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Survey Paper on Renewable Energy Generation Grid Integration with Power Quality Improvement

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ABSTRACT:-Global electrical energy consumption is steadily increasing and there is a necessity to increase the power generation capacity. Conventional power generation schemes have serious environmental issues like climate change, high oil price, and water and oil pollution. These issues are the major drive for the search for new sustainable energy sources. The solution to this problem could be renewable energy sources, which provide significant percentage of required installed capacity addition and also eliminate the harmful emissions from the conventional power generation sources. The availability of renewable energy sources are completely based on daily and seasonal patterns. But the power required by the consumers could have very different characteristics than renewable energy sources. Therefore, it would be very difficult to operate a power system installed with only renewable generation units due to the characteristic differences and the high uncertainty of the availability of the renewable sources. The way of fully exploiting the renewable energy is by grid connection, normally at distribution level. The utility is concerned due to high penetration level of renewable energy sources in distribution systems as it may pose threat to power system in terms of stability, voltage regulation and power quality issues.

KEYWORDS:- Renewable Energy, Grid Integration, Power Quality, Power Generation

I. INTRODUCTION

Traditionally, the electric power system is not designed to accommodate renewable energy generation and storage at the distribution level. The electric utility companies are using numerous types of electric power system architectures based on different designs and choices of equipments [1]. The overall evolution of the grid has not been monolithic or based on a uniform approach to establish the most technically up-to-date, integrated system. As a result, there are major issues and obstacles to an orderly transition to using renewable energy sources with the grid. The optimization of overall electrical system performance is one of most important aspects for the long-term economic viability of distributed renewable energy systems. In order to achieve some of these benefits, power electronic interfaces are necessary to integrate with the existing electrical power system [2]. The power electronic interfaces offer unique capabilities over traditional interconnection technologies. As the price of power electronics and associated control systems decrease, these types of interconnection interfaces, along with their benefits, will become more prevalent in use with all types of renewable energy sources. With the increasing use of renewable energy systems and its technological advancement, it is becoming more important to understand the integration of these systems with the electric power systems [3]. The new markets and benefits for distributed renewable energy applications include the ability to provide ancillary services, improve energy efficiency, enhance power system reliability, and allow customer choice. The advanced power electronic interfaces will allow distributed renewable energy systems to provide increased functionality through improved power quality and voltage/VAR support, increase electrical system compatibility by reducing the fault contributions, and flexibility in operations with various other distributed renewable energy sources, while reducing overall interconnection costs [4, 5].

II. RENEWABLE ENERGY SOURCES

A renewable energy source is a natural resource which can replenish with the passage of time, either through biological reproduction or other naturally recurring processes. The renewable resources are a part of earth's natural environment and the largest components of its ecosphere. The renewable resources may be the source of power for renewable systems.

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A secure supply of energy resources is generally agreed to be a necessary but not sufficient requirement for development within a society. Furthermore, sustainable development demands a sustainable supply of energy sources that, in long term, is readily and sustainably available at reasonable cost and can be utilized for all required tasks without causing negative societal impacts. Supplies of energy resources like fossil fuel and uranium are generally acknowledged to be finite and other energy sources such as sun light, wind, falling water (hydro) are generally considered renewable and therefore sustainable over the relative long term. Wastes convertible to useful energy forms (through, for example, waste to energy incineration facilities) and biomass fuels are also usually viewed as sustainable energy sources. Environmental concerns are an important factor in sustainable development. For a variety of reasons, activities which continually degrade the environment are not sustainable over time i.e., cumulative impact of such activities on the environment often leads over time to a variety of health, ecological and other problems.

National Status and Potential:-India is the fourth largest importer of oil and the 15th largest importer of petroleum products and LNG globally. India has the fifth largest power generation portfolio worldwide with a power generation capacity of 271.722 GW. The increased use of indigenous renewable resources is expected to reduce India's dependence on expensive imported fossil fuels. Renewable energy development in India comes under the Ministry of New and Renewable Energy. India was the first country in the world to set up a ministry of Non-Conventional Energy Resources in early 1980s.

Table 1: Installed Grid Interactive Renewable Power Capacity in India

Source	Total Installed Capacity (MW)
Wind Power	26,866.66
Solar Power	6,762.85
Biomass Power (Biomass & Gasification and Bagasse Cogeneration)	4,831.33
Small Hydro Power	4,273.47
Waste to Power	115.08

Different Types of Energy Resources
There are six ultimate sources of useful energy

(i) Sun
(ii) The motion and gravitational potential of the sun, moon and earth;
(iii) Geothermal energy from cooling, chemical reactions and the radioactive decay inside the earth;
(iv) Nuclear reactions on the earth;
(v) Chemical reactions from minerals sources; and
(vi) Fossil fuel (Coal, Oil and gases)

Solar Energy:- The sun radiates energy uniformly in all directions in the form of electromagnetic waves. The sun provides the energy to sustain life in our solar system. It is a clean, inexhaustible, abundantly and universally available source of renewable energy. The major draw backs of solar energy are that it is a dilute form of energy, which is available intermittently and uncertainly, and not steady and continuous. However, it is more predictable than wind energy. Also, peak solar insolation [3] often coincides with peak daytime demand; it can be well matched to suit commercial power needs.

Wind Energy systems:- The Wind energy is the kinetic energy associated with movement of large masses of air. These motions result from uneven heating of the atmosphere by the sun, creating temperature, density and pressure differences. It is estimated that 1% of all solar radiation falling on the face of the earth is converted into kinetic energy of the atmosphere, 30% of which occurs in the lowest 1000 m of elevation. It is thus an indirect form of solar energy. In

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contrast to daily availability of solar radiation; wind energy can be available continuously throughout a 24 hours day for much longer periods, though it can vary a great extent including no wind periods. It is a clean, cheap, and eco-friendly renewable energy source. The main disadvantages are that it is a dispersed, erratic and location specific source.

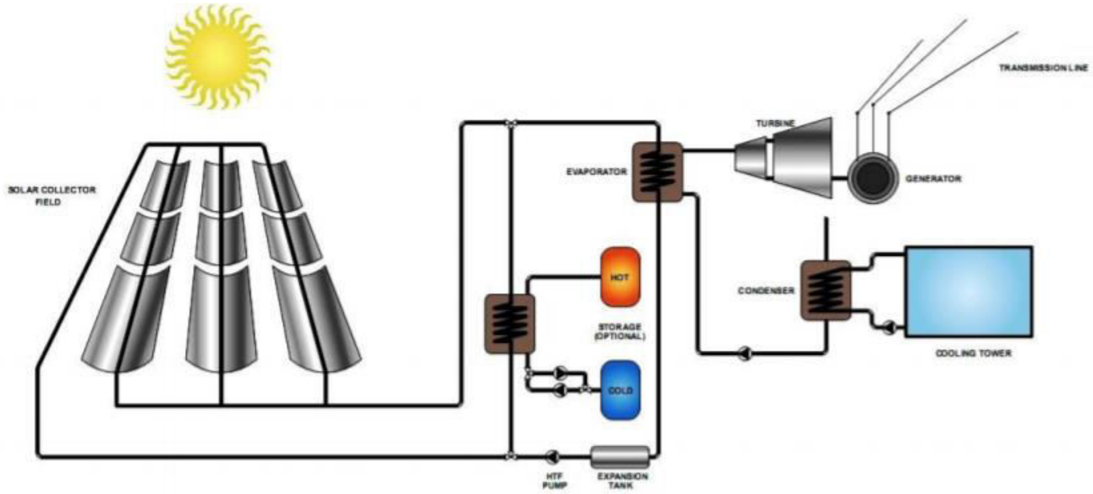

Fig.1: Solar Thermal Power Generation

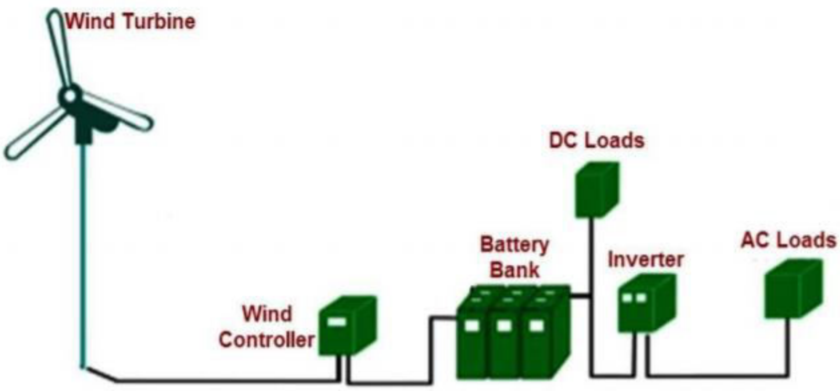

Fig.2: Wind Energy System

III. LITERATURE REVIEW

With the widespread infiltration of renewable energy sources in ac power network, power quality issues become more significant. Among the various power quality events in distributed and renewable energy source generation, harmonics are the most dominant ones [5]. According to IEEE standards, harmonics in the power system should be limited in two ways - limit on harmonic current that a user can inject into/draw from the utility at the point of common coupling (PCC) and the other is limit on harmonics in the voltage provided by utility to any customer at the PCC. The details of these limits and the distributed generation interconnection standards including power quality, protection and stability are reported in [6].

The electric output of distributed energy systems can be integrated to the electrical power grid via three basic interconnection interfaces viz. synchronous machines, asynchronous (induction) machines and power electronic interfaces. Most of the distributed resources are integrated with power electronic converters to improve the quality of power. The power electronic converters have ability to control harmonic content of the output voltage and current and also provide fast switching between utility connected and stand-alone modes of operation. Extensive literature on power electronic converter integration of renewable energy sources are presented in [7-8].

Their disadvantages are their large size, complex control schemes and requirement of additional power converters for power quality improvement which leads to increase in overall cost of the system. Among all the renewable energy sources, solar photovoltaic, wind energy systems and fuel cells are rapidly developing as the most promising renewable

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energy systems worldwide. These systems often require power conditioning units which include inverters and DC-DC converters in order to meet normal customer load demand or send electricity to grid. For wind energy systems, various integration topologies are employed depending upon type of machines used, with partially rated power converter, medium scale power converter and full-scale power converter [9].

In order to maximize the success of the PV systems, high reliability, reasonable cost, and a user-friendly design must be achieved in the PV topologies. With the increasing concern over power quality, extensive research has been done on the development of grid integration topologies for PV systems exclusively reported in [10].

Micro grids are an interesting option for consolidating several renewable energy sources and energy storage elements on a single bus before connecting them to the grid. It is very useful when the system has multiple renewable energy sources with power electronic interfaces, traditional generators, controlled loads, and uncontrolled loads connected in parallel through a common bus. The various topologies of micro grids and their control methods are discussed in [11].

There is ample published literature which presents the shunt active filter/ STATCOM as an interface for renewable energy sources with the grid. The three phase shunt active filter interface for photovoltaic systems is reported in [12]. The single phase shunt active filter interface for solar photovoltaic systems with its topology and practical implementation in the field is discussed in [13].

The three phase shunt active filter interface for wind energy system is discussed in [14] for grid connected and stand alone systems. Most cases of shunt active filter interface for wind energy systems implemented for permanent magnet synchronous machines with voltage source- current controlled inverter (VS-CCI). The implementation of WECS with reactive power control allows the system not only to supply renewable active power to the grid, but also reactive power to maintain the grid power factor at unity. The VS-CCI is capable of providing reactive power support and requires no additional components.

IV. METHODOLOGY

Grid Interface of Renewable Energy Sources:-A general configuration of grid interface of renewable energy source is shown in Fig. 3. The input power in various forms is transformed into electricity by means of a power conversion unit whose configuration is closely related to the input power nature such as solar, wind, hydrogen, etc. The power generated from these various sources can be delivered to the local loads or to the utility network, depending on the need of the hour. The main purpose of input side power electronic interface function is to extract the maximum power from the input source which contains the necessary circuitry to convert power from one form to another.

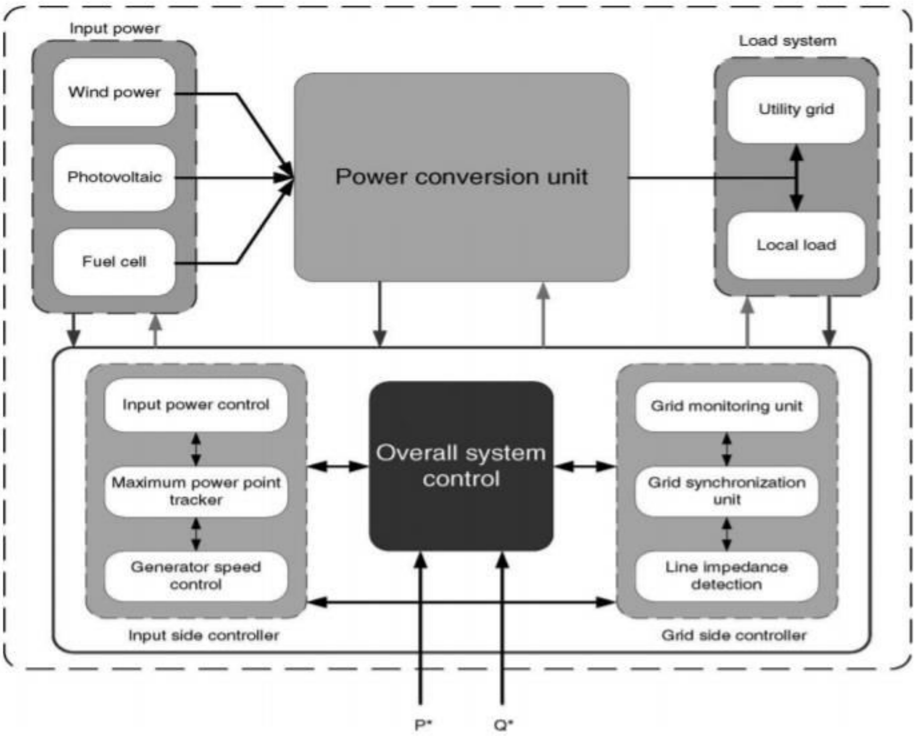

Fig. 3: General configuration of grid interface of renewable energy source with Power Electronics Interface

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The grid interface converters includes both a rectifier and an inverter or just an inverter. The inverter is compatible in voltage and frequency with the electric power system to which it will be connected and contain the necessary output filters. The power electronic interface can also contain protective functions for both the distributed renewable energy system and the local electric power system that allow paralleling and disconnection from the electric power system. These functions would typically meet the IEEE Std. 1547 interconnection requirements[6], but can be set more sensitive depending on the situation and utility interconnection requirements. This interface will also contain some level of metering and control functionality. This will ensure that the distributed energy system can operate as designed.

Controllers for Inverters at Grid Side in Renewable Energy Sources:-

The control of the grid connected inverter is very important for the operation of distributed power generation systems in the utility connected mode. The grid-side controller is designed to handle the following tasks:

- Control of active power supplied to the grid;
- Control of reactive power transfer between the distributed power generation system and the grid;
- Control of dc-link voltage;
- Ensure high quality of the injected power;
- Grid synchronization.

The grid-side converter must have the above mentioned basic features along with ancillary services like local voltage and frequency regulation, voltage harmonic compensation, or active filtering as might be requested by the grid operator. To achieve the above mentioned objectives, on the grid-side converter mainly two cascaded control loops are used. The first one is fast internal current control loop which regulates the grid current and second one is the external voltage control loop which controls and regulates the dc-link voltage. The current control loop is responsible for power quality improvement and harmonic compensation and also dynamics are the important properties of the current controller. The external dc-link voltage controller is designed for balancing the power flow in the system. Frequently, the design of this controller is aimed to have system stability and slow dynamics.

V. CONCLUSION

Among all the renewable energy sources, solar photovoltaic, wind energy systems and fuel cells are rapidly developing and becoming the most promising renewable energy systems worldwide. The solar photovoltaic and fuel cell systems often require power conditioning systems which include DC-DC converters and inverters in order to supply local loads or send electricity to grid. To enhance the quality of power from renewable energy sources, additional filtering units are required which leads to increase in the overall cost of investment in the entire system. In order to maximize the success of the renewable energy power generation, highly reliable, cost-effective and user-friendly grid integration units are required. With the increasing concern over power quality, extensive research has been done on the development of grid integration topologies for renewable energy sources. In this research work, a cost-effective and efficient three phase shunt active filter interface unit for renewable energy source-grid integration with two newly proposed controllers, is proposed. Prototype models for the same are designed, simulated and tested for various loads and varying system conditions. A detailed study of the existing renewable energy source - grid interface units reveals that the existing controllers are more complex and calculation intensive.

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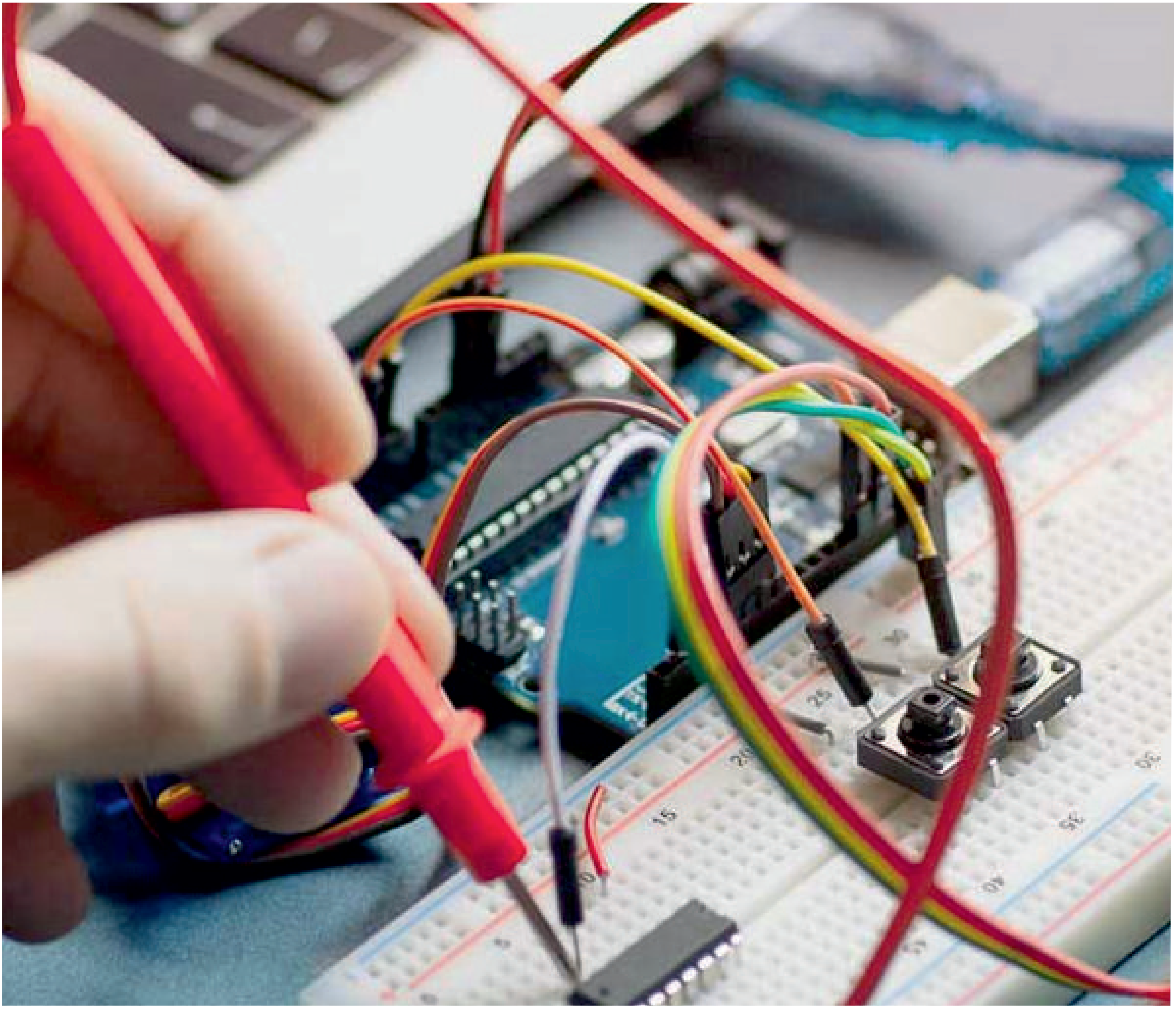

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