# A Review on Stability Improvement of Wind Farm using FACTS Device

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**Abstract:** ***This paper represents a review on Stability improvement of wind farm using Flexible AC Transmission System (FACTS) device. FACTS devices are used to increase the transient stability on the presence of faults and the integration of renewable sources, like wind energy. Due to continuously varying wind speed and also due to fault the active and reactive power along with terminal voltage fluctuates continuously. By connecting Static Synchronous Compensator (STATCOM) into the grid, the active power, reactive power and terminal voltage are maintained constant and also help to improve the transient stability of the system.***

**Keywords:** Transient Stability, Wind farm, FACTS, STATCOM.

## 1. Introduction

Wind power industry is developing rapidly, more and more wind farms are being connected to the power systems to utilise the available wind energy for reducing electricity price and generating clean energy. Although there is a significant growth and great development in wind energy generation technology, the only way of generating electric power or electricity from available wind energy is to use wind turbines which converts the energy available in flowing air into electricity [2]. Due to low maintenance cost of turbines as well as high capacity electric power generation wind turbines has attracted the attentions of utilities.

The most common type of wind turbine is the fixed speed turbine with squirrel cage induction generator directly connected to the grid. These wind turbines based induction generators require reactive power for compensation. Sufficient power has to be supplied to the turbine to maintain the electromagnetic torque of the wind generator. The electromagnetic torque in case of wind generator decreases significantly if the sufficient amount of power is not supplied to the turbine. The wind generator and turbine speeds increase rapidly if the difference between mechanical and electromagnetic torques increases. As a result, the system becomes unstable due to behavior of the induction generator and that results in disconnection of induction generator from the power system. The shutdown of a large wind farm creates serious effects on operation of the power system like loss of generation, voltage and frequency variations and power imbalance. Therefore the shutdown operation has to be decreased [3].

## 2. General Background

The Static Synchronous Compensator (STATCOM) is a controlled reactive-power source, consists of shunt connected voltage source converter through coupling transformer with the transmission line. STATCOM can control voltage magnitude and, to a small extent, the phase angle in a very short time and therefore, has ability to improve the performance of the system [1].Due to the increased load demands as well as the economic growth and rapid increase in emission of $CO_2$ creates the global warming. These problems created the desire for renewable energy sources like solar energy, wind energy etc. Electricity generation using wind turbine generator has attracted more attentions [3].

Fixed speed turbine induction generator with squirrel cage type is the most common type of wind turbine generator directly connected to the grid. Reactive power compensation is required for these types of wind turbines based induction generators. If sufficient reactive power is not supplied, the system becomes unstable due to the imbalances in the torques i.e. electromagnetic and mechanical torques.

Short circuit of power systems network, equipment short circuits, loss of production capacity and tripping of transmission lines creates fault on power system. Faults on power systems are related to the transient stability of the system. Such kind of faults affects the both real and reactive power flow and also their balances. When large voltage drops occur, there will be unbalances and redistribution of real power and reactive power in the power network which may force the voltage to cross the limit of stability even though the induction generator have the suitable capacity. After that, a period of low voltage may occur and possibly be followed by a complete loss of power system and the wind farm connected nearby will be affected by this problem. If a fault strikes the transmission line and causes the voltage at point of common coupling of local wind turbines to drop, then local wind turbines will be simply disconnected from the grid and reconnected when the fault is cleared and the voltage returned to normal operating conditions. Earlier, wind power penetration was low, wind power generation by wind farms increases as the penetration of wind energy increases. Due to the imbalances between electromagnetic and mechanical torques, stability of the system gets affected for that production of wind generation is lost. Therefore a large capacity of wind farm may have to be suddenly disconnected from the systems. The system may suffer a drop in voltage or frequency and possibly followed by a complete blackout unless the remaining power plants replace the loss within a very short time. As a result, to avoid total disconnection from the grid, there might be a new generation of wind turbines that can ride through the disturbances and faults. It is important to ensure that the wind turbine can restore the normal operation in a simple way and within suitable time in order to keep system stability. Optimization of wind turbine technologies may result in adequate design so as to face the future problems. FACTS devices such as STATCOM may be used to limit these problems and support the system stability [1].

## 3. Wind Farm

The combination of wind turbines are called wind farm, which is used for production of electricity. A few dozen to several hundred individual wind turbines constitutes a large wind farm and cover an extended area of hundreds of square miles (square kilometres. Because of strong winds flowing over the surface of an ocean or lake the best location of a wind farm is off-shore.

## 4. Transient Stability

Transient stability of the power system is the ability of the system to maintain or remain synchronism or returned back to its original position after subjected to a large disturbance. Severe or large disturbances like equipment outages, abnormal conditions like faults and load changes result in large excursion of generator rotor angles. The resulting system response is influenced by the nonlinear power-angle relationship. In case of transient stability study the time frame is usually considered as 3–5 s following the disturbance. The duration may extend up to 10–20 s for a very large system with dominant inter-area swings.

The main aspects of wind farm that affect the transient stability are location of wind farm and generator technology.

High wind resources located in one particular area leading high power generation for that modified power flows is required including increased tie-line flows. Critical fault clearing times can be considerably reduced and additional lines might be required to transfer the generated power.

Transient stability margins can be improved when variable speed wind generators being equipped with low voltage ride-through capability, reactive current boosting and ideally with fast voltage control. because the reactive contribution is highly limited due to reactive losses in sub-transmission and distribution systems, the integration of wind has a negative impact on transient stability [10].

## 5. Introduction of grid stability and its requirements

The connection of large wind turbines to the grid has large impact on grid stability. The squirrel cage induction generator of the constant speed systems always consumes reactive power. The consumption depends on the voltage and generated active power. In most of the cases this consumption is compensated by capacitors. By adding capacitors the impact of the wind generator is reduced. However, controllable reactive power sources are needed to fulfil the requirements, such as switched capacitor banks, STATCOM and Static VAR Compensator [10].

## 6. Literature survey of existing work

Bouhadouza Boubekeur *et al.* [1] describe how FACTS devices are used to increase the transient stability on the presence of faults and the integration of wind energy source. Wind turbine system is modeled in this paper. For modelling of wind turbine system, two main blocks are needed that is rotor model and generator model, and then it is connected to the grid. After connecting it to the grid simulation using MATLAB is done on presence of fault. Simulation results shows that using STATCOM shows the active and reactive power at the load bus stabilized faster with less oscillation compared with the results without using STATCOM in the transient state and even after the fault. The research work done by Omar Noureldeen, Mahmoud Rihan and Barkat Hasanin [2] presents about the impact of the fault which ride through on the stability of fixed speed wind farm which connected to the grid. Effect of the location of fault and its duration time are studied for different types of fault. The application of STATCOM to support the fixed-speed wind farm connected to grid during different fault locations and different fault duration times are investigated. Another research work done by Qusay Salem and Ibrahim Altawil [3] presents the transient stability enhancement in different operating conditions. A wind farm consisting of wind turbines which are based on fixed speed induction generators connected to grid has been proposed. A Static VAR Compensator (SVC) and STATCOM have been attached at the transmission system for reactive power support. It was noticed from the simulation results that STATCOM and SVC have strongly supported the point of common coupling voltage and reactive power as well as the grid voltage and reactive power particularly when the system has subjected to severe disturbances. In addition, it was also noticed that STATCOM is more robust and faster than SVC in recovering the system back to a stable operation. M. Tarafdar Hagh, A. Roshan Milani and A. Lafzi [4] described the effects of using a local resistance (stabilizer) and STATCOM in keeping and increasing stability of wind farms by MATLAB SIMULNK software and the STATCOM application role in induction generators stability increase to grid. FACTS devices are used in wind farm in order to keep the stability and also create generated power transmission. It uses 6 turbine which is of 15 mw each and it is connected to the grid by a 400/20 kV transformer. Squirrel cage induction generators are employed in this paper. In addition, the wind farm modelling and STATCOM usage are studied to increase the upper limits of induction generators dynamic stability in various distortion conditions in grid. The work done by Vaishali Chavhan and A. A. Ghute [5] presents the fixed speed induction generator (FSIG) based wind farm connected to interconnected power system. This paper presents the impact of fault on the system stability. After modelling of wind turbine and induction generator, STATCOM is also connected in order to make the system stable. Another research work done by Vimal Patel and Ravi Kumar Paliwal [6] describes the model to maintain the stable operation of grid connected wind farm when the fault ride through the system, voltage stability is a main important function for this operation. This paper investigates voltage source static VAR compensator such as STATCOM for the voltage stability as shunt compensator for DFIG-based wind farm connected to load and a grid Flexible AC Transmission System (FACTS) devices have been used for flexible power flow control, secure loading and damping of power system oscillation. Some of those are used also to improve transient and dynamic stability of wind power generation system (WPGS). The work done by Mohamad Amiri and Mina Sheikholeslami [7] presents the transient stability improvement of wind farms based on fixed speed induction generators using STATCOM and SVC. So the use of the SVC and STATCOM are investigated for wind farm integration. The effect of fault location and its duration time is studied for different types of fault. Simulation test that is using MATLAB-Simulink are implemented on a 9 MW wind farm which exports power to 120 KV grid. The research work done by V. Suresh Kumar, Ahmed F. Zobaa, R. Dinesh Kannan and K. Kalaiselvi [8] presents Power Quality and Stability Improvement in Wind Park System Using STATCOM where wind turbine is connected to an induction generator and synchronous generator was modelled using PSCAD to analyze power quality and reliability problems. STATCOM unit was developed to inject and absorb reactive power to mitigate power quality problems and to get stable grid operation. Voltage flicker and harmonics are the main power quality issues and two approaches are used to mitigate power quality problems, they are load conditioning which ensures that equipment is made less sensitive to power disturbances, allowing the operation even under significant voltage distortion and install line conditioning system that suppresses the power disturbances. The review work done by Sandeep Gupta, Prof. R. K. Tripathi and Rishabh Dev Shukla [9], shows how FACTS controllers are used in order to improve the voltage stability. These FACTS devices are used to adjust the magnitude of voltage in power system with proper control. M. K. Deshmukh and C. Balakrishna Moorthy [10] presented the different models of generators for stable operation of electrical power systems and then analysis the effects and improvement of power system stability of grid connected wind farm. Alok Kumar Mishra *et al.* [11] presented an overall perspective of wind power plants and grid integration. Various wind turbine systems with different generators are described, and different technical features are compared. It summarized the electrical topologies with grid requirement for grid stability of wind farms summarized and gives the possible uses of grid stability with wind farms.

## 7. Wind farm with STATCOM

STATCOM is the method that is used for compensating the transient stability in the System. It is a shunt connected device which is used to compensate the reactive power and it is able of generating or absorbing reactive power in which the output can be varied to control the parameters of an electric power system [7].

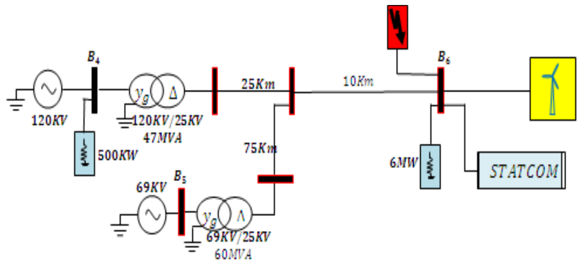


**Figure 3:** Modelling Wind farm with STATCOM[2]

When a fault occurs in the power system, the wind turbine mechanical power has to be reduced in order to improve stability. For fixed-speed rotor short circuited induction generators, it is not possible to control the input mechanical power, and therefore the effective approach would be the use of reactive power compensators such as Static Synchronous Compensator STATCOM or Static Var Compensator (SVC) to help the voltage recovery [2]. Compared with the SVC, the STATCOM has many advantages, such as overall superior functional characteristics, better performance, faster response, smaller size, cost reduction, and capable of providing both active and reactive power [8].

## 8. Conclusion

Wind power which is one of the important renewable sources is considered in order to analyze the effect of this generation on voltage operation and at the voltage stability limits. It can also be concluded that STATCOM can withstand the successive disturbances of the system more efficiently than SVC. In this system many problems occur and this problem compensated by using STATCOM. It full fill the reactive power requirement of the system at the time of fault occur in the system. Because when fault occur on system then voltage low and system get unstable so in that case STATCOM help the system. The impacts of the Static Synchronous Compensator STATCOM on the stability of the system during different fault locations and different fault duration times are studied.

## References


[1] B. Boubekeur, A. Gherbi and H. Mellah, "Application of STATCOM to Increase Transient Stability of Wind Farm", *American Journal of Electrical Power and Energy Systems*, Vol. 2, Issue No. 2, 2013, pp.50-56. Doi: 10.11648/j.epes.20130202.14

[2] O. Noureldeen, M. Rihan and B. Hasanin, "Stability improvement of fixed speed induction generator wind farm using STATCOM during different fault locations and durations", *Ain Shams Engineering Journal*, Vol. 2, Issue No. 1, March 2011, pp. 1-10. Doi: https://doi.org/10.1016/j.asej.2011.04.002

[3] Q. Salem and I. Altawil, "Transient Stability Enhancement of Wind Farm Connected to Grid Supported with FACTS Devices", *International Journal of Electrical Energy*, Vol. 2, Issue No. 2, June 2014, pp. 154-160. Doi: 10.12720/ijoee.2.2.154-160

[4] M. T. Hagh, A. R. Milani and A. Lafzi, "Dynamic stability improvement of a wind farm connected to grid using STATCOM", *2008 5th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology*, Krabi, 2008, pp. 1057-1060. Doi: https://doi.org/10.1109/ECTICON.2008.4600614

[5] V. Chavhan and A. A. Ghute, "Stability Improvement of Wind Generation UsingFACTS Device", *Technical Research Paper Competition for Students (TRPCS-2K17)*, 23 March 2017, G. H. Raisoni College of Engineering and Management, Amravati, Maharashtra, India. Retrieved from https://www.ijsr.net/conf/TRPCS2017/TRPCS2K17-15.pdf

[6] V. Patel and R. K. Paliwal, "A Study on Improvement of the Transient Stability Using STATCOM in DFIG Based Wind Farm", *International Journal of Modern Trends in Engineering and Research*, Vol. 2, Issue No. 3, pp. 56-61. Retrieved from https://www.ijmter.com/papers/volume-2/issue-3/a-study-on-improvement-of-the-transient-stability-using-statcom-in-df.pdf

[7] M. Amiri and M. Sheikholeslami, "Transient stability improvement of grid connected wind generator using SVC and STATCOM", *Proceedings of International conference on Innovative Engineering Technologies (ICIET'2014)*, Dec. 28-29, 2014, Bangkok (Thailand), pp. 136-140. Retrieved from http://iieng.org/images/proceedings_pdf/7452E1214025.pdf

[8] V. S. Kumar, A. F. Zobaa, R. D. Kannan and K. Kalaiselvi, "Power Quality and Stability Improvement in Wind Park System Using STATCOM", *Jordan Journal of Mechanical*

*and Industrial Engineering*, Vol. 4, Issue No. 1, Jan. 2010, pp. 169-176. Retrieved from https://pdfs.semanticscholar.org/b2a3/c241e6c5cd9f3e37c9c77d61861e6e3699d0.pdf

[9] S. Gupta, R. K. Tripathi and R. D. Shukla, "Voltage Stability Improvement in Power Systems using Facts Controllers: State-of-the-Art Review", *2010 International Conference on Power, Control and Embedded Systems*, Allahabad, 2010, pp. 1-8. Doi: https://doi.org/10.1109/ICPCES.2010.5698665

[10] M. K. Deshmukh and C. B. Moorthy, "Review on Stability Analysis of grid connected Wind Power Generating System", *International Journal of Electrical and Electronics Engineering Research and Development (IJEEERD)*, Vol. 3, Issue No. 1, Jan-March 2013, pp, 1-33. Retrieved from https://www.researchgate.net/publication/267331051

[11] A. K. Mishra, L. Ramesh, S. P. Chowdhury and S. Chowdhury, "Review of Wind Turbine System and its Impact for Grid Stability", *Journal of Electrical Engineering*, Vol. 11, Issue No. 1, 2011, pp. 153-170. Retrieved from http://www.jee.ro/covers/art.php?issue=WZ1280390887W4c5136e7ac4d4

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