

## Control System for Solar-Plus-Battery Microgrid

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**Abstract**— With the linking of renewable PV in the critical facility, it is essential to develop a suitable MG control system offering a completely autonomous and self-sustained MG system. This paper presents an MG solution aiming to develop an MG control system battery-based (Solar with Storage) MG to support any critical facility with increasing penetration of PV. Excess electricity generated from the PV can be stored in a battery to be used later, and if required electricity must be taken from the Grid if the PV generation and battery are unable to meet the demand. A microgrid control system is required to monitor efficiently and optimally operate a microgrid with Distributed Energy Resources (DER) and storage devices. This control system should furnish several functions to be able to reliably and optimally manage the microgrid.

**Keywords**— Critical facility, Distributed Energy Resources (DER), grid, microgrid, microgrid control system, photovoltaic (PV).

### I. INTRODUCTION

A microgrid is essentially a collection of loads, Distributed Energy Resources and potential energy storage devices connected to form a relatively small size distribution network. An MG can be defined as an aggregation of DER and controllable loads with the ability to:

- Operate connected to the utility grid.
- Operate isolated.
- Provide a smooth transition between both operation modes.

According to the vision of the Department of Energy (DOE) the future electric power infrastructure, a microgrid is identified as one of the three major technical cornerstones for a more reliable and congestion-free energy delivery system. While microgrid would typically operate connected to the grid, they would have the ability to disconnect from the grid and function in "island mode" when necessary. This would increase customer reliability by reducing their liability to grid disturbances while offering desirable security features. Though, MG technology enabling to support critical facilities for instance hospital, police and fire department, etc., is overlooked because an uninterruptible power supply (UPS) unit or standalone generator is always used as a backup supply and there is no real operation and management for this critical facility.

While operating at connected mode, MG can work exporting or consuming power from the utility grid. These variations occur when MG generation is greater than its loads (exporting power) and when MG loads are greater than its generation (consuming). Operating at island mode, MG must be self-sufficient in terms of generation. In this mode, there is a need for the MG control to maintain frequency and voltage level inside an acceptable threshold. The exporting of power will be kept as a future scope and will be added as required.

All the microgrid assets are equipped with the local controllers which can take decisions according to the set parameters within it and take suitable action.

## II. LITERATURE REVIEW

A literature review focused mainly on topics related to the solar-based microgrid, maximum power point tracking, partial shading condition, a function of the controller.

Jing Wang et.al proposed that the MG is a single distribution feeder that can be operated in an islanded mode when required by the utility grid or in a serious situation such as unacceptable voltage, frequency and power quality, etc. at the Point of Common Connection. In islanded mode, load shedding is very necessary for this small MG as the generation cannot cover all the loads. [I].Zadeh et.al reviewed that the recent DERs are normally equipped with advanced control and communication systems and they can communicate directly with the supervisory controller to receive new commands and control to the DER to achieve the new set-points

[II].Bruno A et.al reviewed that the MG connection point with the utility distribution grid is made through a medium voltage recloser with microprocessor control. This unit is responsible for detecting outages in the utility distribution grid. It also contains the logic that allows MG transit between its operation modes

[III].Achim Woyte et.al proposed that the PV system is simulated as a generic crystalline silicon PV array connected to an inverter with an ideal maximum power point (MPP) tracker. The PV array is represented by a simplified model for its efficiency at MPP as a function of solar irradiance and PV cell temperature. When the available PV power is higher than the inverter's dc rating, the inverter must limit the power to prevent overload

[IV].Ghasemi et.al reviewed that a condition in which the entire modules of an array do not receive the same solar irradiance is called partial shading condition (PSC). PSCs are inevitable especially in solar systems installed in urban areas and in areas where low moving clouds are common.

## III. SYSTEM DESCRIPTION

### 3.1 SOLAR PANEL

PV systems generate electrical energy from sunlight during the day. This energy goes into a grid connected inverter which converts the DC into AC, like that of the grid. This solar electric current can then power all the appliances. Power comes directly from the solar inverter and leftover electricity can then feedback into the grid. If we need more power than our grid-connected solar system produces, that power will simply come from the main distribution grid. On the other hand, if we produce more energy than what you use, then we can store into BESS.

### 3.2 Solar Meter

A solar meter is used to measure KWh production from a PV system. This system will help to give information about whether the panels are generating to their max or so.

### 3.3 Solar Inverter

A solar inverter converts the variable direct current (DC) output of a photovoltaic panel into a utility frequency alternating current (AC) that can be fed into a commercial power grid or used by a local, off-grid electrical network. For using solar inverter with photovoltaic arrays it has adapted a special function such as, maximum power point tracking (MPPT) and anti-islanding protection.

### 3.4 Controller

The controller is the heart of the system which will monitor the entire system with accordance to the usage of the system and also switching purposes, the controller will make appropriate system changes like connecting and disconnecting the grid while excess or low power, the controller will also look after the types of load like differentiating resistive and inductive loads and send accurate power and change appropriate current/voltages.

### 3.5 Battery Energy Storage System

BESS makes it possible for the MG to work isolated from the utility grid. This is the only source that can provide a controllable voltage level for the MG during islanded operation. It is a promising versatile technology to provide electric-grid challenges. Advanced energy storage systems enable users to store excess energy to be later used. Depending upon the facility the BESS can be used adjusted or removed accordingly.

## IV. OPERATION

MG is connected to the utility grid or isolated, operating on islanded mode. With such an ability to operate in different modes, MG can work with different power sources and different loads, which allows a drastic topology change.

It will be operating in two modes:

1. Connected: While connected to the grid it will operate in two ways.
  - If MG generation is less than its load requirement in this scenario the required amount of power will be taken from the grid and will be added to the MG generation. E.g. If load requirement is 100Kw and PV generation is 80Kw then the remaining 20Kw will be taken from the grid to fulfill the load. The advantage of this system is the system will self-adjust with according to its need via the controller.
  - During monsoon, when there is no availability of sunlight the Solar will not be able to generate and charge the battery, so in this case, the controller will shift the entire load-bearing to the grid and maintain continuity in the supply.
2. Islanded Mode:
  - Islanding is the condition in which a Distributed Energy Resources continues to power a load even though electrical grid is no longer present. Island mode operation relates to power plants that operate in isolation from the electrical grid.
  - In this mode, the system will supply power as well as charge the BESS during daytime and during night-time the BESS will supply the power to the system and keep the power in continuity.

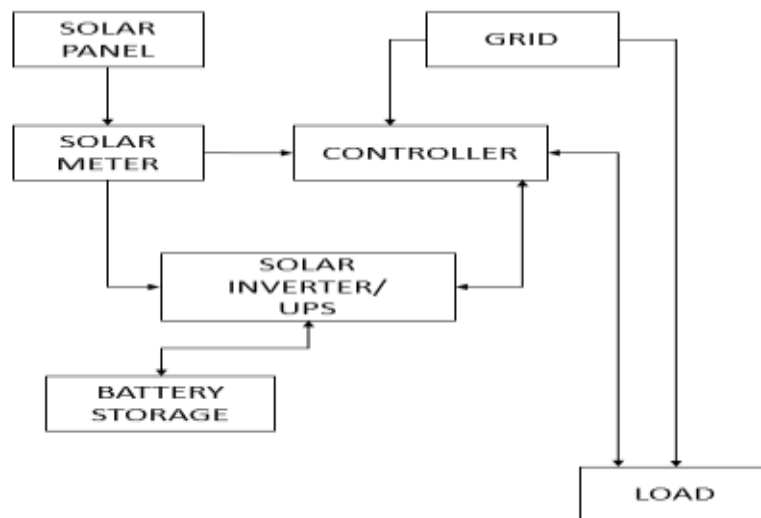


FIGURE 1: Block diagram of control system for solar-plus battery microgrid

### V. CONTROLLER ALGORITHM

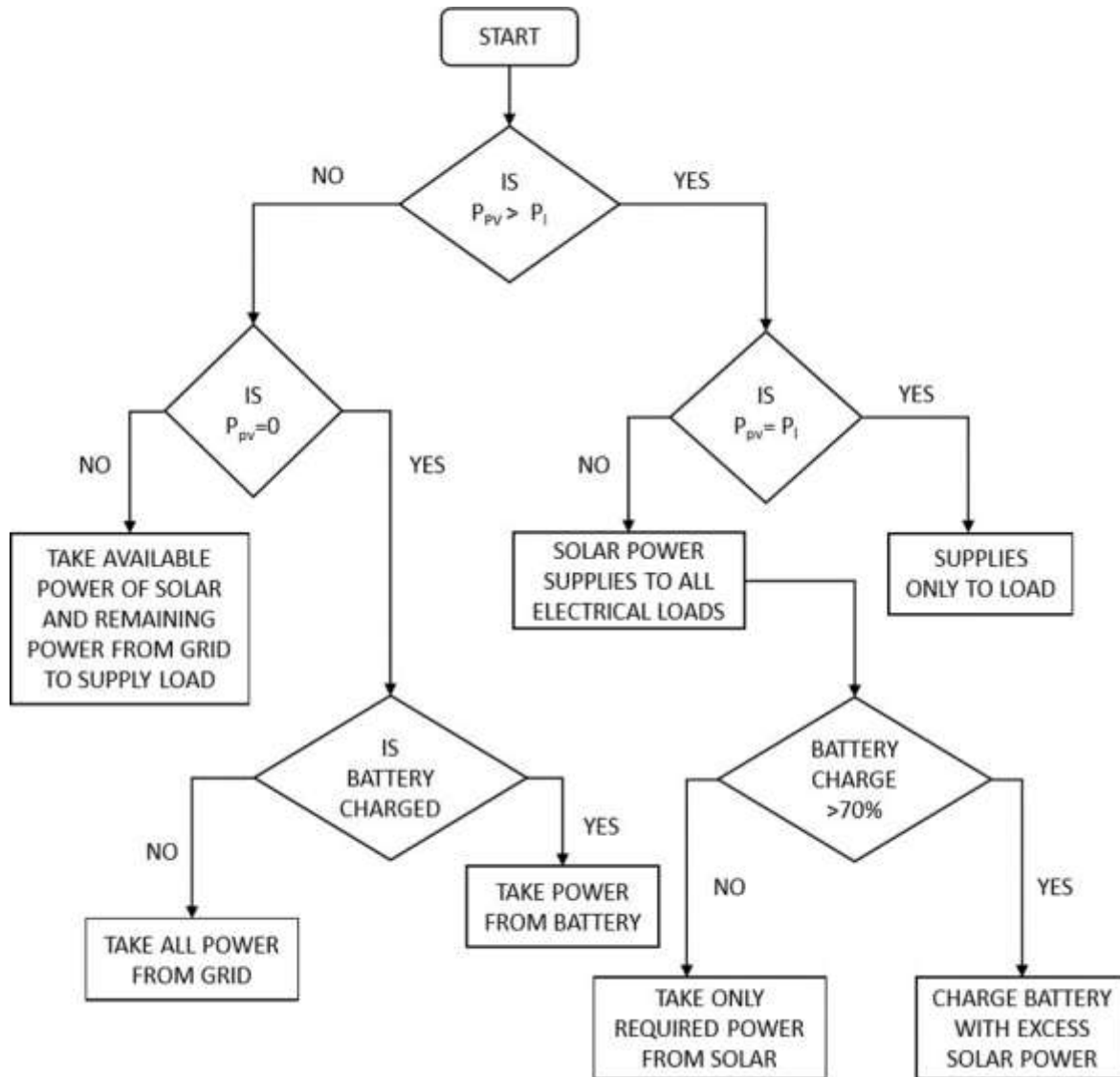


FIGURE 2: Controller algorithm of control system for solar-plus battery microgrid

### VI. CONCLUSION

In this paper, a solution aiming towards the development of an MG Solar-Battery system which helps in giving continuous power supply. Increased focus in such cases will be on the management of the system and accurate management of loads to sustain the load and keep the continuity of the system. The system will often work under islanding and also look after the protection of the system simultaneously.

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