Chapter 8
Synchronized Operation of Grid Power, Solar Power, and Battery for Smart Energy Management

Pawan Kumar
Thapar University, India

Dip V. Thanki
Lovely Professional University, India

ABSTRACT

This chapter gives details of solar photovoltaic, starting from its general pros and cons. It covers the basics of site evaluation when installing a solar powered plant and various ways to overcome the uncertainties in the predicted output of the solar arrays. The efficiency of the plant can be improved with the help of maximum power point tracker (MPPT), which works on algorithms based on perturb and observe, incremental conductance, constant voltage, etc. The output of the solar PV arrays can be utilized more effectively by integrating it with grid to supply ac loads. This integration requires a power conditioning system (PCS), enabling smooth operation. Continuity of supply can be maintained by having a battery backup, for the time when both grid and solar array fail to meet the load demand. Such a system can have wide range of applications and has the potential to meet the energy demand.

INTRODUCTION

The sun is a noteworthy wellspring of energy. The energy supplied by the sun to the earth for 60 minutes can meet the worldwide energy requirements for one year. However, it is just 0.001 percent of that energy. The earth gets 1336 watts for every square meter of direct sun oriented radiation and with the assistance of Photovoltaic (PV) cells it can be changed over straight forwardly into electrical energy. PV is intended to absorb the warm radiations of the sun and change over it to power. However, various arrangement and parallel associated PVs are required to get an adequate measure of energy since the output of PV is small which is due to its small size and technical limitations. Such a gathering of series and parallel associated PV cells is known as a solar array. The output from solar panel majorly depends
upon the temperature and the solar irradiance. So it is challenging to track the maximum power at different temperature and irradiance using different methodology.

BACKGROUND

Kumar et al. (2015) have developed a simulation model of the synchronized operation of the grid power, solar power and battery for a smart home. In this model authors have shown that under different temperature and irradiance the output power varies and the operating time of the grid and solar power changes accordingly. Abdulkadir et al. (2014), presented an improved particle swarm optimization (IPSO) based MPPT technique for photovoltaic system operating under different environmental conditions. Chandwani and Kothari (2016) comprise of detailed study in the field of MPPT in a simulate environment using MATLAB and the same results are reproduced in hardware using Perturb and Observe (P&O) algorithm. However, a method for the reduction of the steady state oscillation (to practically zero) once the maximum power point (MPP) is located is described by the Ishaque et al. (2012) and Shukla et al. (2015) studied the effect of variation in temperature and irradiance and the results are observed from simulation in MATLAB environment. Here, authors have developed program which allows the prediction of PV module behavior under different temperature and irradiance.

A detailed analysis and modeling of Solar and Fuel cells using Cadence SPICE, and to investigate dynamic interactions between the modules and power conversion circuits is presented in the thesis of Krishnamurthy (2009). The results are simulated using equivalent electronic static and dynamic models for Solar and Fuel Cells. Kumar et al. (2011, 2013, 2016 and 2017) presented a detailed analysis of the different load models which are voltage dependent. In these studies author have observed that the system voltage profile not only affect the power loss rather it majorly changes the system loadability and load profile. During peak load conditions the voltage profile usually found to be low and hence the operating efficiency of the system decreases. In order to improve the operating efficiency the integration of the solar power may help in relieving the overload and simultaneously improve the voltage and the load profile at respective nodes. On the other hand, in the ever growing demand scenario a comprehensive stability analysis, reactive power injection, loss minimization under different loading pattern for distribution system are appears in the work presented by Kumar and Singh (2014a, 2014b, 2014c).

Kumar et al. (2015) observed that PV generation depends on solar irradiance, site location and environmental conditions including temperature and wind. As a results, PV output keep on varying and it is found challenging to extract maximum power under these conditions. Kuo et al. (2013) has developed a self-synchronization error dynamics formulation based controller for MPPT in Micro-Grid Systems. Here also authors observed that the output of PV system mainly depends upon the temperature and irradiance and its efficiency is low. Smida and Sakley (2015) presented genetic algorithm based approach for MPPT under partial shaded conditions and uses two-stage conversion system which composed of a dc-dc boost converter and a dc-ac inverter whereas, Venugopalan et al. (2013) uses PSO techniques for the design of MPPT. Hill et al. (2012) presented the challenges in integration of solar power system with distribution system whereas, Jinn et al. (2014) presented the same for small capacity grid connected solar power generation system.

Qinghui et al. (2001) have proposal of different methods in order to improve the efficiency solar power generation system. Liu et al. (2008) compared and the performance of P & O and hill climbing method through theoretical analysis and digital simulation. Lee et al. (2006) proposes an advanced Incremental