International Journal for Innovative Engineering and Management Research

PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL

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IJIEMR Transactions, online available on 26th Dec 2022. Link

:http://www.ijiemr.org/downloads.php?vol=Volume-11&issue=Issue 12

10.48047/IJIEMR/V11/ISSUE 12/150

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Volume 11, ISSUE 12, Pages: 1118-1124

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IMPACT OF WIND TURBINE REACTIVE POWER ON ATC CALCULATION

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ABSTRACT

The size and complexity of the electrical power system are increasing day-by-day due to the enhanced industrialization and public lifestyle requirements. Thus, the government has allowed private sectors to produce, and distribute electricity within certain rules. After the Electricity Act 2003 (IEA) implementation, the Indian power sector has promoted the restructuring process to encourage competitive environment in the electric power market. Restructuring of the power system leads to the violating transmission operating limits (congestion) in the system due to increased loading and contingencies. The ATC based CM is one of the useful research areas as it helps the market operator (MO) and the market participants to place bids strategically during system security and reliability threats. ATC can be calculated using the linear approximation method (DC power flow, PTDF), continuation power flow method, OPF method, and artificial intelligence approach. It outlines state-of-the-art processes, summaries, observations, and issues that need attention in ATC evaluation. Reference discussed the ACT calculation for a 246-bus Indian power system using the DC sensitivity method.

KEYWORDS: Wind Turbine, Reactive Power, ATC Calculation, Indian power sector, DC power flow.

INTRODUCTION

The comparative result shows that the OPF method is more accurate than the reactive power flow and DC sensitivity methods. It describes that firm transfer CBM gives larger value than non-firm transfer. The upper level problem is assigned for ATC whereas a lower-level problem is considered for economic dispatch. The model first converts to an equilibrium constraints program then converts into a mixed-integer linear program. The linear programming approach is used which is fast but less accurate. The result shows that ATC decreases due to tie-line capacity reduction. The results show the importance of the HB limit. It is reported that ATC value increases with SVC placement. The comparative results show SVR gives more accurate results for dynamic ATC than the multilayer perceptron neural network (MLPNN) method. Cat swarm optimization (CSO) is used to locate the optimal position and control parameters of FACTS devices. The comparison with the conventional power flow method shows that the proposed method gives a higher value of ATC. The ATC determination with FACTS devices based on PTDF value for bilateral and multilateral transactions. The optimal location of FACTS devices enhances the ATC in all transaction cases. ATC calculation using ACPTDF and contingency analysis have been proposed in bilateral and multilateral transactions. The reduced Newton Raphson (NR)

Jacobian method and decoupled NR based approach to calculate ACPTDF and ATC under contingency. The results are compared with the DCPTDF method, and it is found that ACPTDF gives accurate results in ATC calculation. In this study, a new approach for ATC calculation, and its variation with a WPG have been discussed. The active and reactive power variations of the DFIG are considered during the ATC calculation. The variation of ATC during different uncertain conditions i.e., active and reactive power change on an hourly basis is also calculated for IEEE 30-bus power system. The contingency cases with wind active and reactive power generation are also considered for ATC determination.

WPG AND ITS IMPACT ON ATC

In the world of aviation, the Wide Area Augmentation System (WAAS) is a technical wonder. WAAS, developed by the FAA in collaboration with the Department of Transportation (DoT), has transformed the way airplanes navigate and interact with Air Traffic Control (ATC). This satellite-based augmentation system improves the accuracy, integrity, and availability of GPS signals, opening the way for safer and more efficient air travel. This article goes into WAAS's enormous influence on ATC, examining how it has enhanced navigation capabilities, expanded airspace capacity, and raised situational awareness for both pilots and controllers.

Enhanced Navigation Capabilities

One of the most important effects of WAAS on ATC is its capacity to improve GPS signal accuracy. Prior to WAAS, GPS signals were susceptible to a variety of causes of inaccuracy, resulting in location errors of several meters. WAAS, on the other hand, considerably decreases these inaccuracies by calculating and transmitting correction signals to GPS receivers through a network of ground-based reference stations and geostationary satellites. This augmentation procedure provides for far more accuracy in detecting an aircraft's location, allowing for more efficient aircraft routing and spacing in the airspace. Furthermore, WAAS makes it easier to apply Required Navigation Performance (RNP) protocols, which establish particular levels of navigation accuracy needed for a certain phase of flight. WAAS allows aircraft equipped with RNP-capable avionics systems to navigate accurately along predetermined routes, even in adverse weather or heavily congested airspace. This feature has resulted in a decrease in the minimum spacing needed between aircraft, thereby enhancing airspace capacity and allowing a more efficient flow of traffic.

Increased Airspace Capacity

WAAS integration into the ATC system has been critical in maximizing airspace use. Prior to its deployment, controllers faced limits in regulating aircraft traffic owing to the limitations of ground-based navigation aids. These devices were expensive to install and maintain, and their coverage was sometimes limited, especially in rural or hilly areas. WAAS, on the other hand, offers continuous and accurate navigation coverage across the continental United States and beyond, obviating the requirement for ground-based infrastructure. This increased coverage enables more direct routing possibilities, allowing airplanes to fly more efficient routes. Pilots may now fly

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ideal routes by properly navigating utilizing GPS signals, decreasing flight durations, fuel consumption, and emissions. This not only benefits airlines economically, but it also helps to reduce aviation's environmental imprint.

Heightened Situational Awareness

WAAS has also had a significant influence on pilot and controller situational awareness. Because GPS signals are more accurate, aircraft locations are reliably and regularly presented on radar displays in ATC facilities. This allows controllers to have a more exact awareness of each aircraft under their jurisdiction's position and intentions. WAAS gives pilots hitherto impossible levels of assurance in their position. The integrity monitoring capabilities of the system instantly notify pilots to any irregularities in GPS signals, enabling for fast action if required. This increased situational awareness minimizes the risk of navigational mistakes, improving overall aviation safety. The Wide Area Augmentation System (WAAS) has greatly improved navigation capabilities, increased airspace capacity, and increased situational awareness in Air Traffic Control (ATC). WAAS has changed airplane navigation accuracy by augmenting GPS signals, allowing the deployment of Required Navigation Performance (RNP) protocols and decreasing separation minima. WAAS coverage expansion has improved airspace usage, allowing for more direct route alternatives and generating in economic and environmental advantages. Furthermore, WAAS's enhanced situational awareness helps both controllers and pilots, resulting in a safer and more efficient aviation system. As technology advances, it is anticipated that the influence of WAAS on ATC will rise, further altering the future of air transport. Wind power and solar power generating are the most common in many nations owing to their superior technology and lower cost when compared to traditional power generation. The grid presently has a big capacity wind energy conversion system (WECS), however its influence on system functioning is negative due to wind power fluctuation correlating to wind speed and poor inertia. It increases unpredictability and has a detrimental influence on the system's power quality, security, and stability.

WF reactive power production is a serious challenge in both steady-state and dynamic circumstances. It is determined by the wind speed and the active power management approach. As a result, the capacity curve defines the reactive power restriction of DFIG. The revised reactive power capacity curve for reactive power consumption/production is shown in reference, which takes three restrictions into account: stator current, rotor current, and rotor voltage. As a result, it is critical to consider reactive power constraints according to the capacity curve in order to get greater power capability from wind power, as well as the power transfer distribution factor for ATC calculation.

RENEWABLE ENERGY SOURCES: THE FUTURE OF POWER INDUSTRY

The search for sustainable and clean energy sources has emerged as a critical worldwide priority in an age characterised by increased environmental consciousness and worries about climate change. Renewable energy is at the vanguard of this transformation because to its capacity to generate electricity from natural resources such as sunshine, wind, and water. As fossil fuels continue to demonstrate their limits, both in terms of environmental effect and limited supply, the move to renewable energy sources has become critical for the power industry's future. This paradigm shift has the potential not only to mitigate the negative consequences of climate change, but also to usher in a new age of energy independence, economic prosperity, and technological innovation.

Solar Power: The Radiant Dawn of Renewable Energy

Solar power has emerged as a beacon of hope for the change of the power sector among the varied array of renewable energy sources. The use of photovoltaic cells to harvest sunlight has seen significant progress, making solar energy a more feasible and cost-effective choice. The growth of rooftop solar panels, open-space solar farms, and even integrated solar solutions in urban infrastructure has democratized energy production, allowing people and communities to create their own electricity. Furthermore, advancements in energy storage technology, such as lithium-ion batteries, have addressed the intermittent nature of solar power, assuring a continuous and stable energy source even when the sun is not shining.

Wind Energy: Harnessing the Breath of Nature

Wind energy, yet another pillar of the renewable energy revolution, harnesses the kinetic energy of flowing air masses. Wind farms have become a common sight in landscapes throughout the globe with the development of tall wind turbines capable of collecting the enormous strength of the wind. Wind energy projects, ranging from small-scale community efforts to gigantic offshore facilities, are scalable and adaptable, highlighting their potential to serve as a key source of clean power. Furthermore, continuous research and development activities aim to improve wind turbine efficiency and cost-effectiveness, driving wind energy to greater importance in the global energy scene.

Hydropower: Tapping into Nature's Flow

Hydropower, a long-standing pillar of the renewable energy industry, derives its power from water's gravitational potential energy. The natural flow of rivers and streams is harnessed to create power by creating dams and canals. Large-scale hydropower projects like the Hoover Dam in the United States and the Three Gorges Dam in China are classic examples of this technology's capacity to generate significant quantities of electricity. Micro-hydroelectric systems, on the other hand, provide limited energy demands, especially in rural or off-grid places. Nonetheless, environmental considerations, such as habitat damage and watercourse change, need responsible and sustainable hydropower production approaches.

Geothermal Energy: Tapping Earth's Inner Heat

Geothermal energy harnesses the Earth's interior heat, which is derived from radioactive element decay and leftover heat from the planet's birth. This kind of renewable energy has found use in areas with geothermal activity, such as geysers,

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hot springs, and volcanic zones. Geothermal power facilities tap on these underground heat stores, transforming it into energy using steam turbines or binary cycle systems. Geothermal energy's dependability and constancy make it an appealing alternative for base-load power production, complementing the intermittent nature of solar and wind resources.

Biomass and Bioenergy: Nature's Cycle of Renewal

Biomass, which is obtained from organic resources such as agricultural wastes, forest products, and organic waste, is a diverse and widely accessible renewable energy source. Biomass may be transformed into power, heat, or biofuels by processes such as combustion, anaerobic digestion, and pyrolysis. Bioenergy, a wide category that covers many types of energy obtained from organic matter, includes biofuels such as ethanol and biodiesel, as well as biogas produced in anaerobic digesters from organic waste. Biomass and bioenergy systems contribute to a closed-loop, sustainable energy paradigm by tapping into natural cycles of growth, degradation, and regeneration.

Challenges and Opportunities in the Renewable Energy Transition

Despite significant advances in the development and implementation of renewable energy technology, some obstacles remain in fully achieving their promise. The intermittent and variable nature of sources such as solar and wind power necessitates the development of energy storage systems to assure ongoing availability. Furthermore, grid renovation and extension activities are necessary to handle renewable energy generation's decentralized character, allowing for effective distribution and integration with existing power infrastructures. Furthermore, legislative frameworks, financial incentives, and regulatory assistance are critical in creating a climate favourable to renewable energy adoption.

A Sustainable Energy Future Beckons

Renewable energy sources have the potential to reshape the power business by providing a more sustainable and ecologically responsible alternative to fossil fuels. The shift to renewable energy has the possibility of not only alleviating the effects of climate change but also driving economic development, improving energy security, and stimulating technical innovation through continued research, technological innovation, and coordinated worldwide initiatives. The bright promise of solar, wind, hydropower, geothermal, and bioenergy solutions illuminates the road towards a cleaner, more sustainable society as countries throughout the globe increasingly understand the urgency of a renewable energy future. Renewable energy production has increased in recent years in order to fulfill consumer power demand. All kinds of renewable energy production are employed in combination with conventional generating sources across the globe. There are several difficulties in producing power from RES. Several measures have been implemented to stimulate the production of renewable energy, such as reduced renewable energy contract prices, tax holidays, incentives, easing sale and acquisition, and so on.

CONCLUSION

The transmission lines' burden is growing day by day due to increased demand.

Renewable energy sources are incorporated into the system for a variety of reasons, however many of these resources are nature-dependent and difficult to control. The ISO has several challenges in keeping the system stable and dependable. ATC plays a crucial function in power transmission to ensure free and fair energy trading. Accurate ATC information for the day ahead will result in a profit for the vendor while maintaining the system's power balance. Congestion in the transmission line will be lessened if ISO precisely schedules the transaction between the buyer and seller. In this study, the ATC is calculated using the DCPTDF and ACPTDF techniques. When the results are compared, it is discovered that the ACPTDF approach produces the best results. The influence of wind active and reactive power outputs was studied using the DFIG reactive power capacity curve. Real-time wind speed data is collected for the active and reactive power variations of WG. ATC variations in various scenarios, such as WG integration and line outage contingency condition, are computed. It has been discovered that incorporating renewable energy improves the voltage profile and raises the ATC values.

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