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Emerging Power Quality Challenges Due To Integration of Solar and Wind Energy Sources: A Review

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Abstract

Today, the demand for energy has increased significantly because fossil fuels are consumed at too high a price. If the current situation persists, the younger generation is likely to be at a disadvantage in energy consumption. The hybrid system is a precise solution to prevent customers from running out of energy and meeting their needs. Solar and wind energy are abundantly extracted and can be considered a reliable source of power generation. The hybrid wind / solar energy RES is integrated into the grid using a grid interface inverter that contains electronic power switches that cause harmonics in the grid, reducing the power quality on the load side.

Index Terms - Doubly Fed Induction Generator, FACTS Devices, Power Quality, and Renewable Energy system

I. INTRODUCTION

Renewable energy systems are proving to be promising and environmentally friendly sources of the energy age, especially in countries with insufficient fossil fuels. In the present years, solar and wind-based systems have attracted additional interest to provide power to remote or electricity-poor regions.

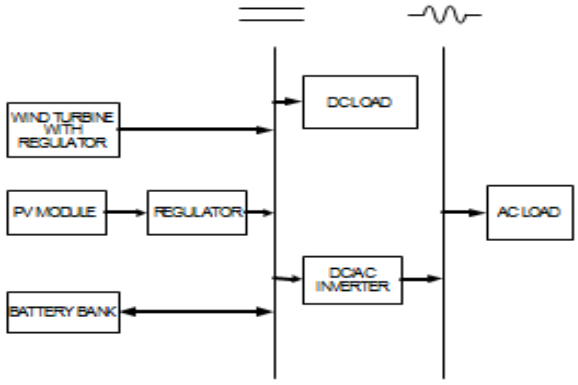

Fig1: Wind & Solar Hybrid Energy System [13]

These resources are connected to the national network or the public network. It works in two modes. They are island mode and network connected mode. As of March 31, 2012, interactive grid power generation from RES amounts to 24,914 MW, or approximately 12.1% of the total installed energy capacity. In addition, the Ministry of New and Renewable Energy (MNRE), Government of India, is aiming for an interactive grid power of 20,000 MW through solar energy and 38,500 MW wind energy by 2022. At some point of combination or network integration, there are numerous of growing issues such as timing, power quality and protection, load sharing, etc.

II. LITERATURE SURVEY

Some of the articles published in IEEE journals and conferences have been reviewed; in the discussed literature on energy quality and reliability in the generation of renewable energy, various prediction elements with regard to harmonic

reduction have been put forward. It mainly focused on various methods for power quality improvement strategies in hybrid power systems. The SVC controller is used to not match the supply and demand of reactive power in the diesel wind hybrid system in different wind power input and load situations. The Ann models have been developed for an autonomous wind-diesel hybrid system with variable speed / slip. About 70% to 80% of power quality problems can be attributed to faulty connections and cables [1]. An overview of grid integration and power quality issues associated with the combination of renewable energy systems and the functions of electronic power equipment and the flexible AC transmission system addresses these issues. The latest developments in power electronics for the integration of wind and photovoltaic (PV) generators are presented. It provides a discussion of common and future trends in renewable energy systems, based entirely on the reliability and maturity of each era. The type of numerous power quality problems used by specific researchers has been carried out. Applications of various techniques performed to reduce discriminatory power quality problems are also presented for consideration in [2]. The simulation and hardware model of the hybrid system of solar and wind energy connected to the grid are carried out. For this, the evaluation is performed in the simulated version to determine the source drop, rise and voltage, supply current and percentage THD. The prototype version of the hardware of the single-phase version has also evolved. The seven-level inverter is used to improve the overall power quality of the system.

The model is simulated by means of the mathematical laboratory simulation package and also by the design of the studied transducer with seven levels. Non-sinusoidal supply voltage, supply current and load voltage have become sinusoidal using the controller. The controller reduces the reactive power introduced by the photovoltaic source, improving the THD to about 3% of the system. The voltage at the common junction increases by 29.11% with the use of the controller in [3]. Paper offers with modeling and simulation work of hybrid wind-solar energy RES and interconnection with the grid with characteristics of improving the quality of the energy. The Grid Interface Inverter also acts as a Hybrid Series Active Filter (HSAF) with the Synchronous Reference Frame (SRF) method that uses a self-tuning filter (STF) to reduce problems related to voltage unbalance and harmonics. Voltage within the grid side. It also creates a contrast between the traditional low-pass filter and the auto-tuning filter. A reduction in the overall harmonic distortion (THD) will be detected with the auto-tuning filter. The expected THD will drop below 5% here, the inverter itself served: one as a network interface converter converting DC to AC and the second as a serial active filter voltage source converter [4]. Fundamental power quality problems such as voltage distortion, harmonics and voltage drop were depicted in a hybrid wind and solar power system.

Since power quality issues are everywhere, it needs to be mitigated to improve power quality. Voltage drop is the most common power quality problem in the power system. When we consider a hybrid power system, there are constant power quality issues. Power quality issues can be mitigated by using a synchronous generator and an active filter. This will help to connect more and more extraordinary types of grid-related power devices with higher power quality. Some other photovoltaic devices are being used as a source of STATCOM for greater use of useful unconventional resources [5]. THD tests of the inverter with

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5 and 7 levels were performed. The simulations were completed using MATLAB Simulink with evolved topology and the developed topology was observed to exhibit the highest amount of THD and, in addition, there may be growth within the fundamental voltage sense suggesting adequate performance.

The photovoltaic generator and boost converter are modeled and their overall performance analyzed. In addition, the inverter is simulated with 7 levels using the photovoltaic array as input and performance has been determined to be accurate in [6]. Presents a bibliographic overview of the tool and application of FACTS technology for energy quality and efficient use of the renewable energy system in [7]. New trends in power electronic technology for the integration of renewable energy sources and energy storage systems are discussed in [8]. Measurements for the active filter in addition to the behavior of UPS compatible inverter systems at some points of grid failure are reported on the utility side. Without APF, the overall harmonic distortion is 32.8%, and using APF in a DG unit reduces THD by approximately 10.2% at non-linear masses. By using the APF series, the THD value in [9] was almost reduced to 9.5%. The combination photovoltaic and fuel cell system consists of a photovoltaic panel. A battery bank is connected to the DC bus. Energy is present in the path of the battery when present in a charged state, the fuel cell will shut down. In this situation, the battery supplies power to the load. It was validated using a virtual test bed (VTB) discussed in [10]. A technical evaluation of power quality issues and how custom devices used to improve the PQ in grid-related renewable energy systems at the common junction point have been discussed in [11]. The evaluation of the overall performance of an active bypass filter with VSI topology, the use of the synchronous frame principle in the network-connected PQ panel was mentioned. It reduced the level of harmonics at the common junction point by 3.94% using active bypass filters [12]. The technique for calculating the optimal size of an autonomous hybrid solar wind battery system is presented in [13].

III. INTEGRATION TECHNOLOGY

The hybrid power system is a combination of renewable solar and wind energy. There are specific types of technology used for the integration of solar and wind energy. A. Wind Turbine Technology The wind turbine uses variable speed turbines as the annual energy consumption is 5% higher than the fixed speed era, and active and reactive power issues can also be easily managed however you want an additional power converter.

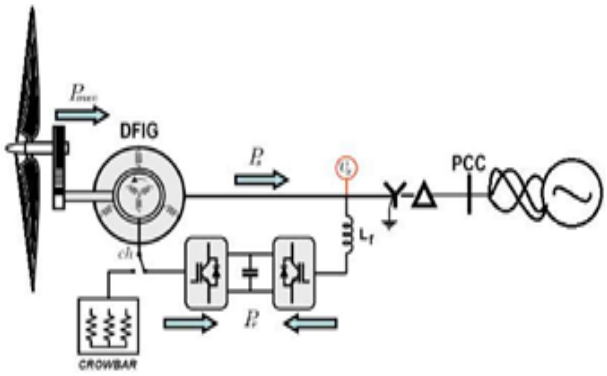

Fig2: The doubly fed induction generation (DFIG) [5]

• Variable speed concept by means of a double feed induction generator (DFIG): In this converter the rotor winding is fed even when the stator winding is directly connected to the network in a variable speed turbine with DFIG. It allows vector control of the active and reactive powers of the device, and a reduction by a high percentage of the harmonic content injected into the network.

• Variable speed concept using a full power inverter: the power from the generator is rectified to an intermediate circuit and then

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converted into suitable AC power for the network using a three-phase inverter.

• Semiconductor equipment technology: Power semiconductors with better electrical properties and lower prices are used.

• Variable speed concept with synchronous permanent magnet generator (PMSG)

B. PV Technology Photovoltaic (PV) energy is the most promising source of energy given that it is pollution free and abundant all over the world. Photovoltaic energy is particularly useful in remote places such as deserts or rural areas where problems with fuel transportation and the lack of power lines use conventional means. Photovoltaic systems as a useful alternative energy source or a supplemental energy source in hybrid systems became feasible due to the growth of research and improvement work in this region. A good way to maximize the success of photovoltaic structures, high reliability, economic value and consumer-friendly design should be pursued in the proposed photovoltaic topologies. The converter is used to convert photovoltaic direct current to alternating current and also to inject energy into the grid.

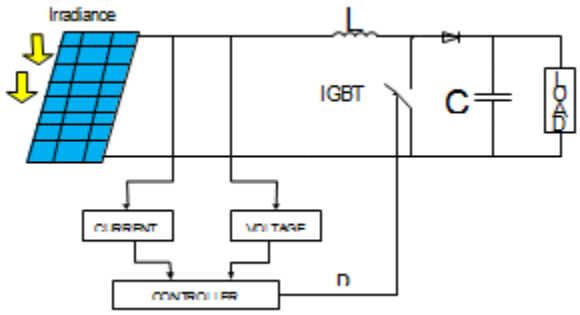

Fig3: Diagram of PV system [2]

IV. POWER QUALITY ISSUES

Power quality issues such as voltage regulation, flicker, harmonic distortion, stability, etc., occur when integrating with the existing network. These power quality issues should be limited to IEC and IEEE standards. Some of them are given below:

Table 1.

Issues	Causes
Voltage Unbalance	Large single phase loads, incorrect distribution of all 1phase loads by the three phases of the systems
Voltage Interruptions	Arc furnace, repeated start/stop of electric motors such as elevators, oscillating loads
Voltage Sag	Faults on the electrical networks, faults in consumers installation, start-up of large motors and connection of heavy loads
Voltage Swell	On/Off of heavy loads, badly dimensioned power sources, badly regulated transformers during off peak hours
Harmonic Distortion	Modern sources, all non-linear loads such as power electronic devices , SMPS, data processing equipments
Short Interruption	Opening and automatic recloser of security equipments to decommission a faulty part of the network
Long Interruption	Material failure in the electrical network, storms, human error, failure of security equipments

Power system stability refers to different kinds of stability problems, including "Rotor Angle Stability", "Frequency" Stability"and"Voltage stability".

V. POWER QUALITY MITIGATION SCHEMES

A) A Using Multilevel Inverter The multi-level technique synthesizes the AC output terminal voltage with low harmonic distortion, reducing filter requirements. The output voltage waveform of multi-level inverter consists of the number of levels of voltages, since the number of levels reach infinite, the output is pure sinusoidal. Recently, multi-level H-Bridge inverter has been used to improve power quality due to cost reduction and switching losses.

B) Application of FACTS devices the main purpose of the FACTS devices is to increase the useful transmission capacity of the lines and regulate the energy flow in the designated transmission routes. FACTS devices are also used to improve power quality. These are Static VAR Compensator (SVC), Dynamic Flow

Controller (DFC), Thyristor Controlled Series Compensator (TCSC), and Back To Back HVDC. Unified Power Flow Controller (UPFC), Static Synchronous Series Compensator (SSSC), Static Synchronous Compensator (STATCOM) and Dynamic Power Flow Controller (DPFC).

C) Using Series Active Self-tuning Filter Grid Interface Inverter acts as Hybrid Series Active Filter (HSAF) with Synchronous Reference Frame (SRF) method using Self-Tuning Filter (STF) to reduce voltage unbalance and harmonic related problems on grid side voltage.

D) With application of UPQC (Unified Power Quality Conditioner) This UPQC performance is enhanced by the fuzzy logic driver. Fuzzy controlled UPQC provides effective and efficient mitigation of both voltage drop and current harmonics than conventional PI controlled UPQC.

VI.CONCLUSION

This review article addresses all power quality issues. Common and future characteristics of renewable energy structures have been described. Grid integration and power quality problems of wind and solar energy systems and their feasible solutions available in the literature. The reasons, influences and mitigation techniques of the solar and wind energy system are presented. Power electronic devices are the viable solution to mitigate fluctuations and intermittent network integration problems. Many researchers had identified several power quality problems and their causes related to power quality in Table 1.

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