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Analysis the Impact of Renewable Energy Effect on Power Quality by Using Time Frequency Method

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ABSTRACT

Fossil fuel sources are reducing faster than ever before, and greenhouse gas emissions are an integral part of their output. Due to the global demand for energy saving and reduction of greenhouse gas emissions, employing renewable energy sources have increased in electricity networks. The use of renewable energy resources is growing worldwide. So there is a growing interest on their effect of on power system operation and control. In this research, the influence of power variation created by different renewable sources such as solar cells and wind) on the performance of frequency is presented. Then, load frequency control (LFC) model frequency response in the presence of renewable energy is investigated.

Keywords: *Golbal Demand, Renewable Energy Source, Load frequency control*

I. INTRODUCTION

The concept of sustainability and renewable energy appeared in different fields such as technology, culture, economics and the environment [1]. The use of renewable energy is growing fast in many countries. There are two common renewable energy sources such as wind and solar photovoltaic's (PV) [2]. The basic assumption of all renewable energy development policies is that they made demand for climate-friendly technologies. A renewable energy system could have a life-cycle efficiency of less than 100% and still be superior to a fossil based system in terms of energy resources sustainability.The growing trend of energy consumption, depletion of fossil fuel sources, and overheating are major causes of countries' tendency to use renewable energy sources (RESs) as an alternative to fossil fuels. The Kyoto Protocol is one of the first steps to replace renewable energies with fossil fuels. In fact, the Kyoto Protocol is the most comprehensive and comprehensive agreement on the environment and sustainable development to date. This Protocol aims to reduce greenhouse gas emissions, which has been one of the main causes of global warming in recent decades. Growing RESs cause restriction of greenhouse gas emissions, prevent the building of new transmission circuits and large generating cells [3,4]. To improve energy security, quality and reliability are important factors in environmental, commercial aspects. The employing of renewable energy technologies, such as wind turbines, solar panels, biomass pellets, small hydro and others are growing quickly [5].

Entering of RESs into power system grids have effects on power flow, power quality, frequency and voltage control, system economics and load transmission.

In the last decade according to the nature of RESs power variation, the impacton the frequency regulation issue has gained increasing research interest. Currently, wind is the most widely used renewable energy technology in power systems, and it has been predicted that wind power global penetration will reach 8% by 2020, about 400 GW installed worldwide [6]. Based on the economic value, the global wind market in2007 was worth about 25 billion EUR or 36 billion US$ in novel generating equipment. With the growing tendency of connecting high penetrations of wind energy conversion systems to the transmission networks cause the challenge of updating the grid code for the connection of high-capacity RESs. However, the novel nature of some RES technologies, like wind turbines and photovoltaic systems, results to uncertainties in their technical performance, especially during abnormal power system operating situations when power system security may be atrisk. It also cause challenges in developing mathematical models that can often predict power system manner with high renewable energy penetration [7-9].

In recent years, the development in wind power development is attracted considerable attention. Considerable research has been made on the technological area and the development of novel energy storage technologies is challenging.

But, there are unresolved issues for wind energy integration, particularly in the area offorecasting and in the general enhancement of frequency regulation. The variable and non-storable nature of some renewable energy forms, such as wind and solar energy, results to a requirement for the accurate prediction of resource availability and then electricity production.

II. Literature Review

Recently, using renewable energy technologies has grown considerably. Due to the energy crisis, environmental, economic, political, market and social issues, researchers have been attracted to develop sources of sustainable and renewable energies to secure energy consumption, protect the environment, and to promote regional development. Kowalski, *et al.* [10], uses a combination of scenario planning and Multi Criteria Assessment (MCA) to decrease uncertainty in energy development, where a diversity of stakeholders is included in the decision-making process, considering a broad spectrum of social, economic, environmental and technical criteria. For instance, Luthra, *et al.* [11] showed the barriers for employing renewable and sustainable technologies in India by using the analytic hierarchy process (AHP) technique; Streimikiene, *et al.* [12],ranked and selected some sustainable electricity production technologies by integration of Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) and MOORA plus Full Multiplicative form (MULTIMOORA) techniques. Some researchers report the impact of wind power components and Impacts of wind power components and variations on power system frequency control. Frequency regulation effect is defined to be those impacts that happen on the basis of a few seconds to minutes [13]. One method for quantifying wind penetration based on the amount of fluctuating power that can be filtered by wind turbine generation and thermal plants is reported. A small power system containing three thermal units(equipped with load frequency control (LFC) system) and a wind farm is determined as a test example. By the Bode diagram of system transfer performance between frequency deviation and real power fluctuation signals, the permitted power fluctuationfor 1% frequency deviation is estimated.

To confirm a regular primary reserve even when the wind generator performs under rated power, without any wind speed measurement, a fuzzy logic supervisor is suggested by Courtecuisse *et al* [14]. This supervisor is used to simultaneously control the generator torque and the pitch angle to keep a primary reserve.

III. Methods

To analyse the additional variation caused by RES units, the total impact is important, and every change in RES power efficiency does not require being corresponded one for one by a change in another generating unit moving in the opposite direction. But, the slow RES power fluctuation dynamics and total average power variation negatively related to the power imbalance and frequency deviation, which should be considered in the LFC control. This power fluctuation must be inserted in the conventional LFC system. A type of LFC model is displayed in Figure 1. Here, to cover the variety of generation kinds in the control area, various values for turbine governor parameters and the generator regulation parameters are taken into account.

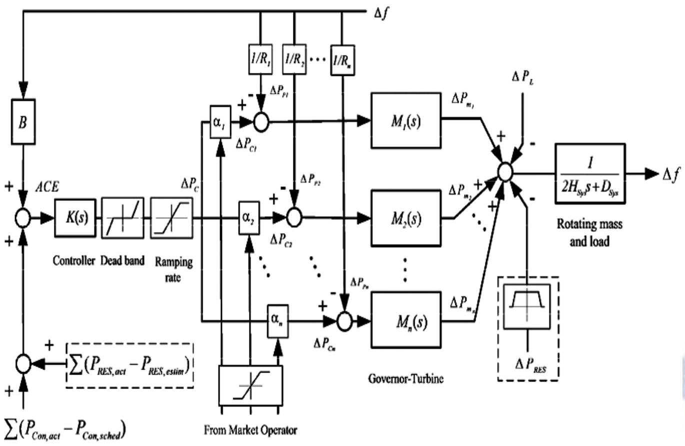

Figure 1: LFC model with according Renewable Energy Sources power fluctuation.

IV. Results and Discussion

A. Frequency analysis response

The system frequency is obtainedin according to the impact of primary and supplementary controls in figure 1.

$$\Delta f(s) = \frac{1}{2H_{\mathrm{Sys}}s + D_{\mathrm{Sys}}} \Big[\sum_{k=1}^{n} \Delta P_{\mathrm{m}_k}(s) - \Delta P_{\mathrm{RES}}(s) - \Delta P \quad (1)$$

Where

$$\Delta P_{\mathrm{m}_k}(s) = M_k(s)[\Delta P_{\mathrm{C}_k}(s) - \Delta P_{\mathrm{P}_k}(s)] \quad (2)$$

And

$$\Delta P_{\mathrm{P}_k}(s) = \frac{\Delta f(s)}{R_k} \quad (3)$$

It is proposedthat the DPL and the area load disturbance contain the effects of tie-line power deviation.The DPP and DPC are primary and supplementarycontrol actions. Equations (2) and (3) substituted into (1) and give the following result:

$$\Delta f(s) = \frac{1}{2H_{\mathrm{Sys}}s + D_{\mathrm{Sys}}} \left(\sum_{k=1}^{n} M_k(s) \left[\Delta P_{\mathrm{C}_k}(s) - \frac{1}{R_k}\Delta f(s) \right] - \Delta P_{\mathrm{RES}}(s) - \Delta P_{\mathrm{L}}(s) \right) \quad (4)$$

For analysis the load disturbance, we are interested in DPL(s) in a step function, that is

$$\Delta P_{\mathrm{L}}(s) = \frac{\Delta P_{\mathrm{L}}}{s} \quad (5)$$

By substituting DPL(s) into (5), the results yield:

$$\Delta f(s) = \frac{1}{g(s)} \left[\sum_{k=1}^{n} M_k(s)\Delta P_{\mathrm{C}_k}(s) - \Delta P_{\mathrm{RES}}(s) \right] - \frac{1}{sg(s)}\Delta P_{\mathrm{L}} \quad (6)$$

$$g(s) = 2H_{\mathrm{Sys}}s + D_{\mathrm{Sys}} + \sum_{k=1}^{n} \frac{M_k(s)}{R_k} \quad (7)$$

Furthermore, several low-order models for turbine-governordynamics Mi(s) to apply in power system frequency analysis and control design have been suggested. The slow system dynamics of the boiler and the fastgenerator dynamics are not consideredin these models. First, a second-order model wasfirst presented by Elgerd et al[15]. Moreover, Anderson et al proposed the a simplified first-order

turbine-governor model. Thus, the frequency deviation in steady state is obtained by Substituting this model and employing the final amount theorem.

$$\Delta f_{\mathrm{ss}} = \frac{R_{\mathrm{Sys}}(\Delta P_{\mathrm{C}} - \Delta P_{\mathrm{RES}} - \Delta P_{\mathrm{L}})}{(D_{\mathrm{Sys}}R_{\mathrm{Sys}} + 1)} \quad (8)$$

4.2. Simulation Study

The power results of solar and wind power generation systems are relying on weather, seasons and geographical places. Thus, they can considerably affect the performance of frequency regulation. In this part, a simulation study about the impact of solar and wind power cellson the power system frequency are studied. Hence, a network with the same topology as the well-known IEEE 39-bus test system is shown in figure 2. This system is taken into account to simulate the effect of RESs on the performance of system frequency. The system that is used consist of 10 generators, 19 loads, 34 transmission lines and 12 transformers. And two wind farms in areas 1 and 3, and a photovoltaic (PV) unit in area 2 added tothe system. The total generation has 842MW conventional power,2000 kW solar power and 46 MW wind power. The load amount in Area 1, Area 2 and Area 3 are 265.5, 233 and 125MW.

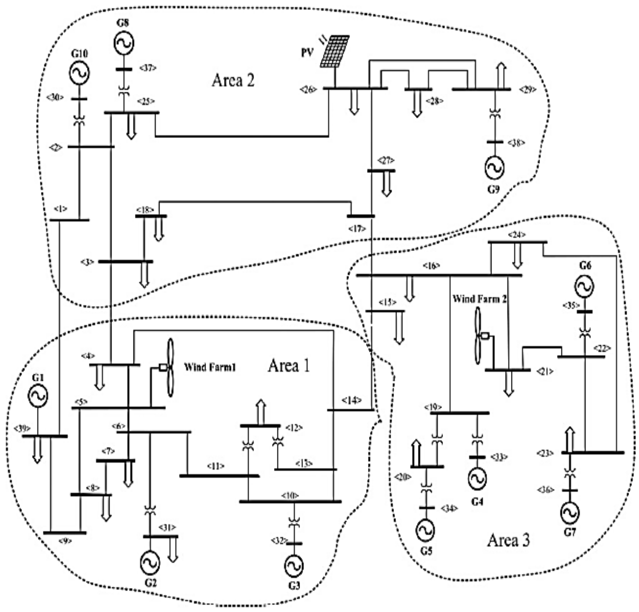

Figure 2: The diagram of 39-bus test system

To analyze of simulation, random variations of solar isolation and wind velocity have been considered. A mix of variable and fixed wind turbines have been employed in the wind farms. The variation of produced powers bywind farms and PV sources perform the source of frequencyvariation in the study system. The wind velocity VWind (m/s),the total output power of wind farms PWT (MW) and theoutput power of PV unit PPV (MW) are presented in Fig. 3.

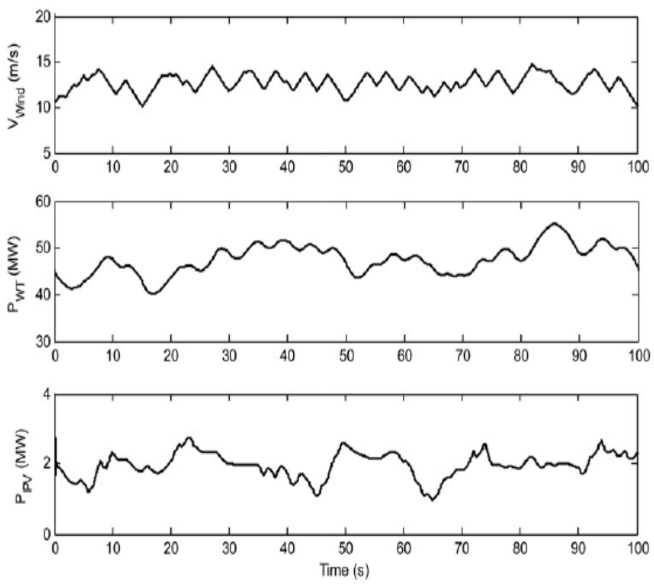

Figure 3: Wind velocity and the power of RES cells.

V. Conclusion

In this work, the issue of combining the RESs into the power system frequency regulation, is studied. A new load frequency control (LFC) is presented and the response of Power system frequency in RESs is investigated.

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