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Comparative Analysis of Voltage and Reactive Power Control in Distribution System with and Without Distributed Generation

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ABSTRACT:- Development of any country depends upon the energy resources of that country by which energy can be extracted in the form of electrical power. Various kind of conventional and non conventional energy resources are used on the basis of availability and technical feasibility of system. With increase the demand of an electrical energy create many problems in electrical power quality, like Sag and Swell in the Voltage level, also Swing in the Frequency. In this paper we have discussed about the Distributed Generation (wind power generation), interconnection of wind power system with conventional power station to improve the voltage profile and power factor using HVDC converter stations. HVDC converter station consists of rectifier and inverter station.

KEYWORDS: HVDC(High Voltage Direct Current), Wind Turbine ,Non-conventional energy recourse, Reactive power, Distributed Generation.

I.INTRODUCTION

This Demand of electricity is ever increasing. Over the past decades, the increment in electricity demand has been largely balanced by capacity development of conventional generations. However, further capacity development of these generations to balance demand of electricity is considered unsustainable mainly due to limited resource of their primary energies and due to negative impacts they introduce to the environment. In order to meet the future demand of electricity as well as to replace ageing existing generations, a number of new generation technologies i.e. wind power, solar thermal, solar photovoltaic, biomass, biodiesel, tidal power and wave power, which make use of the renewable energy resources e.g. wind, solar, biomass, biodiesel, tidal and wave energy as their primary energy, have been developed.

Distribution generations (DG) are electric power generators that produce electricity at a site close to customers or that are tied to an electric distribution system. Distributed generators include, but are not limited to synchronous generators, induction generators, reciprocating engines, micro turbines (combustion turbines that run on high-energy fossil fuels such as oil, propane, natural gas, gasoline or diesel), combustion gas turbines, fuel cells, solar photovoltaic, and wind turbines.

The concept of DG has been recently become commercially extensive. Distributed generation is the interconnection of alternative energy resources to the utility grid system close to the load Point to mitigate the request for an expansion of the electric transmission system.DG is meant to shift the structure of the utility system from a centralized, radial system to energy source connected on the distribution level.

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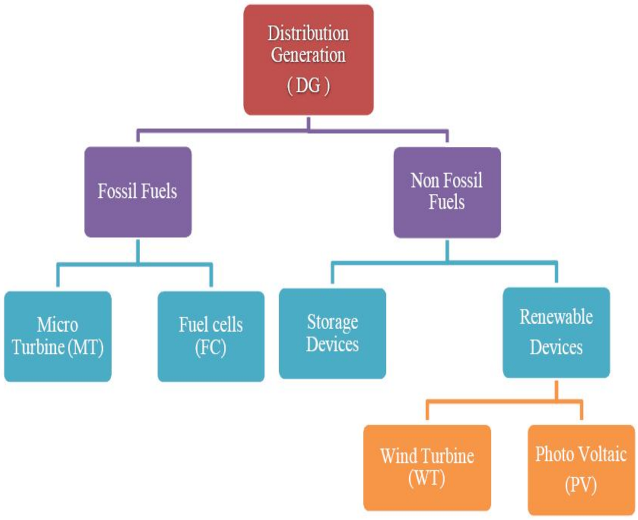

Figure 1: Distribution generation technology

Benefits of Distributed Generating Systems

Distributed Generation:

- Has a lower capital cost because of the small size of the DG.
- May reduce the need for large infrastructure construction because the DG can be constructed at the load location.
- If the DG provides power for local use, it may reduce pressure on distribution and transmission lines.
- With some technologies, produces zero or near-zero pollutant emissions over its useful life.
- With some technologies such as solar or wind, it is a form of renewable energy.

The main advantage of renewable energy systems (RES) is no fossil fuels involved because it is free like sun and wind. This decreases the operational cost of renewable energy systems and reduces operational risks. The major drawback is the initial investment in renewable energy systems, which is often larger than for non-RES. For instance, a gas turbine system may be built for 500 EUR per kW, while for a wind turbine the investment is more than 900 EUR per kW.

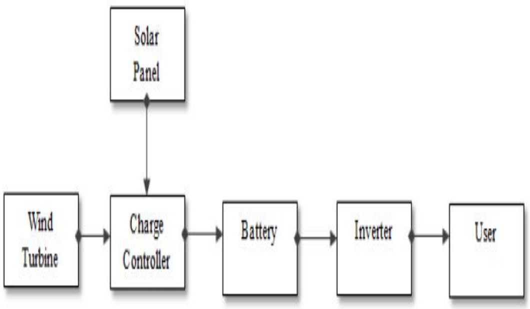

Figure 2: renewable energy sources

Other disadvantages of RES are the specific requirements of the site and the unpredictability of the power generated. The availability of renewable energy (sun, wind, water) largely determines the feasibility of a renewable energy system and this may raise environmental issues. Most of the distribution energy resources need power electronics interfaces to be connected to the micro-grid. Consequently, inverters are adopted to connect the DERs to the local ac bus with the aim to share loads properly.

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Wind Power Technology

Wind power technology captures kinetic energy in wind speed for electricity generation by utilizing a number of wind turbines. These wind turbines are installed in a particular area where the potency of wind energy is high and are linked together forming a WPP. The power generated by the wind turbines is aggregated and delivered to the grid. Depending on their location e.g. onshore or offshore, their connection to the grid may directly or through a dedicated transmission. However, variability in wind speed introduces variability in WPP power both over short period e.g. minutes and long period e.g. hours or days. When a number of WPPs are connected to a grid, the variability in their power may complicate dispatch of other types of generation. The variability in WPP power over short period may decrease when the number of utilized wind turbines increases. The variability over long period however, may decrease only when location of the WPPs are dispersed over a wide area.

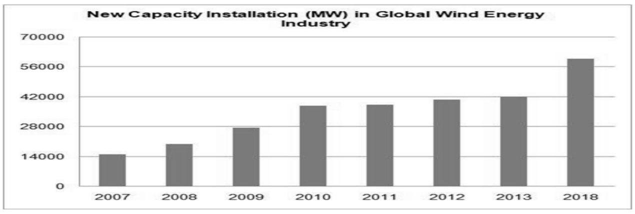

Figure 3 Global installed capacity of wind power, 2007-2018

Over the past decade, development of wind power in the world is rapidly growing (Figure 1.3). This rapid development is mainly influenced by technological advancement which has made possible to increase its turbine size to produce electricity at cost level approaching present market price. This factor also influences the increased size of WPP from utilizing tents of wind turbines to groups of up to hundreds of wind turbines. Moreover, its possibility to be installed offshore allows for development with capacity comparable to that of the conventional generation with less impact to the local society.

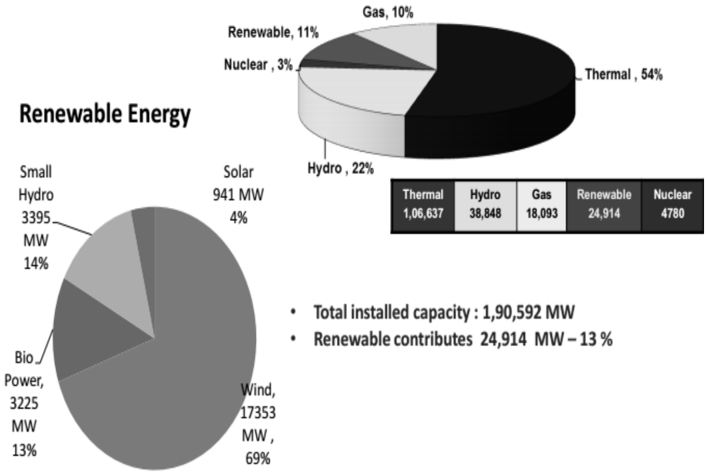

Figure 4 Wind power plants in India

HVDC

HVDC stands for High Voltage Direct Current. There are ‘classical HVDC’ and ‘HVDC Light’. The classical HVDC is useful for the transmission of large amounts of power, from a few hundreds of MW to about 3000 MW, over long distances. The HVDC Light is most cost effective in the lower power range, from a few tens of MW to about 1200 MW. Complex equipment is required for the installation of an HVDC circuit, and does not compete economically with

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an AC transmission line over short distances. For transmitting high power over long distances (several hundred km) HVDC offers the following advantages:

- only two conductors are needed (or even one conductor if the ground is used as return)
- better system stability, i.e. two networks that are not synchronized or do not have the same frequency can be connected.

II. MATHEMATICAL MODELLING

Operating Principle of the Wind Turbine DFIG

The mechanical power and the stator electric power output are computed as follows:

$$P_m = T_m W_r \qquad (3.1)$$

$$P_s = T_{em} W_s \qquad (3.2)$$

Pm Mechanical power captured by the wind turbine and transmitted to the rotor

Ps Stator electrical power output

Pr Rotor electrical power output

Pgc Cgrid electrical power output

Qs Stator reactive power output

Qr Rotor reactive power output

Qgc Cgrid reactive power output

Tm Mechanical torque applied to rotor

Tem Electromagnetic torque applied to the rotor by the generator

Wr Rotational speed of rotor

Ws Rotational speed of the magnetic flux in the air-gap of the generator, this speed is named synchronous speed. It is proportional to the frequency of the grid voltage and to the number of generator poles.

J Combined rotor and wind turbine inertia coefficient

For a loss less generator the mechanical equation is:

$$J\frac{d\omega_r}{dt} = T_m - T_{em} \qquad (3.3)$$

In steady-state at fixed speed for a loss less generator

$$T_m = T_{em} \qquad (3.4)$$

$$P_m = P_s + P_r \qquad (3.5)$$

It fallows that

$$P_r = P_m - P_s = T_m\omega_r - T_{em}\omega_s = -T_m\left(\frac{\omega_s - \omega_r}{\omega_s}\right)\omega_s = -sT_m\omega_s = -sP_s \qquad (3.6)$$

where s is defined as the slip of the generator:

The schematic diagram and the vector-based equivalent circuit of a HVDC converter station station in the synchronous dq reference frame is shown in Fig.2.

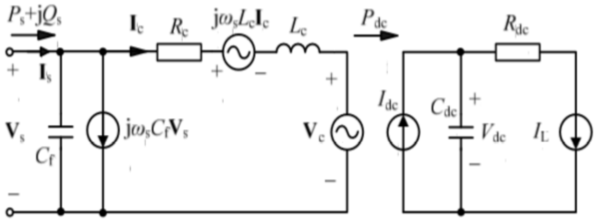

fig.6 Schematic diagram and equivalent circuit of a VSC station

$$V_c = V_s - R_c I_c - j\omega L_c I_c - L_c di/dt$$

$$I_c = I_s - j\omega_s\omega_f V_s - C_f dV_s/dt$$

$$C_{dc} V_{dc}/dt = I_{dc} - I_L$$

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$$P_s+jQ_s=3/2V_sI_s$$

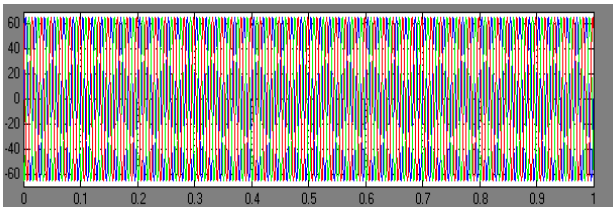
$$P_{dc}=P_s - I_cR_c =V_{dc}I_{dc}$$

$$C_fdV_s/dt_s=I_s-I_c-j\omega C_fV_s$$

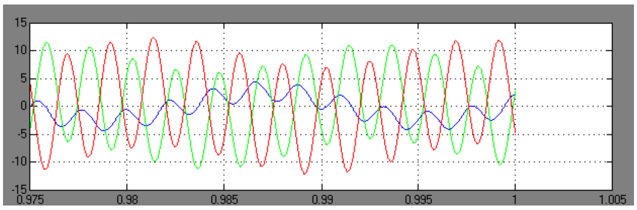
R_c=total loss of vsc, $L_{c=}$filter inductor,C_f=filter capacitor

III.RESULT AND DISCUSSION

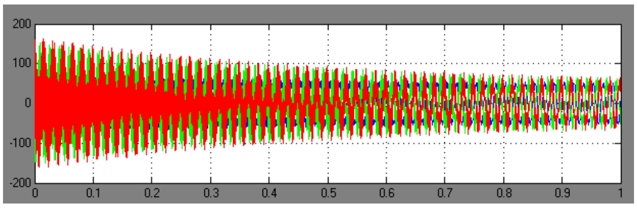
A. *Sending end voltage waveform(Vac1)*



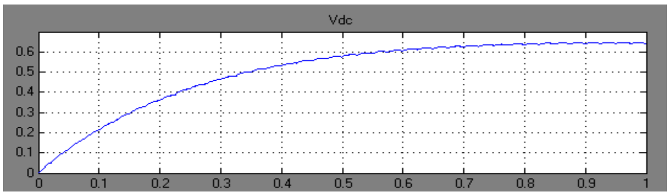
B. *Load end voltage waveform without wind power (Vac2):*



C. *Load end voltage waveform with wind power (Vac3):*



D. *DC voltage transmitted between station1 and station 2.*



IV.CONCLUSION

Simulation results show that HVDC power successfully transmitted and voltage profile as well as power quality is improved. The integration of wind turbine enhances the system reliability and it also serves as peak load plant.

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