

# Transient Stability Analysis of a Power System with Distributed Generation Penetration

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**Abstract**—In recent years, while fossil fuel prices have increased, these fuels have reduced to access. More importantly, it has reached an irreversible point in climate change. This situation has led to increasing importance of renewable energy resources, notably wind and solar energy. In particular, developments in technology and efforts to implement smart grids increase the share of renewable energy sources in energy generation. Due to this increased share, it has caused some changes in the power system. The most important of these changes is the power system stability, which plays a vital role in system planning and operation. These sources have tended to leave the grid in the event of a failure. Also, variable generation features always pose a risk for system stability. In this paper, IEEE 9 bus power system is used to investigate the behavior and risks of these resources with variable generation structures under various fault scenarios.

**Keywords**—power system stability, renewable energy source, distributed generation.

## I. INTRODUCTION

Most of the energy needs in the world are provided by large scale central generation systems. These systems benefit from the potential energy of water as well as fossil and nuclear fuels. Initially, these systems provided huge gains in meeting energy demand. As time passed by, we have faced some limitations arising from the selection of installation places, economic, geographic, political, medical and security-related concerns [1]. In addition to these limitations, the frequent interruption of the existing electrical grids and the increased environmental concerns caused by energy generation have made it necessary to improve the electrical grids. In recent years, developments in both technology and energy have increased the importance of smart grid technologies.

Due to technical and technological reasons, the change from existing grids to the smart grid should not be sudden. The power system must make progress in certain stages. System engineers aim to form a more reliable, flexible and economical network with smart grids. For this purpose, the least certain percentage of the energy consumed need supply by renewable energy sources. The use of distributed generation systems based on renewable energy sources should increase in the grid. This is the first step to be taken.

The increase in distributed generation systems based on renewable energy sources in power systems provides several advantages. The advantages that offer an opportunity for reliable and quality energy supply are as follows;

- It reduces greenhouse gas emissions and has a less negative impact on global warming.

- It has a short-term installation and can be expanded with additions if necessary.
- It reduces losses in transmission and distribution lines, and ensures more efficient use of energy by preventing overloads in transmission and distribution lines at peak power demand.
- It provides fuel diversity along with traditional energy fuels as well as resources such as wind, solar and geothermal energy.
- It reduces power generation, transmission, distribution, maintenance, and repair costs [2],[3],[4],[5].

In spite of all these advantages, the distributed generation systems based on renewable energy sources have cause changes in the grid. The effects of low power distributed generation can ignore in the distribution system. Nevertheless, the effects of high power distributed generation can't ignore in the transmission and distribution system. The reason for this situation is high generation rates and it affects the whole grid [4], [5]. The most noteworthy influence is that it causes some problems in power system stability. These problems can be instantaneous and transient or can turn into serious events such as power blackout. The most prominent example of this serious event is in the case of a power blackout that occurred in South Australia as a result of severe storms in 2016. The storm has caused the electrical faults which can't restore. After a short time, the system began to lose distributed generations, because almost 50 percent of energy demand was meeting by wind and solar energy. Following the loss of generation, angular instability has occurred in the whole system [6]. Southern Australia's power blackout has shown that when high penetration renewable energy sources are used, grid reliability can be dangerous. In order to overcome these difficulties and ensure the reliable operation of smart grids, the stability of distributed generation systems needs to be improved.

This paper consists of the following sections; The second section explains the impact of increasing distributed generations on power system transient stability, thanks to the smart grid. The third section gives information about the test system and distributed generation integration. The fourth section presents the making of various fault scenarios for the test system via Matlab. Finally, it has evaluated the effects over rotor angle stability of distributed generations based on renewable energy sources in the fifth section.

## II. RESEARCH APPROACH

Conventional systems consist of synchronous generators. These generators produce the inertia constant and damping torque that plays a vital role in making system stability. When

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