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Modeling and Analysis of Grid Connected Induction Generator for Wind Power Application: Review

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Abstract- Over the past few decades, there has been an increasing use of induction generator particularly in wind power applications. In generator operation, a prime mover (turbine, engine) drives the rotor above the synchronous speed. Stator flux still induces currents in the rotor, but since the opposing rotor flux is now cutting the stator coils, active current is produced in stator coils, and motor now operates as a generator, and sends power back to the electrical grid. Based on the source of reactive power induction generators can be classified into two types namely standalone generator and Grid connected induction generator. In case of standalone IGs the magnetizing flux is established by a capacitor bank connected to the machine and in case of grid connection it draws magnetizing current from the grid.

Keywords- induction generator, Electric vehicle aggregator, electricity, grid.

I. INTRODUCTION

Wind power is the conversion of wind energy into a suitable form of energy, such as using wind turbines to generate electricity, windmills for mechanical power, wind pumps for water pumping, or sails to propel ships. The total amount of economically extractable power available from the wind is considerably more than present human power use from all sources. Wind power, as an alternative to fossil fuels, is abundant, renewable, widely spread, clean, and produces no greenhouse gas emissions during operation. Wind power is the world‘s rapid growing source of energy.

The majority of electricity is generated by burning coal, rather than more eco-friendly methods like hydroelectric power. This use of coal causes untold environmental damage through CO2 and other toxic emissions.

The energy sector is by far the biggest source of these emissions, both in the India and globally, and if we are to tackle climate change it is clear we need to move away from burning limited fossil fuel reserves to more sustainable and renewable sources of energy.

II. BENEFITS OF WIND POWER

Wind power has many advantages that make it a lucrative source of power for both utility- scale and small, distributed power generation applications.

The beneficial characteristics of wind power include:

1. Clean and endless fuel:
Wind power doesn‘t produce any emissions and is not run down with time. A one megawatt (1 MW) wind turbine for one year can displace over 1,500 tons of carbon dioxide, 6.5 tons of sulphur dioxides, 3.2 tons of nitrogen oxide, and 60 pounds of mercury (based on the U.S. average utility generation fuel mix).

2. Local financial development:
Wind plants can provide a firm flow of income to landowners who lease their land for wind development, while increasing property tax revenues for local communities.

3. Modular and scalable technology:
Wind applications can take many forms, including large wind farms, distributed generation, and single end-use systems. Utilities can use wind resources tactically to help reduce load forecasting risks and trapped costs.

5. Energy price stability:
By further diversifying the energy mixture, wind energy reduces dependence on conventional fuels that are subject to price and supply instability.

6. Reduced dependence on imported fuels:
Wind energy expenditures don‘t need to obtain fuels from abroad, keeping funds closer to home, and lessening reliance on foreign governments that supply these fuels.

III. LITERATURE REVIEW

Varma, A.P. and Chakri, K.B., 2012 et al they concluded DFIGs are enormously used in Wind farms because of their ability to supply power at constant voltage and frequency.Charactristics of DFIG is studied in MATLAB environment. Control techniques of DFIG have been analysed. Magnitude and Frequency control has been studied and a Simulink model for the same has been proposed.

Shi, J., Tang, Y., Xia, Y., Ren, L. and Li, J., 2011 et al his paper proposes a Superconducting Magnetic Energy Storage (SMES) based excitation system for doubly-fed induction generator (DFIG) used in wind power generation. The excitation system is composed of the rotor-side converter, the grid-side converter, the dc chopper and the superconducting magnet.

The superconducting magnet is connected with the dc side of the two converters, which can handle the active power transfer with the rotor of DFIG and the power grid independently.

Protsenko, K. and Xu, D., 2007 et al In their paper they discuss , brushless doubly fed induction generator (BDFIG) used for the wind energy conversion system is proposed. The BDFIG employs two cascaded induction machines to eliminate the brushes and copper rings in the traditional DFIG.

You, Y.M., Lipo, T.A. and Kwon, B.I., 2012 et al this paper performs a shape optimization of a grid-connected-to-the-rotor type doubly fed induction generator (DFIG) in which the rotor winding is connected to the grid instead of the stator winding. To analyze the characteristics of a DFIG accurately, a time step 2D-FEA is carried out, which is coupled with Simplorer.

Dufour, C. and Belanger, J., 2004, June et al their paper describes a real-time simulator of wind turbine generator system suitable for controller design and tests. The simulated generator is a grid-connected doubly fed induction machine with back-to-back PWM voltage source vector control at the rotor.

Rajendran, S., Govindarajan, U., Reuben, A.B. and Srinivasan, A., 2013 et al This work presents the control design for compensating reactive power requirement of induction generator (IG) in wind generation systems using STATic COMpensator (STATCOM). A mathematical model of IG is developed in synchronously rotating *d*–*q*–0 axis. The STATCOM is realised using voltage source inverter for which the switching function model is derived and employed here.

Lunardi, A.S., Chaves, J.S. and Sguarezi Filho, A.J., 2016 et al This paper presents a model-based predictive controller for Squirrel Cage Induction Generator using a Direct Torque Control. The aim of this research is control the flux and the torque to get the maximum output power from generator in a typical wind energy application. The generator is connected to the power grid through a Back to Back Converter using a Voltage Oriented Controller technique.

Pena, R., Cardenas, R., Blasco, R., Asher, G. and Clare, J., 2001 et al their new control scheme of a variable speed grid connected wind energy generation system is presented. The scheme uses a cage induction generator driven by an emulated wind turbine with two back-to-back voltage-fed PWM inverters to interface the generator and the grid. The machine currents are controlled using an indirect vector control technique.

Dekali, Z., Baghli, L. and Boumediene, A., 2019 et al This paper describes a simple indirect power control (IPC) strategy for the machine side converter (MSC) of a grid connected double fed induction generator DFIG based wind energy conversion chain system (WECS). The principle of the algorithm requires application of the field oriented control (FOC) in the dq reference frame on the DFIG model, in order to control the stator power (active P_s and reactive power Q_s) instantly and independently by acting on the rotor current components (T_{qr}, T_{dr}) respectively.

Zhang, Y. and Zhu, J., 2011, et al This paper proposes a novel configuration for wind energy applications by using a cascaded brushless doubly fed induction generator (CBDFIG) controlled by direct torque control (DTC), which eliminates the slip rings and brushes associated with the conventional DFIG and features quick response.

Tunyasrirut, S. and Charumit, C., 2014 et al This paper presents the electrical power conversion system which is developed for a self-excited induction generator in order to apply with wind turbine. In the wind energy conversion system, a self-excited induction generator is converted the mechanical energy into electrical energy.

Kaloi, G.S., Wang, J. and Baloch, M.H., 2016 et al the present paper formulates the state space modeling of doubly fed induction generator (DFIG) based wind turbine system for the purpose of the stability analysis. The objective of this study is to discuss the various modes of operation of the DFIG system under different operating conditions such as voltage sags with reference to variable wind speed and grid connection.

IV. OBJECTIVE

To conduct a study on “Grid-Connected Induction Generator for Wind Power Application [Modeling and Analysis],” the following aspects can be considered:

- To investigate the power conversion process in the grid-connected induction generator system.
- To develop a dynamic mathematical model of the grid-connected induction generator.
- To evaluate the compliance of the grid-connected induction generator system with relevant grid codes and standards.
- To Study the efficiency characteristics of the grid-connected induction generator system.
- To analyse the response of the grid-connected induction generator to various types of faults, such as grid faults or turbine-related faults.

- To investigate the impact of the grid-connected induction generator on grid stability and power quality.

These objectives have been selected for my research work whose result will be discussed.

V. GOVERNMENT POLICIES AND INITIATIVES TO PROMOTE WIND ENERGY

The Government is promoting wind power projects in the entire country through private sector investment by providing various fiscal and financial incentives such as Accelerated Depreciation benefit and concessional custom duty exemption on certain components of wind electric generators. Besides, Generation Based Incentive (GBI) Scheme is available for the wind projects commissioned before 31 March 2017.

In addition to fiscal and other incentives as stated above, the following steps also have been taken to promote the installation of wind capacity in the country: Technical support including wind resource assessment and identification of potential sites through the National Institute of Wind Energy, Chennai. In order to facilitate the inter-state sale of wind power, the inter-state transmission charges and losses have been waived off for wind and solar projects to be commissioned by March 2022. Issued guidelines for Tariff-Based Competitive Bidding Process for Procurement of Power from Grid Connected Wind Power Projects with an objective to provide a framework for procurement of wind power through a transparent process of bidding including standardization of the process and defining roles and responsibilities of various stakeholders.

These Guidelines aim to enable the Distribution Licensees to procure wind power at competitive rates in a cost-effective manner. The wind is an intermittent and site-specific resource of energy. Therefore, an extensive Wind Resource Assessment is essential for the selection of potential sites. India is continuously moving towards complying with its climate change commitments under the Paris Agreement (COP21).

VI. CONCLUSION

The topic as well as objective under the title “electric vehicle aggregators in electricity markets under optimal conditions: review” will be completed.

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