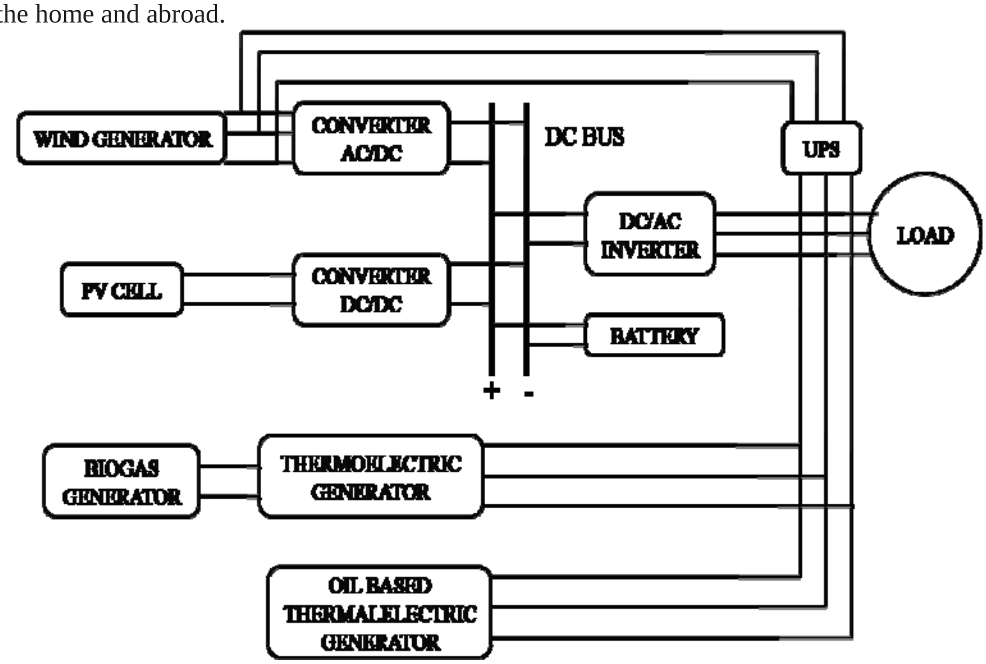

Figure 1: Structure of Distributed Generation

III. PROPAGATION OF POWER IN SYSTEM

The output current of the wind generation is transformed to the DC current by AC/DC and is connected to the DC bus, the BIOFUEL generation is connected to the DC bus with AC/DC and the solar panel is connected by the controller to the DC bus. These generators controllers are connected to the system controller. The current of output power is described as figure: 2 shown. Where, P_1, P_2, P_3, P_4, P_5 are the powers of solar, wind, BIOFUEL, battery, load and grid [3].

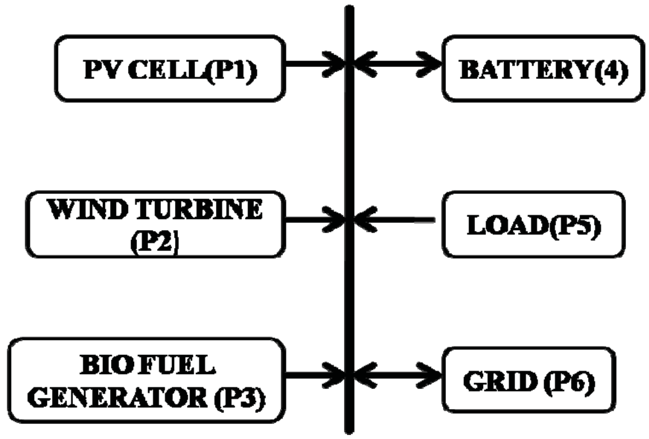

Figure 2: Power flow Direction

STAGE: I

If

$$P_1 + P_2 + P_3 > P_4 + P_5 \qquad (1)$$

Thus

$$PG > 0$$

It means that the DGS provide the electricity to the grid.

STAGE: II

if

$$P_1 + P_2 + P_3 = P_4 + P_5 \qquad (2)$$

The battery gets the electricity from the DC bus or gives the electricity according to the user load.

STAGE: III

$$P_1 + P_2 + P_3 < P_4 + P_5 \qquad (3)$$

Thus

$$P_6 < 0$$

It means that the DGS can't satisfy the need of the user and get the right electricity from the grid. The DGS under control is shown above.

IV. CAPICITY OF HYBRID SYSTEM

The distributed generation system of PV cell energy wind generator and BIOFUEL generator is a good choice for the remote user. It is known to all that the output power of PV cell and wind turbine is varied with the solar intensity and wind speeds change. Thus the output power is varied from the power of starting solar intensity and wind speed to the rating power. The output power range is big, which is not good for the user. To keep the constant power out the capacity of BIOFUEL must be right for the hybrid system. [4]

4.1 PV CELL CAPICITY

$P_1 = A * r * H * PR$

P_1 = Energy (kWh), A = Total solar panel Area (m²), r = solar panel yield (%), H = Annual average solar radiation on tilted panels (shadings not included), PR = Performance ratio, coefficient for losses (range between 0.5 and 0.9, default value = 0.75)

The output energy of PV cell is P_1 and the rating power is PE at the rating annual average solar radiation, then the whole day is presented as [5]

$0 \le P_1 \le P_2$

4.2 WIND TURBINE CAPICITY

The start working wind speed is v_1 and the rating power is P_2 at the rating wind speed *vE*. The relation between the wind speed and the output power is shown as

$$P = Kv_1^3 \qquad (4)$$

Where, K is a parameter which is a constant at a speed. It is concluded that the output power is third order direct ratio to the wind speed. The minimal power of wind generator can be easily gotten by equation

$P_2 = (\frac{V1}{V2}) P_{wo}$ ……………………………………………………………………………………………...... (5)

The output power (P_{wo}) of wind generator on whole day is presented as

$0 \le P_2 \le P_4$ .... (6)

4.3 BIOFUEL GENERATOR CAPICITY

The BIOFUEL generator is usually composed by the motor and gas engine. The efficiency of engine is high from a power point to rating output power. Assuming that the output power of BIOFUEL generator is P_3, it is shown as

$P_{ST} \le P_3 \le P_{BE}$………………..…………………………………………………………………………… (7)

Where, P_{ST} is the start power with the high efficiency, P_{BE} is the rating power of bio fuel generator.

Assuming that the load is P_5 and load rating is P_{LE} it is shown as [6]

$0 \le P_5 \le P_{LE}$……………………………………………………………………………...………………… (8)

Comparing these relations the capacity of BIOFUEL generator is presented as

$P_1 \le P_{LE}$ ……………………………………………………………………………………..…………. (9)

4.4 HYBRIDE SYSTEM CAPCITY

For stable electricity supply is important to the user; hence the relation between the capacity of solar energy, wind generator, BIOFUEL generator and load is shown as [7]

$P_5 \le P_2 + P_1 + P_3$…………………………………………………………………………………………… (10)

V. PHOTOVOLTAIC SYSTEM

Solar energy is the most readily available source of energy and solar energy systems are the most eco-friendly. It does not belong to anybody and is, therefore, free. It is also the most important of the non-conventional sources of energy because it is non-polluting and, therefore, helps in lessening the greenhouse effect. Solar energy can also be used to meet our electricity requirements. Through Solar Photovoltaic (SPV) cells, solar radiation gets converted into DC electricity directly. [8]

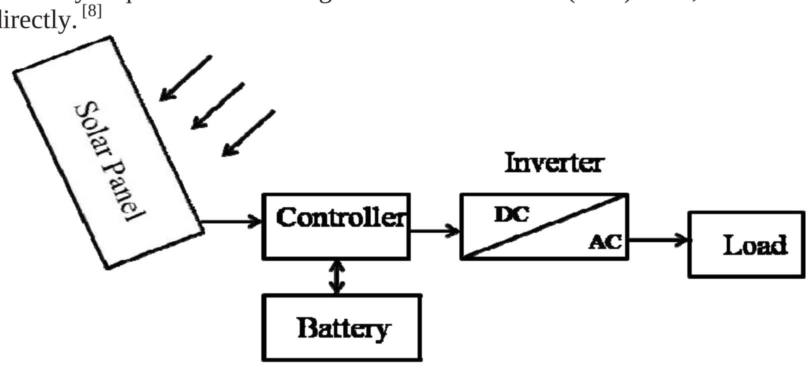

Figure 3: Photovoltaic System

VI. WIND CONVERSION SYSTEM

Wind electricity generation systems convert wind energy into electricity with the use of wind turbines. The kinetic energy in wind is converted into mechanical energy, which is then converted into electrical energy. It is the conversion of wind energy into a useful form of energy, such as using wind turbines to make electricity, wind mills for mechanical power, wind pumps for pumping water or drainage, or sails to propel ships.. [9]

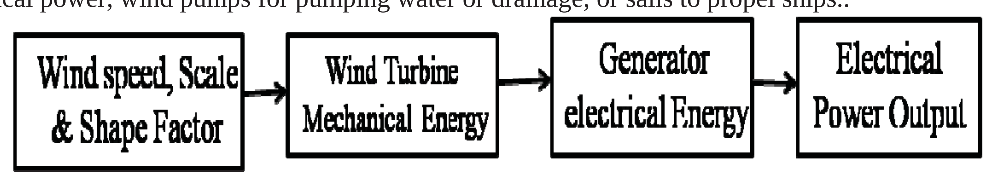

Figure 4: Energy conversions from Wind to Electrical

Wind turbine converts the wind power to a mechanical power, which in turn, runs a generator to generate electrical power. The mechanical power generated by wind turbine can be expressed as

$P_m = \frac{1}{2} C_P (\beta,\lambda) \rho A u^3$ ……………………………………………………………………………....(11)

Where

C_p: Turbine power coefficient.

ρ: Air density (kg/m^3).

A: Turbine sweeping area (m^2).
u: wind speed (m/s).
λ: tip speed ratio of the wind turbine which is given by the following equation (12):

$\lambda=$ [illegible] ………………………………………………………………………………………………….. (12)

Where r_m is the turbine rotor radius, ω_r is the angular velocity of turbine (rad/s).
The C_p-λ characteristics, for different values of the pitch angle β. The maximum value of C_p is achieved for $\beta = 0$ degree and for λ_{opt}. The particular value of λ is defined as the optimal value (λ_{opt}). Continuous operation of wind turbine at this point guarantees the maximum available power which can be harvested from the available wind at any speed. [10]

VII. BIO FUEL ENERGY

Bio fuels are produced from living organisms or from metabolic by-products (organic or food waste products). In order to be considered a bio fuel the fuel must contain over 80 percent renewable materials. It is originally derived from the photosynthesis process and can therefore often be referred to as a solar energy source. There are many pros and cons to using bio fuels as an energy source. This page contains articles that explore the many bio fuel technologies. [11]

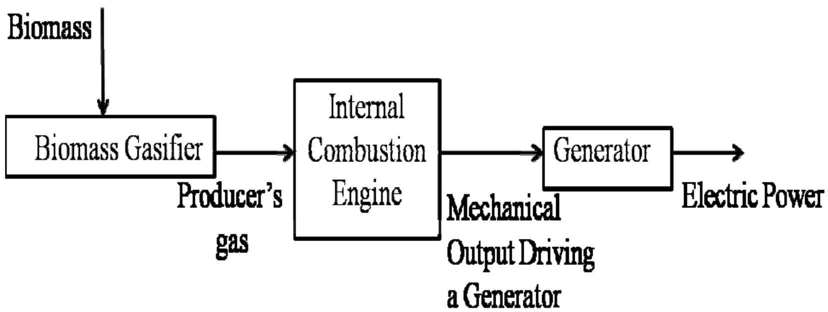

Figure 6: Biomass conversion system based on a synchronous generator

The process flow diagram of bio gas plant is shown in figure 7.

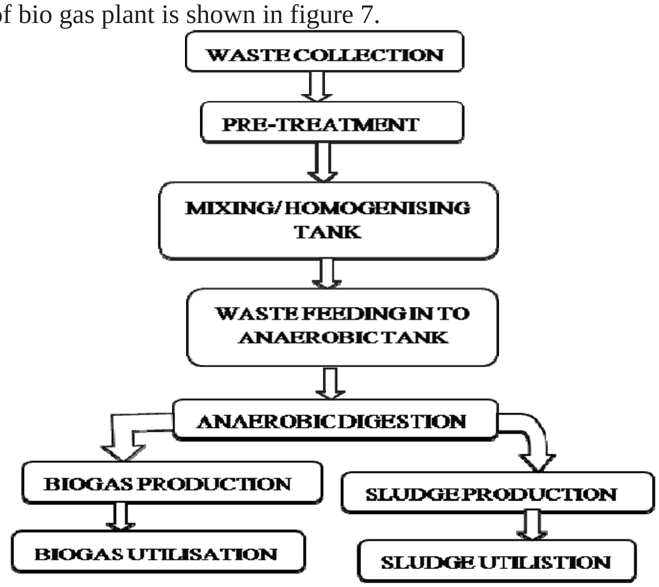

Figure 7: Process Flow Diagram

VIII. MULTI-AGENT SYSTEM (MAS) CONTROL STRATEGY OF DGS

Distribution system with distributed generations (DGs) especially considering the operation of micro-grids (MGs) composed of DGs and loads, a service emancipation model aiming at the emancipation of the most loads with the least number of switching actions is built. On the basis of the proposed hierarchical control strategy among dispatching center of distribution network, MGs and DGs. The proposed system applies the multi-agent theory with the satisfaction of the restriction of radial supplying, voltage, current and power capacity limits of distribution

network. The proposed multi-agent service emancipation system is composed of single central control agent (CAG), several distributed generation agents (DGAGs) and micro-grid agents (MGAGs), and many bus agents (BAGs).
(i) It is a multiple link, inter-coupling and nonlinear system, and it integrates wind, solar light and bio-gases etc resources to have various and different characteristics, and also easy to affect by outside various factors to present the obvious nonlinear group.
(ii) It is dynamic and random because the various resources of DGS show the large scatter in space, the uncontrollable and random feature in time and difficult to predict accurately because it is con-strained to external conditions of wind and solar light.
(iii) It is an integrated generation, storage, distribution and trans-mission into an autonomous micro-grid system, and whose generation sources, storages, control methods and operation modes, etc are all different and diverse. Based on the characteristics of DGS and agent modeling theory [13], this paper adopts Multi-agent system (MAS) and the federated architecture to study, and appoints each device or sub-system as an individual agent and define their mutual work relations for the mutual cooperation and coordination to maintain the safe and stable operation of the whole system.

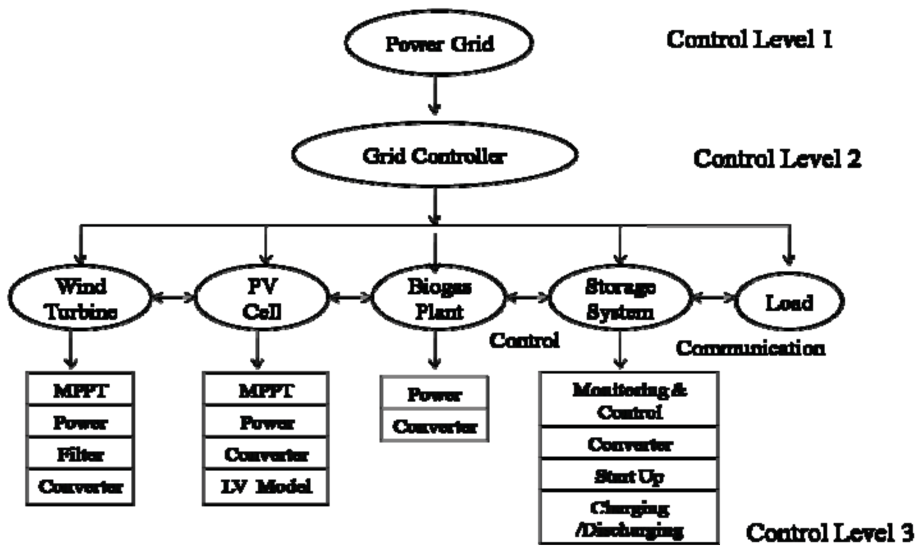

Figure 8: MAS structure of DGS

The control flow of DGS based on MAS shows in Fig.9.

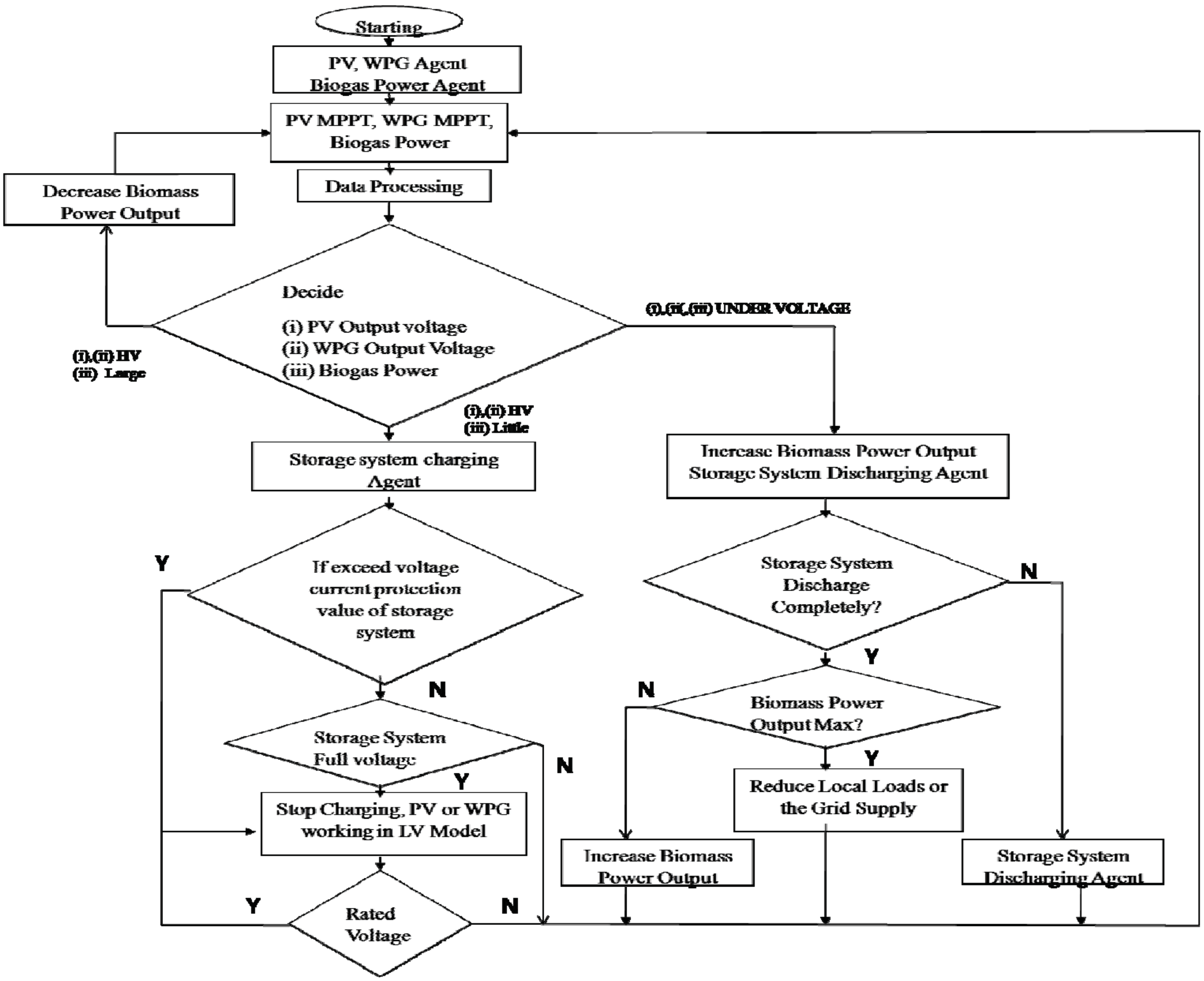

Figure 9: Control Flow of DGS

IX. CONCLUSIONS

The renewable energy is attracting more and more notice for its clean. The solar panels can used in places only where sunlight is proper, the wind power plant can only be used at spaces where speed of wind is high an adequate amount of to rotate the fan. The BIOFUEL is produced by squander and departed plant. The wind generator is broadly applied in the world and many other generators are introduce to merge the biofuel generator is only controlled by the quagmire gas pond. It is convenient and the capacity can be planed. The amalgam system of solar power, wind generator and biofuel generator keep the stable output electricity.

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